Laboratoire de Recherche en Informatique 2013 - 2018 report



Dossier d'évaluation
d'une unité de recherche

Vague E : campagne d'évaluation 2018-2019

Nom de l'unité:	**Laboratoire de Recherche en Informatique**
Acronyme:	**LRI**
Nom du directeur pour le contrat en cours:	**Yannis MANOUSSAKIS**
Nom du directeur pour le contrat à venir:	**élections à venir**

Type de demande:	**Renouvellement à l'identique avec possibilité de restructuration au cours du prochain quinquennal**

Choix de l'évaluation interdisciplinaire de l'unité de recherche: **Non**

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1/ Présentation de l'unité

LRI

Le LRI

Directeur: Yannis Manoussakis

Résume Le Laboratoire de Recherche en Informatique, unité mixte de recherche de l'Université Paris-Sud et du CNRS (LRI UMR8623), constitue avec le LIMSI le Département d'Informatique de l'Université Paris-Sud. Créé il y a plus de 40 ans, il accueille plus de 230 personnes dont environ 115 permanents et 80 doctorants, organisés en neuf équipes de recherche, un service administratif et deux services techniques. Quatre des équipes de recherche sont tout ou partie commune avec Inria Saclay; deux autres équipes sont tout ou partie commune avec CentraleSupélec. Le LRI, rattaché aux instituts INS2I et INSYS du CNRS (rattachements respectivement primaire et secondaire), a ainsi INRIA et CentraleSupélec comme partenaires privilégiés.

Le laboratoire, situé sur le plateau du Moulon dans les batiments mitoyens Ada Lovelace et Claude Shannon, a un large spectre de recherches fondamentales et appliquées en informatique : algorithmique, combinatoire, graphes, optimisation discrète et continue, programmation, génie logiciel, vérification et preuves, parallélisme, calcul à haute performance, grilles, réseaux, bases de données, représentation et traitement des connaissances, apprentissage, fouille de données, bioinformatique, interaction homme-machine. Cette diversité thématique est l'une des forces du LRI, facilitant les recherches et l'innovation aux interfaces.

Le laboratoire, participant à de nombreux projets nationaux et internationaux, a une très forte activité en termes à la fois de publication (plus de 2 000 publications sur la période 2013-2018) et de transfert vers l'industrie (logiciels et plateformes). Partenaire fondateur du réseau thématique de recherche avancée Digiteo (2010-2017), le LRI est un pilier du département STIC dans la COMUE de Saclay, rassemblant 2,500 chercheurs et enseignants chercheurs en informatique.

Le LRI est très fortement impliqué dans les *Programmes des Investissements d'Avenir* : porteur de l'Equipex Digiscope, initiateur du Labex Digicosme, partenaire du pole de compétitivité mondial System@tic Paris-Region comprenant 200 membres industriels, académiques et institutionnels dans le domaine des logiciels et des systèmes complexes, partenaire de l'IRT SystemX, partenaire de l'Institut de Convergence Dataia, il participe activement à l'Idex Paris-Saclay et à la conception de l'Université Paris-Saclay qui verra le jour en 2020, intervenant en particulier au niveau des futures Graduate Schools, de l'Ecole Doctorale STIC et des Masters informatique et bio-informatique.



LRI

Director: Yannis Manoussakis

Abstract The *Laboratoire de Recherche en Informatique*, LRI, constitutes together with the LIMSI Lab the Computer Science Department of Université Paris-Sud. LRI is a joint research unit of the CNRS (primarily attached with INS2I and secondarily with INSYS), in close partnership with Inria and CentraleSupelec. Founded circa 40 years ago, it has over 240 members, including 115 faculty and staff members and 80 Ph.D. students. LRI is structured along nine research groups, supported by an administrative and a technical group. Four of the research groups are totally or partially joint with Inria Saclay; two other research groups are totally or partially joint with CentraleSupélec. The laboratory is located at the neighbor Ada Lovelace (since 2011) and Claude Shannon (since 2013) buildings on the Plateau du Moulon. The LRI covers a wide spectrum of fundamental and applied research in computer science: algorithms, combinatorics, graph theory, discrete and continuous optimization, programming, software engineering, verification and proofs, parallel systems, high performance computing, grids, architecture and compilation, networking, databases, knowledge representation and processing, machine learning, data mining, bioinformatics, human-computer interaction. This thematic diversity is one of the strengths of the laboratory, fostering research at the boundaries across areas, where the potential for innovation is highest. The laboratory, participating in many European and national projects, is highly productive in both terms of publications (over 2,000 publications in the 2013-2018 period), and knowledge and software transfer toward industry. Founding partner of the former Digiteo Research Network, LRI is a key partner of the Information Sciences & Technologies Department in Université Paris-Saclay, gathering circa 2,600 researchers in Computer Science on the Saclay area. LRI is strongly involved in the *Programmes des Investissements d'Avenir*: coordinator of Equipex Digiscope, founding partner of Labex Digicosme and Institut de Convergence Dataia, partner of System@tic Paris-Region, a world-class cluster gathering over 200 industrial, academic and institutional members in the domain of complex software and systems, and partner of IRT SystemX. It actively participates in the Idex Paris-Saclay and to the construction of the Paris-Saclay University, to be launched in 2020 (e.g., through the setting of the Graduate Schools, the Doctoral School and the Masters).

Introduction

Historique et évolution de l'Unité de Recherche. Le *Laboratoire de Recherche en Informatique* (LRI UMR8623) constitue avec le *Laboratoire d'Informatique pour la Mécanique et les Sciences de l'Ingénieur* (LIMSI UPR3251) le départment d'informatique de l'Université Paris-Sud. Il est situé sur le plateau du Moulon, dans les deux batiments mitoyens Ada Lovelace et Claude Shannon (bat. 650 et 660, environ 7,000 m^2).

Le LRI, fondé il y a 40 ans, est une unité jointe de l'Université Paris-Sud et du CNRS, ayant l'INS2I (section 06) et l'INSYS (section 7) respectivement comme rattachements primaire et secondaire. Historiquement, le LRI couvre un large spectre de recherches fondamentales et appliquées en informatique : algorithmique, combinatoire, graphes, optimisation discrète et continue, programmation, génie logiciel, vérification et preuves, parallélisme, calcul à haute performance, grilles, réseaux, bases de données, représentation et traitement des connaissances, apprentissage par machine, fouille de données, bio-informatique, interaction homme-machine. Ces thèmes de recherche, structurés selon neuf équipes, sont complémentaires de ceux du LIMSI, dont les thèmes couvrent en particulier le traitement du langage naturel, la perception et l'interaction multimodale, la réalité virtuelle et augmentée, la mécanique des fluides et des transferts, et l'énergétique.

La dynamique de recherche du LRI a suscité de forts liens avec INRIA depuis 2004 et avec CentraleSupélec depuis 2011. En particulier, plusieurs équipes de recherche commune LRI - CNRS - INRIA ont été créées ; elles incluent EX-SITU et ILDA dans le domaine de l'interaction centrée sur l'humain, TAU dans le domaine de l'apprentissage machine et de l'optimisation, et TOCCATA dans le domaine de la vérification et de la validation du logiciel. Par ailleurs, une quinzaine d'enseignants chercheurs de CentraleSupélec ont rejoint le LRI en 2014, formant la neuvième équipe MODHEL du LRI (12 membres) ou s'intégrant directement dans l'équipe existante GALAC (3 membres).

Au-delà des activités des équipes, détaillées dans les chapitres suivants, les évènements principaux au LRI pendant la période 2013-2018 se situent au niveau international, national et local.

Au niveau international et européen, le LRI a reçu deux ERC Advanced Grant, en 2013 et 2016. Parmi les deux projets majeurs de la période sont le projet H2020 OpenDreamKit coordonné par le LRI, dont le coeur est le langage Sage, et le projet *Knowledge and Innovation Community ICT Labs* de l'*European Institute of Innovation and Technology*.

Au niveau national, depuis 2010 le LRI est fortement et continument impliqué dans tous les *Programmes des Investissements d'Avenir*, en interaction avec ses partenaires du *Réseau Thématique de Recherche Avancée* Digiteo, qui a contribué à structurer la communauté scientifique en informatique, et préfiguré le Département STIC de l'Université Paris-Saclay :

- L'*Equipement d'Excellence* Digicosme, réunissant 11 laboratoires issus de 8 partenaires sur le plateau de Saclay, a été créé en Mars 2011 pour 10 ans dans le but de concevoir, de réaliser et de valider une plateforme de visualisation et de calcul pour l'interaction collaborative avec de grandes masses de données ; DigiCosme, coordonné par un Professeur du LRI, est unique au niveau international par son échelle, ses capacités de calcul et la versatilité de sa configuration;
- Le *Labex* Digicosme (*Mondes numériques : données, programmes et architectures distribués*, structuré selon 3 axes respectivement consacrés à la sureté et vérification du logiciel, aux réseaux à large échelle, et à la science des données) a été créé en Mars 2012 pour 8 ans, unissant 300 membres permanents de 14 laboratoires issus de 11 partenaires sur le plateau de Saclay ; il a été lancé et coordonné par un Professeur du LRI (2012-2015) et plusieurs permanents du LRI ont assumé et assument les charges de responsables des programmes de Recherche et Formation du Labex;
- L'*Institut de Recherche Technologique* SystemX a été crée en 2012 avec la forte participation de plusieurs membres du LRI ; il rassemble 44 partenaires comprenant 35 industriels, focalisés sur l'ingénierie numérique des systèmes du futur au coeur des filières transport, communication, sécurité numérique et energie ; la forte implication du LRI dans SystemX reflète l'importance attachée par le laboratoire à la dimension technologique et au transfert vers l'industrie ;
- Un nombre important de membres seniors du LRI ont participé aux divers groupes de travail et instances qui ont élaboré l'*Initiative d'Excellence* (Idex) Paris-Saclay, créée en 2012, rassemblant 2 universités, 10 grandes écoles et 6 organismes ou instituts. Un Professeur du LRI dirige actuellement le Département STIC ; d'autres membres ont été élus au Conseil Académique dès sa création ; deux Professeurs du LRI sont respectivement responsables du Master et de l'Ecole Doctorale de la COMUE Paris-Saclay ;

- Le LRI a participé à deux Lidexes (2013-2016) : Center for Data Science et Institut de la Société Numérique; il participe à quatre *Initiatives de Recherche Stratégiques* (IRS) créées in 2015 : i) CDS2.0, prolongeant le Center for Data Science; ii) IMSV, centré sur la modélisation des systèmes du vivant; iii) Nutriperso, centré sur la modélisation des liens entre nutrition, biologie, épidémiologie et sociologie; iv) B5G, centré sur les réseaux 5G ;
- L'*Institut de convergence* DataIA, créé en Sept. 2017, centré sur l'intelligence artificielle et la science des données pour la société, rassemble 14 partenaires fondateurs incluant l'Univ. Paris-Sud, avec deux membres seniors du LRI comme responsables des programmes Formation et Recherche ;

Au niveau local, les évènement principaux comprennent :

- Le déménagement du batiment historique 490 du LRI dans la vallée vers les batiments Ada Lovelace (650) et Claude Shannon (660) sur le plateau, qui s'est achevé en 2013 ;
- L'arrivée de 15 membres permanents de CentraleSupélec, qui ont rejoint le LRI en Jan. 2015; certains ont rejoint l'équipe GALAC, d'autres ont formé l'équipe MODHEL du LRI, en étroite interaction avec les équipes VALS et LAHDAK, qu'ils ont vocation à intégrer en Jan. 2019 ;
- Un diagnostic organisationnel du LRI a été conduit de Février à Décembre 2016, à l'initiative des tutelles UPSud et CNRS, pour améliorer la structure des activités et des process des équipes administrative et techniques, et reconsidérer leurs interactions avec les autres équipes à la lumière de l'évolution du laboratoire. Un résultat important de ce diagnostic organisationnel a été la création d'un pôle nouveau en charge de l'aide au développement logiciel ;
- En parallèle, une forte pression s'est exercée sur les équipes administrative et technique, en raison de plusieurs départs (retraites, promotions, mutations) d'une part, et de l'acroissement de la charge de travail d'autre part (due à la complexité administrative croissante liée à la diversité des statuts des membres du laboratoire et la diversité des financements). Le laboratoire a fait face à cette pression grâce au CNRS (mise en place de postes NOEMI par l'INS2I) et par le recrutement de plusieurs CDD financés sur le soutien de base du laboratoire.

Structuration de l'unité. Le LRI est structuré en 12 équipes, 9 équipes de recherche, deux équipes en charge respectivement du support administratif et technique, et un service d'aide au développement logiciel (depuis 2017), comme décrit par l'organigramme, Fig. 1.3.
Chaque équipe de recherche a un responsable et un responsable adjoint élus pour un mandat de 5 ans renouvelable une fois. Chaque équipe s'intéresse à plusieurs thèmes de recherche, dont chacun est animé par un membre permanent ; les permanents s'intéressent typiquement à plusieurs thèmes. Les équipes sont rattachées à la section 6 du CNRS, à l'exception de l'équipe HCC rattachée à la section 7. Toutes les équipes sont rattachées à la section 27 du CNU. Comme dit précédemment, quatre équipes sont en tout ou partie des équipes projet commun (EPC) INRIA.

Les thèmes de recherche du LRI et leur ventilation entre les équipes, présentés visuellement en Fig. 1.1, sont détaillés ci-dessous (voir Table 1.2 pour la composition des équipes).

- A&O (EPC TAU) : Apprentissage et Optimisation
  Responsable : Michèle Sebag ; Co-responsable : Marc Schoenauer
  Mots Clés : Décision Optimale en Contexte Incertain, Optimisation Stochastique Continue, Sélection et calibration automatique d'algorithmes, Apprentissage Profond et Théorie de l'Information, Sciences Sociales Computationnelles
- BIOINFO : Bioinformatique
  Responsable : Alain Denise ; Co-responsable : Sarah Cohen-Boulakia
  Mots clés : Analyse de séquences et de structures biologiques, Biologie des systèmes et biologie de synthèse, Intégration et analyse de données biologiques.
- GALAC : Graphes, Algorithmes et Combinatoire
  Responsable : Johanne Cohen ; Co-responsable : Yannis Manoussakis
  Mots Clés : Algorithmes (séquentiels distribués, aléatoires), complexité, théorie et algorithmes des graphes, optimisation, combinatoire algébrique et énumérative, systèmes en réseaux, théorie des jeux.
- HCC (EPC Ex-Situ et ILDA) : Informatique Centrée sur l'Humain
  Responsable : Michel Beaudouin-Lafon ; Co-responsable : Olivier Chapuis
  Mots Clés : L'interaction (en grand, gestuelle, tangible), la visualisation, l'exploration de données sémantiques, études empiriques.

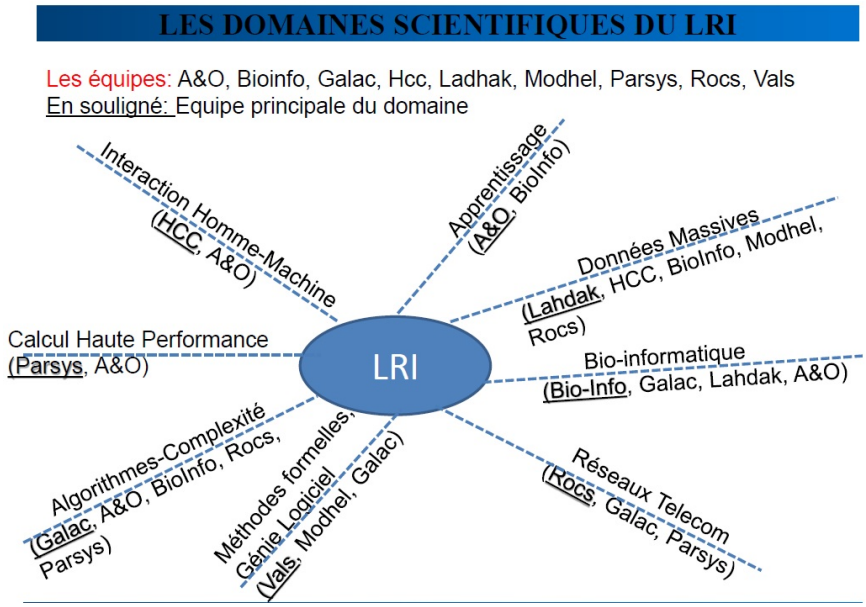


Figure 1.1: Thèmes de recherche et positionnement des équipes du LRI (Jan. 2018)

- LAHDAK : Données et Connaissances Massives et Hétérogènes
  Responsable : Nathalie Pernelle. Co-responsable : Nicole Bidoit
  Mots-clés : Bases de données, Données hétérogènes, Web sémantique, Réseaux sociaux
- MODHEL : Modélisation Hétérogène
  Responsable : Frederic Boulanger; Co-responsable : Nacéra Bennacer
  Mots Clés : Hétérogénéité des paradigmes dans la modélisation et la vérification des systèmes logiciels, intégration de données hétérogènes et de connaissances.
- PARSYS : Systèmes Parallèles
  Responsable : Marc Baboulin ; Co-responsable : Janna Burman
  Mots Clés : conception, preuve, analyse de complexité et implémentation d'algorithmes distribués; calcul haute performance; calcul quantique.
- ROCS : Réseaux et Optimisation Combinatoire Stochastique
  Responsable : Dominique Quadri ; Co-responsable : Lila Boukatem
  Mots Clés : Réseaux, Optimisation Combinatoire et Stochastique, Optimisation dans les réseaux.
- VALS (EPC Toccata) : Vérification d'Algorithmes, Langages et Systèmes
  Responsable: Evelyne Contejean; Co-responsable : Burkhart Wolf
  Mots Clés : Démonstration automatique, langages et systèmes centrés-données, formalisation de langages, test formel à base de modèles, arithmétique machine certifiée, vérification déductive de programmes

Les activités des équipes administrative et techniques sont décrites ci-dessous :

- Service Administratif
  Responsable : Myriam Joseph, Administratrice de l'unité
  Mots Clés : Gestion financière, ressources humaines, logistique, communication
- Service Informatique
  Responsable : Laurent Darré
  Mots Clés : Support et réseau, développement Web et systèmes d'information
- Service d'aide au développement logiciel
  Responsable : Anne-Catherine Letournel
  Mots Clés : soutien aux logiciels scientifiques, veille technologique

Equipe	EPC	Chercheurs CNRS	Chercheurs INRIA	Enseignants-chercheurs
A & O	TAU	4	4	5 (+1 émérite)
BioInfo		2 (+1 émérite)		6
GALAC		5		14 (+1 émérite)
HCC	ILDA, EX-SITU	3 (+1 émérite)	3	4
LAHDAK		0	0	12
MODHEL		0	0	12
PARSYS		0	1	8 (+1 émérite)
ROCS		0	0	7
VALS	TOCCATA	3	3	12 (+1 émérite)

Table 1.1: Effectifs et composition des équipes de recherche du LRI (Jan. 2018)

SERVICES	CNRS	Univ. Paris-Sud	CentraleSupélec
Administratif et logistique	3 permanents	2 permanents, 1 CDD	1 CDD
Développement logiciel	1 permanent, 2 CDD		
Informatique	3 permanents	1 permanent, 1 CDD	

Table 1.2: Effectifs et composition des équipes administrative et techniques du LRI (Jan. 2018)

Effectifs et moyens de l'unité

Les moyens du LRI comprennent outre les dotations des tutelles et partenaires (Fig. 1.4), les ressources propres formées des contrats et subventions. L'évolution (Fig. 1.5) montre que les ressources propres représentent environ 75% des moyens, un pourcentage stable voire en légère hausse par rapport au précédent quadriennal (voir Annexe financière pour le budget détaillé). Les salaires des permanents ainsi que les salaires des doctorants titulaires d'une allocation de recherche du MESR sont directement versés par les organismes (Ministère de la recherche, CNRS ou Inria). Les coûts d'infrastructure (fluides : chauffage, électricité) sont pris en charge par l'Université et Inria. Les EPC reçoivent par ailleurs un soutien d'Inria.

Les dépenses récurrentes comprennent l'équipement, notamment informatique, les missions et les salaires des personnels temporaires sur contrats et les frais de fonctionnement. Un poste de dépenses exceptionnelles majeures est lié au déménagement dans les bâtiments Ada Lovelace et Claude Shannon : ingénieur CDD en maintenance immobilière (2013-2014); aménagement des bureaux, des espace-projets, des salles de réunion, des espaces détente. Une dépense récurrente et nouvelle est la participation aux frais de gardiennage 24/24 du batiment Shannon, partagé avec le CEA. Enfin, comme dit précédemment, du personnel a été embauché en CDD sur les fonds propres du laboratoire pour faire face au surcroît de travail administratif lié à l'augmentation des contrats et la complexité des procédures de gestion.

Personnels permanents	
86 enseignants chercheurs	43 MdC, 43 PR dont 4 émérites
19 chercheurs CNRS	12 CR, 7 DR dont 2 émérites
11 chercheurs INRIA	4 CR, 7 DR
13 administratifs et techniques	7 ITA CNRS, 3 OTARFs UPS, 3 ITA CNRS
Personnels non permanents	
81 doctorants	41 UPS, 4 CNRS, 16 INRIA, 5 CentraleSupélec
12 postdocs	5 UPS, 1 CNRS, 5 INRIA, 1 UVSQ
18 ingénieurs	11 UPS, 2 CNRS, 5 INRIA
2 techniciens	1 T UPS, 1 T CS
12 visiteurs	> 1 mois
63 stagiaires	
44 membres associés	

Table 1.3: Membres permanents et non permanents du LRI au 30 Juin 2018

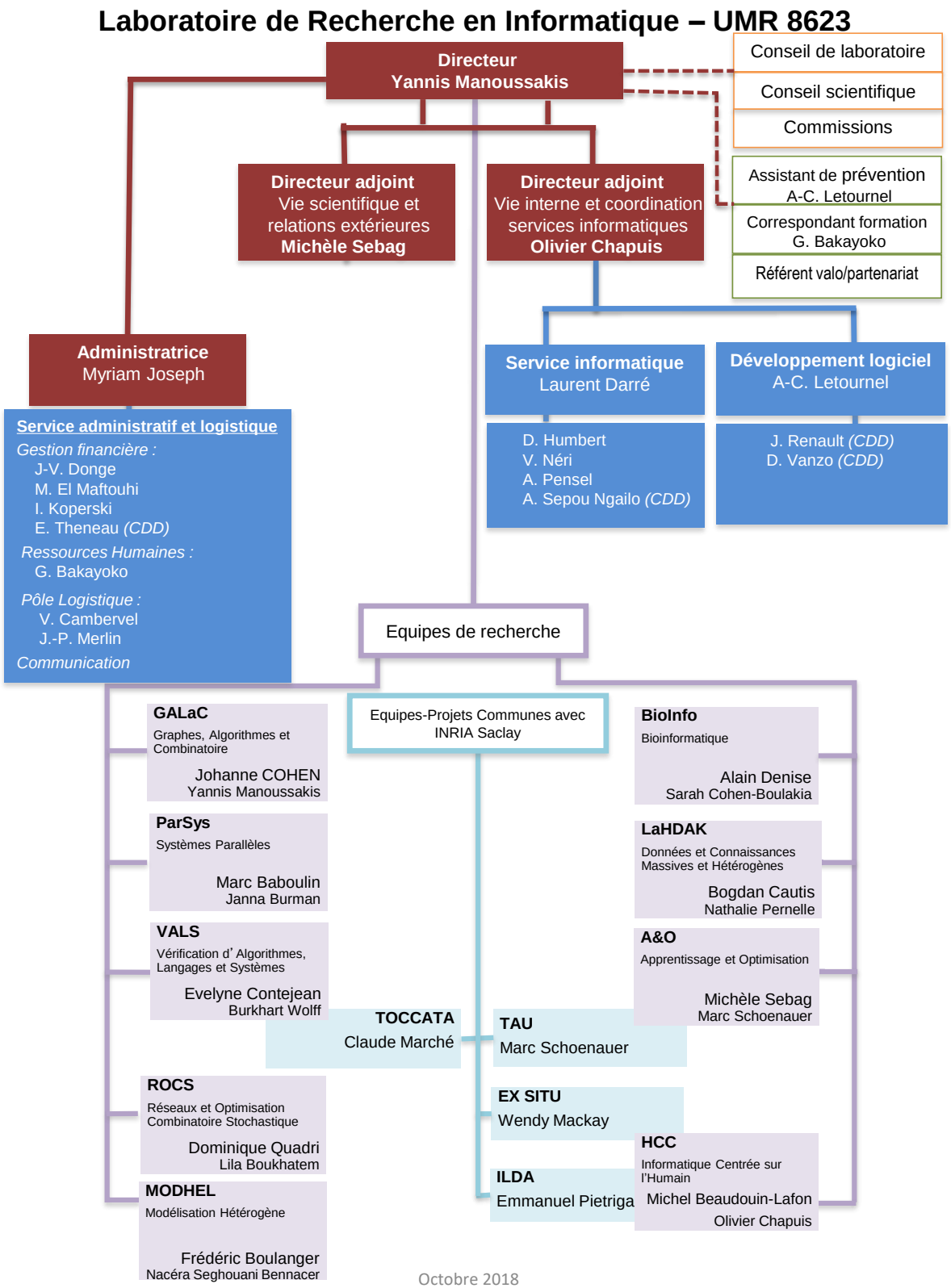


Figure 1.2: Organigramme du LRI

Synthèse consolidée des ressources financières de l'unité						
		2013	2014	2015	2016	2017
Dotations		600370	504930	548181	489615,92	519487
Ressources propres de l'unité		2352579,13	2255168,92	4212894,32	2759332,74	3211767,19
Total des ressources de l'unité		2952949,13	2760098,92	4761075,32	3248948,66	3731254,19
Masse salariale		7199744,26	7650073,48	8996219,71	8684366,88	9105274,72
Autres crédits		0	0	0	0	0
Budget consolidé de l'unité		10152693,4	10410172,4	13757295	11933315,5	12836528,91



Période 2013-2018

Figure 1.3: Budget consolidé du LRI (30 Juin 2018)

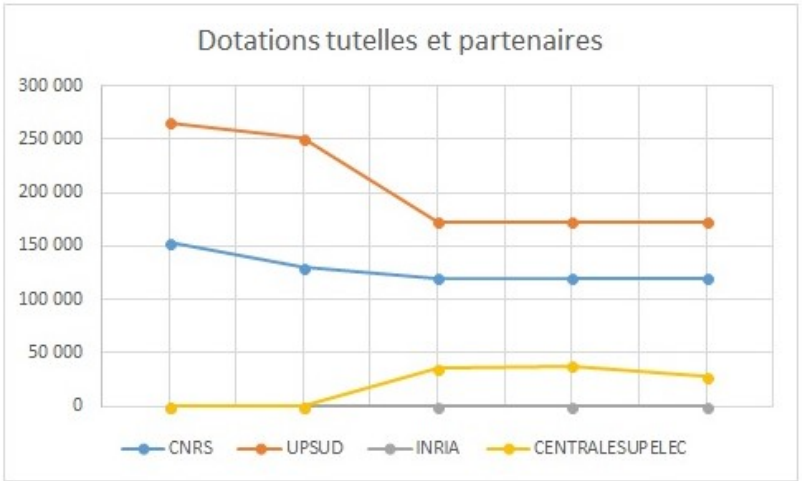


Figure 1.4: Evolution des dotations du LRI (Période 2013-2018)

	2013	2014	2015	2016	2017	TOTAL
Financements internationaux	9700	2500	0	0	0	**12200**
Programmes européens hors ERC et hors fonds structurels	310710	296746	1951904	333117	110583	**3003060**
Subventions ERC	10294	3248	132963	307718	392818	**847041**
Fonds structurels européens	0	0	0	0	0	**0**
Appels à projet ANR (hors PIA)	572526	576100	719999	627746	476991	**2973362**
Programme Investisement d'Avenir	946277	684657	525779	903485	1469333	**4529531**
Autres financements publics sur appels à projets	96405	189765	180408	45758	98957	**611293**
Collectivités territoriales	96462	72842	76646	1181	11363	**258494**
CPER	0	0	0	0	0	**0**
Fondations, associations, mécénats	242078	266354	419881	355394	362065	**1645772**
Contrats de recherche industriels	20457	26156	110520	94541	133936	**385610**
Prestations (expertise, service, conseil, recette de colloque)	45631	84497	4500	6750	33500	**174878**
Institut Carnot	0	0	0	0	0	**0**
Financement de l'innovation (SATT, BPI, ...)	0	0	3308	2576	28063	**33947**
Valorisation des résultats de la recherche	0	0	0	0	0	**0**
Autres financements	2039	52304	86986	81067	94158	**316554**
TOTAL	2352579	2255169	4212894	2759333	3211767	**14791742**

Figure 1.5: Evolution des dotations et fonds propres du LRI (Période 2013-2018)

Le LRI a continué la politique d'accueil des nouveaux arrivants mise en place lors de la période antérieure (financement d'ordinateurs, missions), et inauguré une politique de soutien des activités de recherche : budget pour financer des missions, invitation, petites visites, gratification de stages de Master sous la responsabilité de chaque chef d'équipe ; appel à projets internes aux interfaces de deux équipes du LRI pour créer ou renforcer les collaborations ; financement de manifestations scientifiques et écoles d'été organisées par des membres du laboratoire ; promotion de l'informatique et de la recherche (auprès des lycéens et collégiens ; journées portes ouvertes). Ces initiatives sont abondées par le fonds de soutien du LRI, alimenté par un prélèvement de 10% sur ses ressources propres (hors salaires des personnels).

Le LRI a de nombreuses collaborations aux niveaux national, européen et international, visibles au niveau des chercheurs individuels par les publications jointes et les visites. D'autres collaborations sont formalisées dans le cadre d'une importante activité contractuelle, d'un montant global de 15 millions d'euros sur la période 2013-mi 2018 (à comparer avec 8,5 millions d'euros sur la période 2008-2012). Le montant moyen des contrats (250 contrats et subventions) a diminué par rapport à la période antérieure. Malgré l'apport substantiel du KIC ICT Labs et des subventions ERC et H2020, on observe une baisse des contrats européens : compte tenu du taux d'acceptation, de la lourdeur du montage et de l'investissement en temps requis, les chercheurs se sont tournés vers l'ANR, vers les Programmes d'investissement d'avenir, et vers les industriels (outre les financements Digiteo et les financements par les tutelles ou les réseaux nationaux tels le réseau Francilien de Sciences Informatiques). La croissance des contrats industriels d'une part et institutionnels d'autre part, atteste la visibilité du LRI, la qualité des transferts aussi bien que le rôle majeur que joue le LRI dans l'écosystème local.

Politique scientifique

Durant la période 2013-2018, la politique scientifique du LRI s'est manifestée par ses positionnements dans le cadre de l'Université Paris-Saclay d'une part et ses ouvertures thématiques d'autre part, à travers i) la consolidation de ses axes de recherche; ii) la création d'axes transverses fondés sur les collaborations intra-équipes; et iii) l'émergence de nouveaux axes. Cette politique s'est accompagnée d'une forte activité d'animation de la recherche (organisation de conférences) et de transfert (thèses Cifre et contrats industriels ; développements logiciels et plateformes). Nous nous limiterons à donner quelques exemples pour illustrer la politique scientifique conduite, sans trop de redites avec les activités des équipes :

Consolidation des axes de recherche. Les recrutements ont été ciblés sur quatre thèmes : calcul haute performance (2 MdC, 1 CR), les bases de données (4 MdC, 1 Pr), l'apprentissage machine (1 chaire d'excellence, 2 MdC, 2 CR) et les méthodes formelles/génie logiciel (1 Prof, 2 MdC, 2 CR).

Facilitation d'axes transverses. Ainsi que dit précédemment, le laboratoire a financé sur ses fonds propres un appel à projets interne, ouvert à tous les membres du laboratoire sous condition d'impliquer des membres de deux équipes. Les projets soumis ont été sélectionnés par le Conseil Scientifique, et ont conduit à la définition d'axes ambitieux (e.g. évaluation de la distribution des données Twitter, entre les équipes Ladhak et Modhel; problèmes inverses en dynamique des populations, entre les équipes BioInfo et A& O). Ces projets permettent également de financer des stages de Master et de faciliter le recrutement de doctorants de très bon niveau.

Emergence de nouveaux axes. Le thème *Internet of Things Analytics* (IOTA) est apparu au LRI, lié notamment au projet Emergence DigiCosme de Albert Bifet (Telecom) et Silviu Manu (équipe MODHEL), visant la réalisation de plateforme logicielle Open Source pour l'analyse de flots de données (Data Stream Mining) incubée sur l'*Apache Software foundation*. Ce thème est destiné à prendre une nouvelle ampleur, en bénéficiant d'une convergence d'intérêts avec l'équipe ROCS et la problématique des réseaux multicapteurs. L'algorithmique quantique sera également considéré comme possible thème émergent (voir la partie Perspectives).

Développements logiciels. Les développements logiciels emblématiques du LRI, internationalement visibles, comprennent en premier lieu l'assistant de preuve interactif Coq, et le logiciel de combinatoire algébrique et de calcul symbolique Sage. Ce dernier est au coeur du projet européen H2020 OpenDreamKit, coordonné par le LRI. Par ailleurs, la retombée majeure du diagnostic organisationnel conduit sur l'année 2016 est la création d'un service d'aide au développement logiciel, visant la dissémination des bonnes pratiques de génie logiciel dans toutes les équipes d'une part, et la consolidation ou valorisation des logiciels issus des travaux des équipes d'autre part. L'un des projets de valorisation sélectionné par le Conseil Scientifique, à l'interface des équipes PARSYS et GALAC, concerne l'algorithmique linéaire en grandes dimensions (CDD CNRS Daniel Vanzo).

Positionnement dans l'Université Paris-Saclay. Les rapprochements avec les laboratoires voisins ou rejoignant le site de Saclay conduisent à identifier les domaines d'expertise unique du LRI dans le paysage informatique saclaysien. Un tel domaine est celui de l'algorithmique fondamentale, partie immergée de l'iceberg du Labex DigiCosme (dont les trois axes concernent respectivement la sécurité du logiciel, les réseaux et la science des données), et dont l'importance en général et l'excellence au LRI ont été reconnues par la médaille de bronze du CNRS attribuée à un chercheur de GALAC en 2018.

Communication, relations internationales et industrielles. L'environnement de Saclay est très porteur vis à vis de l'informatique et de nombreuses universités étrangères ainsi que des industriels nationaux ou étrangers ont pris contact et ont été accueillis au LRI, notamment Huawei; EdF; Atos; Univ. Singapour; Univ. Tainan (Taiwan). Les membres du LRI ont pris part aux rencontres avec les industriels, les politiques ou le public (Big data 2015 à HEC, journée IA à CentraleSupélec en 2018), et ont porté l'image de l'informatique, du LRI, de Saclay et des tutelles lors de tables rondes, et d'interviews radio, TV (par ex, journal de 20h00, France 2 en 2017 sur le BigData et chômage) ou presse (2 pages dans Le Monde, un portrait dans Usine Nouvelle). Des activités plus classiques (participation aux comités de programmes, organisation des conférences internationales, mise en place de collaborations bilatérales, invitation de chercheurs étrangers, thèses en cotutelle et Cifre) contribuent également à la grande visibilité du LRI.

Présentation de l'écosystème du LRI

Structures de coopération. Le LRI, unité mixte de recherche de l'Université Paris-Sud et du CNRS, a été de tout temps un pilier des initatives de coopération unissant les laboratoires de la région. Le réseau thématique de recherches avancées (RTRA) Digiteo (2006-2016) a permis de fédérer la communauté informatique et de se doter de procédures de collaboration qui ont notablement facilité la constitution du Département STIC de la COMUE Paris-Saclay.

Le Labex DigiCosme a repris une partie des missions du RTRA Digiteo, avec un spectre scientifique et une gouvernance resserrés. Les trois thèmes retenus sont parmi les activités majeures du LRI : Scilex (sureté du logiciel), Comex (Réseaux) et DataSense (science des données). La proposition DigiCosme a été portée par un professeur du LRI (responsable jusqu'en 2016), et les priorités scientifiques ont été définies en étroite interaction entre les membres du LRI et des laboratoires partenaires. Les membres du LRI ont ainsi assuré les tâches de vice-président recherche (depuis 2015), de responsable de l'axe DataSense (jusqu'en 2016), puis de l'axe Comex (depuis 2016). Les activités de DigiCosme comprennent des appels à projets (PhD, post-doc, chaires émergence), l'animation de groupes de travail et d'écoles d'été ; les membres du LRI ont été fortement partie prenante de ces activités (e.g. responsables ou co-responsables de 9 sur 25 groupes de travail).

Le RTRA s'est ensuite fondu dans l'Idex Paris-Saclay, rassemblant présentement 3 Universités (Université Paris-Sud, Université d'Evry Val-d'Essonne, Université de Versailles Saint-Quentin-en-Yvelines), 4 grandes écoles (Ecole CentraleSupélec, Ecole Normale Supérieure Paris-Saclay, Institut d'Optique Graduate School, AgroParisTech) et 7 organismes ou instituts (Institut des Hautes Etudes Scientifiques, CNRS, CEA, Inra, Inria, Inserm et Onera).

Université Paris-Saclay. Ainsi que dit précédemment, le LRI s'est fortement et continument impliqué dans la création de Paris-Saclay à tous les titres depuis 2010 : participation au Sénat puis au Conseil Académique Consultatif interlocuteur de la gouvernance de Paris-Saclay (2 membres élus) ; participation aux groupes de travail dessinant le contour de la School of Engineering & Information Sciences and Technologies; participation au Conseil de Département STIC (président + 3 membres ès qualités ou élu) ; participation forte à deux Lidex (Center for Data Science, Institut de la Société Numérique) ; participation forte à 4 Initiatives de Recherche Stratégiques, dont 4 labellisées et 3 financées.
Une action de très grande envergure concerne l'EquipEx DigiCosme, porté par un Professeur du LRI. Une activité connexe, dont les retombées sont très importantes en termes non seulement de recherche mais aussi de dissémination, est le montage d'un FabLab, accueilli par le LRI dans les locaux du batiment Shannon à partir de 2018.
Enfin, l'attractivité du LRI a permis de recruter un Professeur de rang international sur la Chaire d'Excellence Idex Big Data (sur support Université Paris-Sud et Inria). Il faut souligner que seules 3 chaires d'excellence UP-Saclay ont été attribuées depuis leur lancement, toutes disciplines confondues.

Université Paris-Sud. Au niveau de l'Université Paris-Sud, le LRI assure une forte partie de la formation en informatique (Université du L1 au M2; Polytech, IUT d'Orsay et de Sceaux ; lancement du Master BioInformatique ; lancement du EIT European Master Cursus) et de la gouvernance (les charges de chef de département, de chef de l'école doctorale, de vice-présidents recherche et éducation, puis doyen de la Faculté des Sciences sont assurées par des Professeurs du LRI).

Le LRI entretient des liens directs avec d'autres départements et laboratoires, notamment en maths (animation jointe du séminaire de l'IHES) et physique (LAL: organisation de challenges et d'hackathons). Le LRI avec le LIMSI réalise la mise à disposition d'une plate-forme GPU localisée à l'IDRIS.

Poles IA. Le LRI s'est également fortement impliqué dans le projet d'Institut de Convergence DataIA (labellisé en 2017 pour une durée de 8 ans) ; deux membres du LRI sont respectivement en charge des programmes de recherche et d'éducation. La mission sur l'IA confiée à Cédric Villani l'a été en collaboration avec un membre du LRI. Enfin, plusieurs membres du LRI participent au montage d'une proposition d'Institut Interdisciplinaire d'IA (3IA), jointe entre Univ. Paris-Saclay et New Uni.

Relations industrielles. Le LRI est un des premiers partenaires de l'Institut de Recherche Technologique System'X (membre du Conseil Scientifique ; nombreuses thèses Cifre co-encadrées), ainsi que du Pole de compétitivité Systematic.

Produits et activités de recherche

Bilan Scientifique

Ainsi que nous l'avons dit, une énergie intense en terme de politique et de stratégie scientifiques a été investie dans le contexte de l'Université Paris-Saclay, compte tenu de la rapide évolution du paysage et de l'importance croissante dévolue à l'informatique. Cependant, les activités scientifiques à proprement parler se sont poursuivies au meilleur niveau ; chaque équipe publie dans les meilleurs journaux ou conférences de son domaine, et les avancées réalisées sont visibles internationalement. Nous allons résumer ci-dessous certains des faits marquants et résultats, qui seront détaillés dans la présentation des équipes.

- L'axe de recherche *Interaction Humain-Machine* (équipe HCC, Human Centered Computing), comprenant les deux EPC Inria EX-SITU et ILDA) du LRI est reconnu internationalement. Cette équipe a obtenu deux ERC (Advanced grant) en 2013 et 2016, une nomination senior à l'IUF (2011), et l'un de ses membres a recu un doctorat Honoris causa de l'Université d'Aarhus (Danemark) en 2013. L'attractivité de l'équipe est attestée par ses recrutements et promotions (CR CNRS nouvellement recruté, un DR CNRS en mutation, promotion DR d'un CR CNRS) ; le LRI a par ailleurs recruté 2 MdC sur ce thème dans la période 2013-2018. L'ensemble des récompenses de l'équipe (Best Paper Awards, papiers Chairs) témoigne de sa reconnaissance internationale. L'EPC *Extreme Situated Interaction*, EX-SITU qui succède à l'EPC IN-SITU atteinte par la limite des 12 ans d'une équipe Inria, s'intéresse aux utilisateurs extrêmes de l'informatique, notamment aux créateurs (musiciens, danseurs), ouvrant des pistes extrêmement originales. L'EPC *Interacting with Large Data*, ILDA, s'interesse aux systèmes interactifs centrés sur les données ; les domaines d'application, s'appuyant aussi sur l'EquipEx Digiscope et les murs d'images WILD et WILDER, comprennent en particulier l'astronomie et la gestion de situation de crise.
  Cette équipe s'investit également fortement dans l'enseignement de l'IHM (Master international M1-M2 HCID dans le cadre d'ICT Labs).
- L'axe de recherche *Apprentissage Machine et Optimisation* (équipe A & O, comprenant l'EPC Inria TAU) du LRI, est reconnu au niveau international. L'extrême pression exercée par les entreprises du GAFAM sur les chercheurs académiques dans le domaine de l'IA a conduit au départ de deux seniors vers respectivement Google Zurich et Facebook Paris; la collaboration continue avec encadrement de thèse Cifre et accès aux plateformes de calcul. L'attractivité de l'équipe a permis de recruter une des stars internationales de l'Apprentissage Machine sur une chaire d'Excellence de Paris-Saclay en 2015. Le profil Maths-Info de l'équipe est à souligner[1]. L'activité d'optimisation stochastique boite noire de

[1] L'un des membres de l'équipe a été chargé de la l'exposition organisée à l'IHP et au Musée des Arts et Métiers pour le centenaire de la naissance de Claude Shannon. Un autre membre de l'équipe est chargé du séminaire Apprentissage de l'IHES en collaboration avec un membre du Laboratoire de Maths d'Orsay.

l'EPC TAO, atteinte par la limite des 12 ans d'une équipe Inria, a ainsi donné lieu à la création de l'EPC *Randopt* au Centre de Mathématiques Appliquées de l'Ecole Polytechnique, et deux chercheurs ont quitté le LRI pour rejoindre le CMAP. L'un des domaines défrichés par A & O dans la période (2008-2013) concernait l'adaptation d'algorithmes de bandit manchots arborescents pour jouer au Go (travaux qui ont inspiré les algorithmes AlphaGo et AlphaZéro de DeepMind). Cette ligne de recherche a été reprise par un membre de A & O ; son adaptation au jeu de bridge a gagné les championnats internationaux de bridge computationnel en 2016 et 2017. Le membre de A & O a demandé sa disponibilité pour fonder une start-up et explorer le potentiel de cette approche.

- L'axe de recherche *Graphes, Algorithmes et Combinatoire* (équipe GALAC) a atteint le but fixé lors de l'intégration des équipes antérieures *Algorithmique* et *Théorie des Graphes et Optimisation Combinatoire* du LRI, i.e. former un axe fort et internationalement visible en informatique fondamentale. Deux recrutements au niveau Professeur ont permis de créer une masse critique dans le domaine de la combinatoire et du calcul symbolique, qui a conduit à proposer et à coordonner le projet H2020 OpenDreamKit (15 universités et industriels partenaires). La renommée des recherches fondamentales de l'équipe et son attractivité sont démontrées par l'accueil de membres issus d'autres équipes du LRI, ou de l'Université Versailles ou CentraleSupélec. Sa reconnaissance est attestée au niveau national (médaille de bronze CNRS; deux membres nominés à l'IUF; recrutement DR2 CNRS; chaire Digiteo) et international (Best Paper Awards dans les meilleures conférences du domaine).
- L'axe de recherches *Vérification d'Algorithmes, Langages et Systèmes* (équipe VALS, comprenant l'EPC Inria TOCCATA) du LRI, intègre les équipes antérieures *Démonstration* et *Génie Logiciel*. Cette équipe est extrêmement reconnue au niveau international, en particulier en lien avec l'excellence académique et la richesse des applications industrielles des logiciels Coq et Isabelle. Coq a recu l'Award ACM SIGPLAN Programming Languages Software en 2013. L'équipe VALS, qui a vocation à accueillir certains membres de l'équipe MODHEL issus de CentraleSupélec, a recruté un professeur, 2 MdC et 2 CR CNRS sur la période 2013-2018. La communauté d'intérêts avec le laboratoire LSV de l'ENS-Saclay, qui rejoindra le plateau du Moulon en 2019, devra permettre de créer un pôle d'excellence en Méthodes Formelles au niveau de l'Université Paris-Saclay.
- L'axe de recherche *BioInformatique*, joint jusqu'en 2016 avec l'EPC Inria pluri-établissements AMIB (Université Paris-Sud – Ecole Polytechnique), joue un rôle moteur dans ce domaine, notamment au niveau de la recherche nationale (CID 51 CNRS), de l'enseignement (création du Master BioInformatique à l'Université Paris-Sud), ainsi que dans l'animation de la communauté Saclaisienne (dans le cadre du Labex DigiCosme et du Lidex *Center for Data Science, CDS*) et nationale (vice-président de la SIF). Au niveau local, les activités conduites dans le cadre du Lidex *Center for Data Science* ont permis d'établir et de resserrer des liens avec les laboratoires de biologie de Paris-Sud. L'équipe dispose d'un réseau de collaborations internationales et européennes très actif et étendu.
- L'axe de recherche *Calcul à haute performance* (équipe PARSYS) intègre les équipes antérieures *Parallélisme* et *Architecture Machine* du LRI, anciennement jointes avec les équipes projet Inria ALCHEMY et GRAND LARGE. Le déploiement de cette équipe s'est heurté a certains obstacles (le projet d'équipe commune avec des membres du laboratoire Jacques-Louis Lions de l'UPMC n'a pas reçu de feu vert institutionnel ; certains chercheurs Inria ont rejoint Rocquencourt). Le LRI a ainsi mis en œuvre le recrutement d'un MdC sur chaire Inria (2010), puis sa promotion sur un poste de Professeur (2013), pour sécuriser l'expertise acquise dans le domaine stratégique du HPC ; cinq autres recrutements (4 MdC et 1 CR CNRS) ont été effectués dans la période 2013-2018 et l'arrivée récente d'1 Professeur CentraleSupélec et d'un MdC viennent renforcer l'équipe. Au cours de cette période, un enseignant chercheur a fondé son entreprise NUMSCALE, accueillie dans les batiments AdaLovelace et Claude Shannon.
- L'axe de recherche *Données et Connaissances Massives et Hétérogènes* (équipe LAHDAK) intègre les équipes antérieures du LRI *Bases de Données* et *Intelligence Artificielle et Systèmes d'Inférence*, anciennement jointe avec l'équipe Inria OAK. La grande pression actuelle dans le domaine des sciences des données a contribué à de nombreux mouvements de personnes dans l'équipe (promotions, mutations). Le LRI a affirmé sa volonté de consolider cet axe par le recrutement d'1 Professeur et 3 MdC sur la période ; l'arrivée d'une partie des membres de l'équipe MODHEL est également prévue en Jan. 2019. En lien avec l'équipe ROCS (voir ci-dessous), l'équipe LAHDAK souhaite s'ouvrir vers le thème *Internet of Things* (IOT), qui fait par ailleurs partie de l'expertise de certains membres de MODHEL. Le LRI a en conséquence profilé un poste de professeur sur ces thématiques (campagne 2018).
- L'axe de recherche *Réseaux et Optimisation Combinatoire* (équipe ROCS) intègre les équipes antérieures *Réseaux* et *Optimisation combinatoire* du LRI. Bénéficiant de sa très grande expertise et de l'essor du domaine des réseaux, le responsable de l'équipe Réseaux a fondé son entreprise GREEN COMMUNICATIONS. D'autres mouvements (mutation vers l'équipe GALAC de certains membres de ROCS) ont pénalisé le déploiement de l'équipe, qui assure par ailleurs une forte activité d'animation de la com-

munauté (vice-président enseignement de l'Univ. Paris-Sud, responsable de l'axe Comex du Labex DigiCosme). En concertation avec l'équipe LAHDAK, ROCS s'intéresse à IOT et ses rapports avec les réseaux multi-capteurs. Le LRI (direction, conseil scientifique) approuve cette orientation et la soutient en profilant un poste de professeur.

Données chiffrées

Publications Sur la période 2013-201 (cinq ans et demi), les membres du LRI ont produit plus de 2 000 publications (production stable par rapport à la période antérieure), décomposées comme suit :

- Articles de revues majeures internationales : 315, autres: 206
- Article de conférences majeures internationales: 431, autres: 573
- Édition de livres: 26
- Chapitres de livres: 48

Le ratio est ainsi de 7.2 publications majeures par permanent[2]. En comptabilisant toutes les formes de publication, le ratio est de 8.6 par membre du laboratoire, y compris les doctorants et postdocs (soit 10.1 en équivalent-chercheur). Le ratio de publication est ainsi de l'ordre de deux publications par an par équivalent-chercheur en moyenne.

La définition des publications dites majeures repose comme précédemment sur la classification originellement définie par l'association australienne CORE pour la recherche et la formation en informatique, qui comprend quatre catégories : A+, censé représenter les 5% meilleures, A, pour les 15% suivantes, B, pour les 30% suivantes, et C, pour les 50% restantes. Les publications majeures sont les publications notées A+ ou A, soit les 20% réputées les meilleures.

Logiciels, brevets, start-ups. Concernant les logiciels et brevets, les équipes du LRi ont produit un total de 109 logiciels, et deux brevets ont été déposés dans la période 2013-2015. Les équipes GALAC et VALS font partie des leaders développeurs des logiciels mondialement connus Sage et Coq, respectivement.

V. Ventos, membre de l'équipe A & O est co-fondatrice de la start-up Nukkai, créée en 2018. Joel Falcou, membre de l'équipe PARSYS, est fondateur de la start-up Numscale. Khaldoun Al Agha, membre de l'équipe ROCS est co-fondateur de la start-up Green Communications.

Serveurs et plateformes. L'équipe technique du LRI administre deux serveurs (le cluster TIPI et le serveur GPU Kepler) et co-administre avec l'équipe technique du LIMSI, le cluster GPU DSP@Saclay dans les locaux de l'IDRIS.

Les équipes HCC et A & O du LRI administrent respectivement les plateformes d'audience internationale :

- Digiscope : Réseau de plateformes pour la visualisation interactive de grandes quantités de données et de calculs complexes. Le responsable scientifique de Digiscope est M. Beaudouin-Lafon membre de HCC, et l'un des deux responsables techniques, C. Fleury, est également membre du LRI. Trois plateformes Digiscope (Wild, Wilder et Fablab) sont présentes dans les locaux du LRI et directement accessibles aux membres du LRI.
- CodaLab : Plateforme open-source pour l'organisation de Challenges en apprentissage machine dans un contexte de recherche, d'exploration industrielle, et d'enseignement ; cette plateforme accueille notamment le challenge européen See4C dans le domaine de l'énergie (https://codalab.lri.fr/). Le responsable scientifique de CodaLab est I. Guyon, membre de A & O.

Sélection des produits et des activités de recherche

Publications majeures

- Y. Olivier, L. Arnold, A. Auger and N Hansen, Information-Geometric Optimization Algorithms: A Unifying Picture via invariance principles, J of Machine Learning Research 18(18):1-65, 2017.
- C. Furtheler and A. Decelle, Cycle-based Cluster variational method for direct and inverse inference, J. of statistical Physics, 164(3):531-576, 2016.
- D. Ellison, A. Mugler, M. D. Brennan, S. H. Lee, R. J. Huebner, E. R. Shamir, L. A.Woo, J. Kim, P. Amar, I. Nemenman, A. J. Ewald, and A. Levchenko. Cell-cell communication enhances the capacity of cell ensembles to sense shallow gradients during morphogenesis. Proceedings of the National Academy of Sciences of the United States of America , 113(6):E679-E688, 2016.

[2] Soit 10.9 par équivalent-chercheur, en considérant qu'un enseignant-chercheur est compté la moitié d'un chercheur.

- J. Starlinger, B. Brancotte, S. Cohen-Boulakia, and U. Leser. Similarity Search for Scientific Workflows. Proceedings of the VLDB Endowment (PVLDB), 7(12):1143-1154, 2014.
- F. Hivert, A. Schilling, and N. M. Thiéry, The biHecke monoid of a finite Coxeter group and its Representations, Algebra & Number Theory, 7(3):595–671, 2013.
- M. Mangili, F. Martignon and A. Capone, Performance Analysis of Content-Centric and Content-Delivery Networks with Evolving Object Popularity, Computer Networks, 94:80-98, 2016.(best paper among 841 accepted papers and 2,272 submitted papers).
- T. Tsandilas, A. Bezerianos, and T. Jacob, SketchSliders: Sketching Widgets for visual exploration on wall displays, CHI'15:3255-3264, 2015.
- I. Avellino, C. Fleury, W. Mackay and M. Beaudoin-Lafon, CamRay: Camera arrays support remote collaboration on Wall-sized displays, CHI'17:6718-6729, 2017.
- P. Lagree, O. Cappe, B. Cautis, S. Maniu, Effective large scale online influence maximization, ICDM:937-942, 2017
- N. Bidoit, M Herschel, A Zompanaki, Efficient computation of polynomial explanantions of Why-Not questions, CIKM:713-722, 2015
- P. Arrighi, A. Diaz-Caro and B. Valiron, The vectorial lambda Calculus, Information and Computation, 254(1):105-139, 2017
- JJ Vie, F. Popineau, E. Bruillard and Y. Bourda, Automated assembly for handling learner cold-start in large-scale assessments, Int. J. of AI in Education, Feb 2018.
- A. Khabou, J.W. Demmel, L. Grigori and M. Gu, LU factorization with panel rank revealing pivoting and its communication avoiding version, Siam J. on Matrix analysis and applications 34(3) 2013
- J. Beauquier, J. Burman, F. Dufoulon, and S. Kutten, Fast beeping protocols for deterministic mis and (D+1)-coloring in sparse graphs, Infocom 2018, to appear.
- K. Yang, S. Martin, D. Quadri, J Wu and G. Feng, Energy-Efficient Downlink Ressource Allocation in heterogeneous OFDMA networks, IEE Trans. Vehicular Technology 66(6):5086-5098, 2017.
- G. Li, L Boukhatem, J Wu, Adaptative quality-of-service-based routing for vehicular adhoc networks with ant colony optimization, IEE Trans. Vehicular Technology 66(4):3249-3264, 2017.
- C. Dross, S. Conchon, J. kanig and A. Paskevich, Adding decision procedures to SMT solvers using axioms with triggers, J. of Automated Reasoning, 56(4):387-457, 2016.
- V. Benzaken, E. Contejean, C. Keller and E. Martins, A Coq formalization of SQL's execution engines, ITP, Oxford, Juillet 2018.

Plateformes et logiciels

- La plateforme Codalab. Fondée en 2013 entre Microsoft et l'université de Stanford, cette plateforme est actuellement hébergée au LRI et administrée par I. Guyon, membre de l'équipe A&O
- La plateforme Cartolabe. Créée en 2015 par Philippe Caillou et Michèle Sebag, co-financée par le CNRS et Inria, cette plateforme permet de visualiser l'activité scientifique d'un institut à partir des données bibliographiques disponibles sur HAL.
- CaRNAval : Développé par des membres de l'équipe Bioinfo ce logiciel online offre la possibilité d'explorer en 3D les structures ADN.
- Colomoto Interactive Notebook, développé en collaboration avec l'équipe Bioinfo du LRI, Ibens et l'institut Curie, offre une palette d'outils logiciels et un interface graphique pour la biologie de systèmes.

- Logiciel Sage, La partie Sage-combinat est coordonnée par N. Thierry, professeur au LRI et membre de l'équipe Galac. Ce même logiciel bénéficie d'un financement H2020 depuis 2015.
- Smarties, Wildos, ZVTM : Bibliothéques de logiciels pour l'utilisation de murs d'images.
- CQAPRI : Un prototype pour les réponses de requêtes sous AR, IAR sémantiques pour des BD DL-LiteR.
- La bibliothéque sameAs.cc ressource développée par l'équipe LAHDAK en collaboration avec l'université d'Amsterdam, offre la plus grande palette de liens pour des services Web.
- Plusieurs librairies pour le logiciel Coq, comme Coccinelle, Coq.interval, Coquelicot, Floq sont (co)developpés par des memebres de l'équipe VALS.
- La plateforme Why3, dédiée à la vérification des logiciels, et piloté par des membres de VALS a reçu la "Distinguished user-assistance tool feature" award.

Visibilité et attractivité

- C. Villani et M. Schoenauer, membre de A & O, ont été co-responsables de la mission Meaningful Artificial Intelligence, commanditée par le gouvernement sur l'IA.

- I. Guyon a été Program Chair de la conférence Neural Information Processing Systems en 2016 (6 000 participants).
- M. Sebag, membre de A & O, est élue chair of the European Steering Committee for Machine Learning and Knowledge Discovery from Databases.
- Des membres de l'équipe BIOINFO participent activement à des réseaux nationaux et internationaux comme ELIXIR et l'institut Français de bioinformatique.
- N. Thiéry, membre de l'équipe GALAC, coordonne le projet H2020 OpenDreamKit.
- Lin Chen, membre de l'équipe GALAC est lauréat de la médaille de bronze CNRS 2018, et junior membre IUF depuis 2018.
- W. Mackay, membre de HCC, est lauréate ERC 2013 et Doctorate Honoris causa de l'Université d'Aarhus, Danemark.
- M. Beaudoin-Lafon, membre de HCC, est lauréat d'un ERC 2016.
- Les membres de l'équipe LAHDAK participent systématiquement à de comités exécutives et scientifiques des conférences majeures du domaine comme SIGMOD, EDBT, IEE TCDE etc.
- L'équipe LAHDAK a obtenu deux projets Jean d'Alembert permettant de d'inviter deux chercheurs étrangers de renommé mondiale.
- Les membres de l'équipe MODHEL participent à des instances de normalisation, e.g., l'AFNOR et ISO.
- M. Baboulin, responsable de l'équipe PARSYS a été lauréat d'une chaire Inria/Upsud de 2013 à 2015.
- J. Falcou, membre de l'équipe PARSYS, a été plusieurs fois orateur invité à des conférences majeures sur C++.
- L. Boukhatem, membre de l'équipe ROCS a reçu le prix de la fondation Canon en 2015.
- S. Martin et D. Quadri ont obtenu des résultats remarquables sur des réseaux OFDMA qui ont conduit à une publication dans le prestigieux journal IEE Trans. Vehicular Technology en 2017.
- Le logiciel Coq, dont le LRI est un partenaire très actif, a reçu en 2013 le prestigieux prix ACM software system award.
- C. Paulin a reçu en 2015 le prix « Michel Monpetit » de l'académie des sciences française.

Aspects socio-économiques et culturels

- Interview le Monde, I Guyon, 2018.
- V. Ventos, membre de l'équipe A&O est co-fondatrice de la start-up Nukkai.
- C. Froideveaux est Vice-présidente de la société savante SIF.
- N. Thiéry et F. Hivert, membres de l'équipe Galac, ont des collaborations très actives avec les organisations Logilab et Quantstack sur le développement logiciel.
- Plusieurs interviews TV et radios des membres de l'équipe HCC sur l'IHM.
- Plusieurs interviews TV, radio et presse des membres de l'équipe A& O sur l'IA.
- N Pernelle, responsable de l'équipe Lahdak, est membre de CNECA (Commission nationale des enseignants-chercheurs relevant du ministère de l'agriculture) et de CEI (Comité national pour l'évaluation des ingénieurs de l'Inra).
- Actions de dissémination et de médiation scientifique (émissions radio, interventions dans les écoles) par des membres de l'équipe Modhel.
- J. Falcou, membre de l'équipe Parsys, est fondateur de la start-up Numscale.
- M. Baboulin, responsable de l'équipe Parsys a des collaborations étroites avec l'EDF sur les solveurs HPC et avce Atos sur le quantum computing.
- K. Al Agha, membre de l'équipe Rocs, est fondateur de la start-up Green Communications.
- Deux brevets sont déposés par des membres de l'équipe Rocs en collaboration avec G. Pujolle, professeur à l'université Paris VI.
- C. Paulin est doyenne de la faculté de sciences d'Orsay, Upsud.
- V. Benzaken a été vice-doyenne RH à la faculté des sciences d'Orsay, Upsud

Faits marquants

Plusieurs membres du LRI ont été récipiendaires de prix ou d'honneurs :

Grants and Honors

- Lin Chen, *CNRS Bronze medal* (2018)
- Michèle Sebag, élue membre de l'Académie des technologies
- Nathann Cohen, David Coudert, *Flinders Hamiltonian Cycle Project Challenge* (2016)

- Nicolas Thierry: H2020 Grant " OpenDreamKit", started on October 1st, 2015
- Wendy Mackay: ERC Advanced Grant "CREATIV: Creating Human Computer Partnerships", started on June 1, 2013
- Wendy Mackay: ACM SIGCHI Lifetime Service Award (2014), which "goes to individuals who have contributed to the growth and success of SIGCHI in a variety of capacities. This award is for extended services to the community at large over a number of years" (**http://www.sigchi.org/about/awards/2015-sigchi-awards**).
- Michel Beaudouin-Lafon: ACM SIGCHI Lifetime Service Award (2015)
- Fabio Martighnon, October 2013 September 2018: Junior Member of the Institut Universitaire de France
- Lin Chen, October 2018 September 2023: Junior Member of the Institut Universitaire de France
- Michel Beaudoin-Lafon, October 2011 September 2016: Senior Member of the Institut Universitaire de France
- Michel Beaudouin-Lafon: ERC Advanced Grant "ONE – Unified Principles of Interaction", started on October 1, 2016
- Wendy Mackay: Doctor Honoris Causa, Aarhus University (Denmark), September 2017
- G. Grefenstette: INRIASAC Winner, Taxonomy Induction task, SemEval 2015.
- N. Belkhir, J. Dréo, P. Savéant and M. Schoenauer: (AS-AC-CMA-ES) Winner, single objective track, **BB-Comp**, the Black Box Competition for continuous optimization at ACM-GECCO 2017. (see Appendix A in Nacim's PhD dissertation).
- F. Gonard, M. Schoenauer, and M. Sebag: (ASAP V2 and V3) Winner and second place at the Open Algorithm Selection Challenge 2017, The official results.
- Yolaine Bourda received the *IEC 1906 Award* (2016) in recognition to her major contribution to the work of the international standardisation committee ISO/IEC JTC1 SC36 « Information technology for Learning, Education and training »
- Yolaine Bourda, Chevalier dans l'ordre des palmes académiques (2016)
- P. Dague, Lifetime Achievement Award DX (2017)
- Lila Boukatem, Prix Canon Foundation Fellowship, (2015)
- The Coq proof assistant received the ACM SIGPLAN Programming Languages Software Award in 2013 **http://www.sigplan.org/Awards/Software/Main**. The development of Coq was initiated by Thierry Coquand and Gérard Huet in 1984. The current environment is the result of the work of more than 40 direct contributors, including major contributions by Christine Paulin-Mohring and Jean-Christophe Filliâtre from LRI.
- C. Paulin was elected member of the Informatics Section of Academia Europaea **http://www.ae-info.org/**, 2014.
- C. Paulin-Mohring received the award "Michel Monpetit Institut National de Recherche en Informatique et en Automatique" of the French Academy of Sciences (**http://www.academie-sciences.fr/fr/Laureats/laureats-2015-prix-thematiques.html**).
- C. Paulin-Mohring was nominated for "chevalier de la Légion d'Honneur" (2015).
- M.-C. Gaudel, Doctor Honoris Causa of the University of York (2013)
- M.-C. Gaudel, Visiting Professor at the University of York (2015)
- J.-C. Filliâtre and G. Melquiond received the "Best team" award of the VerifyThis@ETAPS2015 verification competition(**http://verifythis2015.cost-ic0701.org/results**). The Why3 tool also received the "Distinguished user-assistance tool feature" award.
- J.-C. Filliâtre received the "Best overall team" award of the VerifyThis 2017 verification competition.
- S. Boldo: Best Talk Award at workshop NSV Computing a correct and tight rounding error bound using rounding-to-nearest (2016)
- V. Benzaken nominated as "Chevalier des Palmes Académiques", 2018.

Chaires

- Titulaire : Marc Baboulin, professeur Upsud
  Période : Du 01/01/2011 à 31/12/2015
  Type de chaire : MdC (prolongé PR à partir du 01/09/2013), Chaire d'excellence Inria/université Paris-Sud
  Domaine scientifique : HPC
  Montant : 50000€ + 1/3 de service enseignement
- Titulaire : Isabelle Guyon, professeur Upsud
  Période : Du 24/06/2016 au 31/12/2021
  Type de chaire: Université Paris-Saclay

Titre de la chaire: Big Data for e-science
Montant : 590,000 euros

- Titulaire : Antoine Deza, DR CNRS
  Période: du 1er Janvier 2014 au 31 décembre 2017
  Type de chaire: DR et financée par Digiteo
  Titre de la chaire: Combinatorics & Optimization (acronyme : C&O)
  Montant : 300,000 euros

Best paper awards

- PPSN XIII, 2014 *Maximum Likelihood-based Online Adaptation of Hyper-parameters in CMA-ES*, I. Loshchilov, M. Schoenauer, M. Sebag, N. Hansen.
- GP track, ACM-GECCO 2015 *Memetic Semantic Genetic Programming* by R. Ffrancon, M. Schoenauer.
- Geometric Science of Information 2017 *Natural Langevin Dynamics for Neural Networks* by G. Marceau-Caron, Y. Ollivier.
- runner-up, EMO track, ACM-GECCO 2017 *Progressively Adding Objectives: A Case Study in Anomaly Detection*, L. Marti, A. Fansi-Tchango, L. Navarro, M. Schoenauer.
- Lin Chen, *Best paper at Conference on Decision and Game Theory for Security* (2017)
- J. Beauquier, J. Burman, J. Cohen, M. Laveau , G. Manoussakis, L. Pilard, *Best paper at 19th International Symposium on Stabilization, Safety, and Security of Distributed Systems SSS* (2017)
- Lin Chen, S. D'Oro, F. Martignon, *Best Student Paper Award awarded by the Network of Excellence in Wireless Communications* (2015)
- J. Cohen, *Best paper at IEEE International Conference on Communications ICC* (2015)
- M. Mangili, Fabio Martignon, *Best paper at the IEEE Globecom 2013 conference* (2013)
- M. Mangili, Fabio Martignon, *Best 50 papers of the IEEE Globecom 2014 conference* (2014)
- M. Mangili, Fabio Martignon, *Best paper at the IEEE Globecom 2013 conference* (2013)
- Michele Mangili, *Best Student Paper Award awarded by the IEEE Technical Committee on Simulation (TCSIM)* (2013) *Une Formalisation des Représentations des Groupes Symétriques en Coq/SSReflect* (2016)
- Anastasia Bezerianos: Best paper award (Brian Shackel Award) at INTERACT 2013 for "Storytelling in Visual Analytics Tools for Business Intelligence"
- Cyprien Pindat, Emmanuel Pietriga, Olivier Chapuis, and Claude Puech: Best paper award at VRST 2013 for "Drilling into Complex 3D Models with Gimlenses"
- Can Liu, Olivier Chapuis, Michel Beaudouin-Lafon, Eric Lecolinet, and Wendy E. Mackay: Best paper award at ACM CHI 2014 for "Effects of display size and navigation type on a classification task"
- Lobo María-Jesús, Pietriga Emmanuel, Appert Caroline: Honorable mention award at ACM CHI 2015 for "Evaluation of Interactive Map Comparison Techniques"
- Ghita Jalal, Nolwenn Maudet, and Wendy E. Mackay: Honorable mention award at ACM CHI 2015 for "Color Portraits: From Color Picking to Interacting with Color"
- Theophanis Tsandilas, Anastasia Bezerianos, and Thibaut Jacob: Honorable Mention award at ACM CHI 2015 for "SketchSliders: Sketching Widgets for Visual Exploration on Wall Displays"
- Michel Beaudouin-Lafon and Wendy E. Mackay: Best paper award at UIST 2015 for "Webstrates: Shareable Dynamic Media"
- Morales Gonzalez Rafael, Appert Caroline, Bailly Gilles, Pietriga Emmanuel: Honorable Mention Award at ACM CHI 2016 for "TouchTokens: Guiding Touch Patterns with Passive Tokens"
- Dimara Evanthia, Bezerianos Anastasia, Dragicevic Pierre. Honorable Mention Award at IEEE InfoVis 2016 for "The Attraction Effect in Information Visualization"
- Wanyu Liu, Rafael Lucas D'Oliveira, Michel Beaudouin-Lafon, Olivier Rioul: Best paper award at ACM CHI 2017 for "BIGnav: Bayesian Information Gain for Guiding Multiscale Navigation"
- Wanyu Liu, Olivier Rioul, Joanna McGrenere, Wendy E. Mackay, Michel Beaudouin-Lafon: Honorable Mention award at ACM CHI 2018 for "BIGFile: Bayesian Information Gain for Fast File Retrieval"
- Best Resource Paper Award, at the International ESWC conference 2018 (Joe Raad)
- Best Paper Award, at the International conference ICBO 2017 (V. Henry, F. Saïs, E. Marchadier, J. Dibie, A. Goelzer, V. Fromion).
- Best Paper Award, at the national conference IC 2017 (J. Raad, N. Pernelle, F. Saïs)
- Kinda Khawam, *Best Paper Awards IEEE conference on communication* (2015)

Prix de thèses et prix articles étudiants

- George Manoussakis, Accessit de prix de thèse, Charles Delorme, 2018.
- Qiang Sun, Accessit de prix de thèse, Charles Delorme, 2016.
- J. Dos Reis, Prix de thèse EGC, 2016.
- Jill-Jênn Vie has been awarded the *Machine Learning and Data Science* "Trophies K2" from "Cercle K2" for his PhD thesis co-supervised by Yolaine Bourda and Fabrice Popineau. The Trophies K2's objective is to value and support researchers who, owing to their imagination and creativity, but also to they working force, have made a discovery in their field of research or found an application likely to address the challenges that our societies are faced with.
- Benjamin Bach: Honourable mention at the IEEE VGTC VPG Doctoral Dissertation Competition (2014), supervised by Jean-Daniel Fekete and Emmanuel Pietriga.
- T. Benjamin (Master 2, internship with Florent Hivert), *Prix du Stage de recherche en Informatique de l'École Polytechnique*,
- Jérémie Garcia: "Prix Jeune Chercheur Science et Musique" (2015), a best thesis award organized by IRISA (Rennes) and sponsored by the Association Française d'Informatique Musicale for his thesis "*"Le papier interactif pour la composition musicale"*, supervised by Wendy Mackay, Theophanis Tsandilas and Carlos Agon (IRCAM) (**http://jsm.irisa.fr/index.php/prix-jc**.
- Nolwenn Maudet: "Prix Spécial du Jury du premier concours (2015) EDUCNUM Opération Vie privée", organized by CNIL (national commission for informatics and freedom), for her project *Data Fiction* with Thomas Thibault. This online game is designed to help teenagers better understand how their personal data can be exposed online and how to protect it.
- Wanyu Liu: "1er Prix Doctorants ED STIC" of Université Paris-Saclay, November 2017, for "BIGNav: Information Theory meets Human-Computer Interaction"
- Céline GICQUEL, *Prix de la ROADEF du meilleur mémoire de Master pour son étudiant* (2017)
- M. Pereira and R. Rieu-Helf received the "Best student team" award of the VerifyThis 2017 verification competition.
- R. Rieu-Helf received the "Student team gold medal" award of the VerifyThis 2018 verification competition.
- Martin Clochard, Léon Gondelman, Mário Pereira: jointly receive the "Best student team" award of the *VerifyThis@ETAPS2016 verification competition*

1/ Présentation de l'unité

Organisation et vie de l'unité

Données chiffrées

Comme illustré en Table 1.3, les effectifs du laboratoire sont restés stables dans la fourchette de 230 à 250 personnes sur la période 2013-2018. La stabilité des effectifs d'enseignants-chercheurs permanents – malgré les départs (mutations, promotions externes, départs à la retraite) et le gel de certains postes sur la période 2015-2017 – s'explique par l'intégration au LRI du personnel CentraleSupélec (15 Enseignants-Chercheurs). La diminution des effectifs des chercheurs Inria s'explique par l'arrêt des EPC OAK, AMIB et POSTALE. L'évolution principale concerne le personnel permanent administratif et technique, où 5 postes sont passés de la catégorie CDI à la catégorie CDD, exerçant une tension sur les postes ITA et BIATSS (efforts de recrutement et de formation).

Sur la période, le ratio de chercheurs a varié entre 28% et 35%.Il y a donc en moyenne un chercheur pour deux enseignants chercheurs, soit une parité d'un chercheur pour un équivalent-chercheur parmi les enseignants-chercheurs.

On observe une légère diminution du nombre de doctorants.

Pilotage, animation, organisation de l'unité

La direction du laboratoire se compose du directeur, de deux directeurs adjoints (chargés respectivement de la vie interne et de la coordination des services informatiques et de la vie scientifique et des relations extérieures), et de l'administratrice. Aux réunions mensuelles consacrées au budget et aux affaires

Personnel Permanent CNRS		
	2013	*2018*
Directeurs de recherche	3	7
Chargés de recherche	9	12
ITA	11	7
Total	23	26
Personnel Permanent Universitaire		
Professeurs	36	37
Maîtres de conférences	33	34
BIATSS	5	3
Total	74	74
Personnel Inria		
Directeurs de recherche	7	7
Chargés de recherche	10	4
Total	17	11
Personnel Permanent Centrale-Supélec		
Professeurs	-	6
Professeurs assistants	-	9
Techniciens	-	1
Total	-	16
Personnel Non-Permanent		
Doctorants	88	81
ATER/Post-docs	22	12
Ingénieurs, ITA ou BIATSS en CDD	13	18
Total	123	111
Total Personnel	237	238

Table 1.4: Effectifs du LRI par catégorie de personnel sur la période 2013-2018, arrêté au 1er Jan. 2018.

courantes, s'ajoutent des réunions en fonction des besoins de l'actualité et des décisions à prendre[3].

Le conseil scientifique, formé de la direction et des responsables élus des équipes de recherche, se réunit une fois par mois pour débattre des questions liées à la politique scientifique du laboratoire (notamment le profilage des postes) et de l'Université Paris-Saclay.

Le conseil de laboratoire, formé de membres élus et de membres nommés, représente l'ensemble des personnels du laboratoire. Il est réuni une fois par trimestre, et saisi de toutes les questions concernant la vie de l'unité : politique scientifique, budget, gestion des ressources humaines. Le conseil de laboratoire émet des suggestions et des avis ; il peut proposer la création de commissions (voir ci-dessous) ; il est chargé de discuter, amender et voter sur les motions proposées. Son rôle est consultatif, la décision appartenant au directeur.

Les deux conseils sont convoqués simultanément lorsque la circonstance l'exige.

Enfin, l'assemblée générale, à laquelle tous les membres du laboratoire sont conviés, a lieu traditionnellement au mois de Janvier : le directeur fait le bilan de l'année écoulée, présente les orientations de l'année qui commence et répond aux questions. En cas de circonstances exceptionnelles, l'assemblée générale et/ou les deux conseils simultanément sont convoqués (présentation du diagnostic organisationnel, projet de recomposition des laboratoires en informatique du plateau de Saclay).

Au terme du nouveau réglement intérieur élaboré en 2013, le laboratoire s'est doté de deux commissions permanentes (matériel, locaux). Des commissions de durée de vie limitée peuvent être créées pour répondre à un besoin ponctuel (e.g. Elections ; Aménagement de la bibliothèque) sur la proposition du directeur ou du conseil de laboratoire.

Les questions liées à la carrière des enseignants chercheurs sont examinées collégialement par la CCSU, à laquelle participe le directeur.

Au niveau de la communication interne et de l'accueil des nouveaux arrivants, le laboratoire organise la *Journée du LRI* chaque année en juin, souvent à l'extérieur des locaux, au cours de laquelle tous les nouveaux enseignants-chercheurs et chercheurs récemment recrutés font un exposé de vulgarisation de leurs travaux. Une demi-journée est consacrée en Octobre à présenter aux nouveaux arrivants les services support administratif et technique. Enfin, le *Café du LRI* est organisé à intervalles réguliers, le matin de 9 à 10 ou l'après-midi de 13h à 14h, pour créér des opportunités de communication fluide.

Au niveau de la communication externe et de la promotion de l'informatique, le LRI participe chaque année très activement à la *Fête de la Science* en octobre : accueil des scolaires et du public avec de nombreuses démonstrations. Des *Journées Portes Ouvertes* sont organisées également à destination des élèves et de leurs familles. Le LRI sponsorise enfin certaines manifestations scientifiques sur la vulgarisation de la science, conférences organisées par ses membres ou visites des écoliers au LRI.

Parité

Pour des raisons historiques, la parité homme/femme est excellente parmi les permanents au LRI, en contraste avec la moyenne de la discipline. Le pourcentage de permanentes est passé de 40% en 2013 à 44% en 2018. Par contre, le pourcentage des étudiantes est de 25%, stable sur la période. De manière plus détaillée :

- Dans l'équipe de direction, l'un de deux Directeurs adjoints est une femme.
- Parmi les responsables et coresponsables des neuf équipes du LRI, 10 sur 18 sont des femmes.
- Cinq femmes ont été respectivement recrutées comme Professeur ou promues DR (sur 6 postes) sur la période.
- La composition des comités de recrutement est statutairement composée à 40% de femmes.

[3]Le directeur a des contacts quasi-journaliers avec l'administratrice sur les questions budgétaires (par exemple les demandes de financement sur le fonds de soutien à la recherche), de logistique et infrastructure, avec les directeurs adjoints sur les questions stratégiques, orientations scientifiques, préparation des conseils mais aussi des questions de communication, du site web du laboratoire et de l'activité de soutien aux logiciels scientifiques. Il a aussi des contacts plusieurs fois par semaine avec la gestionnaire RH, notamment pour l'accueil du personnel temporaire (doctorants, post-doctorants, chercheurs en délégation, ATER, stagiaires, invités, visiteurs, etc.) et en cas de problème.

Integrité Scientifique

Aucun cas de malconduite (plagiat, falsification ou fabrication de résultats et/ou des données, travail collectif, partenariat public-privé, fraudes) ou de comportement limite (concernant par exemple la signature des publications, l'évaluation de celles-ci ou le traitement des réponses à des appels à projets) n'a été reporté au LRI sur la période. L'excellente réputation d'intégrité scientifique des membres du LRI est favorisée et préservée par les bonnes pratiques mises en place :

- Le responsable de chaque équipe est au courant du contenu des publications de chaque membre.
- Une formation d'une journée intitulée *Introduction à l'éthique de la recherche et intégrité scientifique*, mise en place par le collège doctoral et le Conseil Polethis (conseil pour l'éthique de la recherche et l'intégrité scientifique de Paris-Saclay) est obligatoire pour les doctorants du LRI, avec le but d'initier la réflexion, de donner des critères et de sensibiliser aux enjeux pratiques et sociétaux de l'éthique en termes de travail collaboratif, de conduite de la discussion, des validations expérimentales et des rapports.
- Le sujet est également abordé par la direction du LRI lors de la demi-journée annuelle dédiée aux nouveaux arrivants, permanents et non-permanents.

Protection et Sécurité

La nature des risques est liée à la nature des activités de recherche et d'enseignement, essentiellement constituées de travail sur ordinateur en bureau, ainsi que d'enseignement sur le campus et de missions scientifiques sur l'ensemble du territoire et à l'étranger.

Depuis 2013, l'ensemble du Laboratoire est localisé dans deux batiments mitoyens reliés par des passerelles contrôlées par badge électronique. Les dispositifs de sécurité sont différents, le batiment Claude Shannon étant partagé par le CEA, le LRI, l'INRIA et le laboratoire SATIE.

Si les permanents (environ la moitié du laboratoire) sont très familiers de l'environnement et des règles de sécurité, les personnels non-permanents (doctorants et contractuels) sont régulièrement mis au courant des règles et sensibilisés aux aspects sécurité (en français et en anglais). Le laboratoire accueille également des stagiaires, des visiteurs ou des associés sur des durées courtes (de quelques mois à quelques semaines) ou avec un taux de présence faible (un jour par semaine ou quelques jours par mois). La mise au courant est réalisée par l'affichage clair et concis des consignes ainsi que la sensibilisation des membres permanents qui les accueillent.

Concernant les acteurs de la prévention, 3 établissements sont directement impliqués : i) l'université Paris-Sud au premier chef puisque le LRI est hébergé sur le campus de Paris-Sud dans l'UFR des Sciences; ii) La DR4 du CNRS, impliquée via le contrat quadriennal, intervient au niveau de l'organisation d'actions de formation renforçant celles de UPSud et de communication vers le réseau des assistants de prévention; iii) Inria, impliqué au titre de la cogestion des bâtiments dans le cadre des conventions.

Un assistant de prévention est nommé au conseil de laboratoire pour mettre en œuvre les règles de sécurité : tenue des deux registres de sécurité à la disposition du personnel dans chacun des deux bâtiments, vérification des trousses de secours et de la maintenance du défibrillateur, désignation des chargés d'évacuation par zone de bâtiment, coordination des exercices d'évacuation avec les services de l'université et recensement des secouristes du travail.

Le document unique d'évaluation des risques (DUER) du laboratoire est également rédigé. Régulièrement mis à jour, il est transmis aux 4 tutelles et partenaires du LRI selon un format réglementé: Paris-Sud, CNRS-DR4, Inria-Saclay et Centrale-Supelec. Il recense notamment les sauveteurs et secouristes du travail, les personnels formés (protection incendie, chargés d'évacuation, ...) et surtout, il identifie les risques professionnels et met en place le programme annuel d'actions de préventions.

Un élément de risque concerne l'ensemble des chantiers environnant les batiments, qui génèrent des perturbations importantes sur la circulation routière et piétonne à proximité du LRI ; quelques accidents corporels de faible gravité sont à déplorer.

Équipe Administrative



Présentation et missions du service

De 2013 à 2016, l'équipe administrative du LRI a assuré des activités de gestion de proximité dans le domaine : administratif et financier, juridique, des ressources humaines, documentation et de communication.

En 2016, le diagnostic organisationnel lancé par les tutelles du LRI a modifié la structure de l'équipe en lui rattachant notamment le pôle logistique (jusqu'ici rattaché à l'équipe informatique) entraînant ainsi un élargissement de ses missions. Le titre de " équipe administrative " a donc laissé place à compter de mars 2017 à " SERVICE ADMINISTRATIF ET LOGISTIQUE " structuré en 1 pôle et 2 cellules :

- Pôle achat et gestion
- Cellule RH
- Cellule Logistique

Depuis mars 2017, le service administratif et logistique assure au quotidien des activités de gestion de proximité dans le domaine : administratif et financier, juridique, de ressources humaines, de communication et de logistique. Il gère et suit le budget de l'unité constitué des dotations d'État et divers crédits sur contrats de recherche (Industriels, Collectivités Territoriales, Europe, ANR, Labex, Equipex, Idex, Digitéo, H2020, ERC) et subventions (AAP, PICS, PEPS etc). La part des contrats et subventions représente en moyenne près de 86 % du budget du LRI.

Pôle achat et gestion. Pour mener à bien les activités administratives et financières, le pôle utilise les outils informatiques de comptabilité et de gestion mis à sa disposition par les tutelles et partenaire : Sifac pour UPSud, Geslab pour CNRS et Sifac-Web pour CentraleSupélec. Ces activités s'articulent autour de six axes principaux : Vérification et suivi des crédits, passation des commandes, traitement des factures, remboursement des frais de missions, suivi des inventaires et reporting.

Il aide et conseille au quotidien les équipes de recherche dans toutes les phases d'exécution de leurs divers contrats et subventions. Il leur apporte aussi une aide de premier niveau dans le montage des dossiers de réponse aux appels d'offres. Ce pôle effectue une veille juridique et réglementaire relevant du domaine de la gestion et veille par ailleurs à leur mise en application. Il opère les contrôles inhérents aux actes de gestion (disponibilité des crédits, imputation des dépenses, validité des marchés publics...). Il suit les salaires des personnels non-permanents et des indemnités de stage.

Ce pôle gère et traite également les déplacements des personnels permanents et non permanents du LRI (plus de 600 missions/an) dans le respect des règles et procédures relevant du domaine des missions et applicables à UPSud, au CNRS et à CentraleSupélec. Il fournit à la direction des tableaux de bord et indicateurs financiers actualisés et pertinents pour l'aider dans ses prises de décisions. Il apporte également une aide administrative au directeur du LRI : Tenue à jour de son agenda électronique, prise de note et rédaction des comptes rendus des conseils de laboratoire et conseils scientifiques.

Cellule RH. Elle conseille et accompagne la communauté scientifique et le cas échéant, la direction dans le montage des dossiers de recrutement de personnel non-permanents issus des crédits de contrats de recherche et dotation d'Etat. Elle gère et suit également en liaison avec le service du personnel de UPSud et CentraleSupélec le recrutement des stagiaires rémunérés. Cette cellule exécute l'ensemble des tâches liées à la gestion du personnel (gestion des congés et des absences, CET, accès cantine, accès aux locaux (badges), compte informatique etc). Elle garantit l'application de la réglementation et des procédures RH et utilise à bon escient les outils mis à sa disposition par les tutelles et le LRI. Elle a en charge le recueil des besoins de formation, rédige et suit la mise en oeuvre du plan de formation de l'unité, sous la responsabilité du directeur. Au travers de sa cellule RH, le service est le relais des tutelles de l'unité et travaille en étroite relation avec le conseiller RH/Formation des tutelles.

En matière de communication, il participe à son niveau à l'élaboration de plan de communication interne et externe (finance, évènementiel, institutionnel etc) Il interagit autant de fois que nécessaire avec les services de UPSud, du CNRS et CentraleSupélec (ressources humaines, partenariat et valorisation, cellule contrat, cellule budget, service financier et comptable). Il utilise différents supports (site intranet, notes d'information, courriers électroniques, documentation, panneaux d'affiches, réunions d'information) pour diffuser régulièrement à l'ensemble du personnel toute information qu'elle juge utile, pertinente et adaptée.

Cellule logistique. Au niveau logistique, le service exécute l'ensemble des tâches qui concourent au bon fonctionnement du laboratoire notamment dans les domaines suivants : accueil, distribution du courrier, gestion des stocks de fourniture, organisation évènement, prévention, sécurité, surveillance, travaux et entretien du bâtiment, maintenance. Elle veille à l'application des politiques de sécurité et à l'amélioration des conditions de travail en lien avec les instances concernées.

Pour conclure, les missions que doit remplir le service administratif et logistique sont exigeantes, notamment compte tenu du cadre juridique et règlementaire qui rend les relations internes et les positionnements complexes et subtils, nécessite un exercice au quotidien pour trouver les solutions optimales car il est garant de la bonne gestion de tous les actes relevant de son champ de compétences.

Effectifs de l'entité et personnels ayant quitté l'entité pendant le contrat en cours

Permanent Membres permanents				
Name	*First name*	*Position*	*Institution*	*Remarks*
Joseph	Myriam	IE	CNRS	
Lelievre	Martine	TCS	CNRS	
Bakayoko	Gladys	TCE	CNRS	
Menou	Sylvie	TCN	CNRS	détachement UPSUD depuis Juin 2016
Cambervel	Valéry	AJTP	UPSUD	
Merlin	Jean-Pierre	AJTP	UPSUD	partira à la retraite fin 2018
Fixois	Bea trice	AI	CNRS	Septembre 2017-Mai 2018 détachement UPSUD
Le Marcou	Sabrina	AJTP	UPSUD	Septembre 2015-Février 2017 mobilité interne UPSUD
Roucheyroux	Agathe	AJTP	UPSUD	Septembre 2012-Août 2014, réussite concours externe, cat.B
Dubrac	Elodie	TCN	Supélec	Juillet 2015-Décembre 2015 départ secteur privé
Goy	Florence	TCN	Supélec	Décembre 2015-Mai 2018 mobilité interne
Bretenoux	Claude	SAENES	UPSUD	départ à la retraite Août 2017
Sabater	Geneviève	AI	CNRS	départ à la retraite Mars 2014
Congnard	Sylvie	AI	CNRS	départ à la retraite Septembre 2016

Membres non Permanents				
Name	*First name*	*Position*	*Institution*	*Remarks*
Montaudin	Marie Pierre	AJTP	CDD Paris Sud	Janvier 2012-Décembre 2013
Charles	Aléxia	stagiaire		1 mois 2013
Manoussakis	Alexandre	stagiaire		2 mois 2013
Silotia	Jérémy	TCN	CDD Paris Sud	Octobre 2014-Juillet 2015, départ secteur privé
Voradeth	Sylvie	TCN	CDD Paris Sud	Septembre 2015-Décembre 2016, départ secteur privé
Laroche	Mailys	TCN	CDD Paris Sud	Novembre 2017-Août 2018
Theneau	Emmanuelle	TCN	CDD Paris Sud et Supélec	Janvier 2017-Août 2018
Perrot	Elise	TCN	CDD CNRS	Janvier 2016-Mai 2016

Evènement majeur

2015 : Intégration de l'équipe SUPELEC. L'arrivée de l'équipe MODHEL au LRI en janvier 2015 a impacté l'organisation et le partage du travail de l'équipe induisant une charge de travail supplémentaire :

- Pour rattacher administrativement cette nouvelle équipe au LRI, il a fallu saisir les données RH de chaque personnel dans toutes les bases RH
- Un nouvel outil comptable et budgétaire (SIFAC-WEB) a été déployé au sein de l'équipe administrative qui a dû suivre des formations dispensées par CentraleSupélec pour appréhender cet outil.

- Pour obtenir des réponses et avoir accès à l'information pertinente, l'équipe a dû, d'une part, apprendre les règles, le mode de fonctionnement et les procédures propres à CentraleSupélec, et d'autre part, identifier ses nouveaux interlocuteurs du secteur financier et comptable et RH.
- L'équipe a organisé l'environnement de travail d'une nouvelle collègue (statut CentraleSupélec - Présence physique au LRI tous les après-midis hormis le mercredi après-midi pour s'occuper de la partie " Recherche " car le matin cette collègue était présente dans les locaux de CentraleSupélec pour la partie " Enseignement " de l'équipe MODHEL)
- L'équipe a accompagné et soutenu cette nouvelle collègue pour faciliter et favoriser son intégration dans son nouveau milieu de travail

2016 : Diagnostic organisationnel. En février 2016, les deux tutelles du LRI ont lancé un diagnostic organisationnel au sein du LRI. Pour l"équipe administrative, il s'agissait de repérer les dysfonctionnements et définir des actions et point d'amélioration dans la conduite de ses missions et activités. De ce diagnostic, au regard des objectifs des tutelles, il en résulte pour l'équipe une nouvelle structuration avec le rattachement du pôle logistique. L'avantage de cette nouvelle structuration est de pouvoir répondre facilement aux demandes qui rentrent dans le champ de compétences élargi des membres de l'équipe.

Bilan

Du 01 janvier 2013 au 30 juin 2018, le service administratif a géré et traité près de 120 contrats et subventions divers pour un montant de plus de 9 millions d'euros. Face aux évolutions et impacts des procédures et outils informatiques (service facturier UPSud, dématérialisation des factures (SCTD CNRS), Web-contrat, Agate, Php congés, GBCP, Sifac-Web, RESEDA) les membres du service ont constamment veillé à mettre à jour leurs connaissances, compétences techniques et savoir-faire. Des changements importants dans l'organisation du travail ont été opérés à chaque fois que nécessaire pour faire face au contexte et l'environnement du LRI (Université Paris-Saclay) qui évoluent et continuent de l'être.

Quelques chiffres clés :

- 8 % de contrats de recherche à gérer en plus sur la période 2017 par rapport à 2016
- 2 700 actes de gestion et 765 missions traités en 2016 (sur différentes sources de crédits)
- 20 recrutements / 50 stages (dont 31 gratifiés) en 2016 (sur différentes sources de crédits)
- 64 badges créés ou modifiés/ 50 interventions sur site / 97 prestations " café " fournies / 346 livraisons réceptionnées

Interaction de l'équipe avec son environnement

Le service se mobilise sur les projets communs et s'inscrit dans une dynamique positive en intégrant le " réseau des administrateurs ", le " réseau des secrétaires-gestionnaires des unités ", le réseau des Co-com et Co-fo de Gif sur Yvette. De 2012 à 2013, il a participé aux ateliers sur l'outil Zento "Laboratoire" du CNRS. Cet outil d'aide à la décision pour l'équipe de direction des unités a été déployé dès 2013 par le CNRS. Forte de son expertise, il a été en 2014 membre du " Comité Projet Sifac-Web " de UPSud destiné à une utilisation par des personnes n'ayant pas un profil financier. A l'occasion de la journée du LRI en juin 2017 et de la demi-journée " Accueil nouveaux arrivants au LRI " en janvier 2018, il a présenté pour la première fois son organisation et ses missions à l'ensemble du personnel.

Il rencontre, partage ses expériences, échange de bonne pratiques entre collègues, confronte ses idées. Il a ainsi accès à des informations privilégiées, qualifiantes et pertinentes qui lui ouvrent la possibilité d'enrichir ses connaissances en lien direct avec ses missions et activités.

Le service informatique

L'équipe technique assure 2 missions pour l'ensemble du personnel du LRI hébergé dans les bâtiments voisins 650 et 660 : La mission 'support et réseau' assure un rôle quotidien de service pour tous les utilisateurs des moyens informatiques du laboratoire. La mission 'développement web et SI consiste à exploiter et développer le site Web institutionnel du LRI qui repose sur le Système d'informations du LRI.

Membres de l'équipe

Membres Permanents				
Name	*First name*	*Position*	*Institution*	*Remarks*
DARRÉ	Laurent	IR	CNRS	
HUMBERT	Denis	IE	Paris Sud	
LIEBGOTT	Jean-Roch	IE	CNRS	parti en NOEMI en septembre 2015
NERI	Vincent	IE	CNRS	
PENSEL	Anthony	AI	CNRS	arrivé en décembre 2013
ZIMMERMANN	François	IR	CNRS	parti à la retraite en mars 2017

Membres non permanents				
Name	*First name*	*Position*	*Institution*	*Remarks*
CHEVREAU	Maxime	stagiaire	Polytech Paris Sud	1 mois - juin 2018
GY	Bastien	Apprenti	Licence PRISM Paris Sud	Oct 2016 - Sep 2017
SALIBA	Victor	stagiaire	Polytech Paris Sud	1 mois - juin 2016
SEPOU NGAILO	Awa	IE	Paris Sud	arrivée en juin 2018

Evolution des effectifs

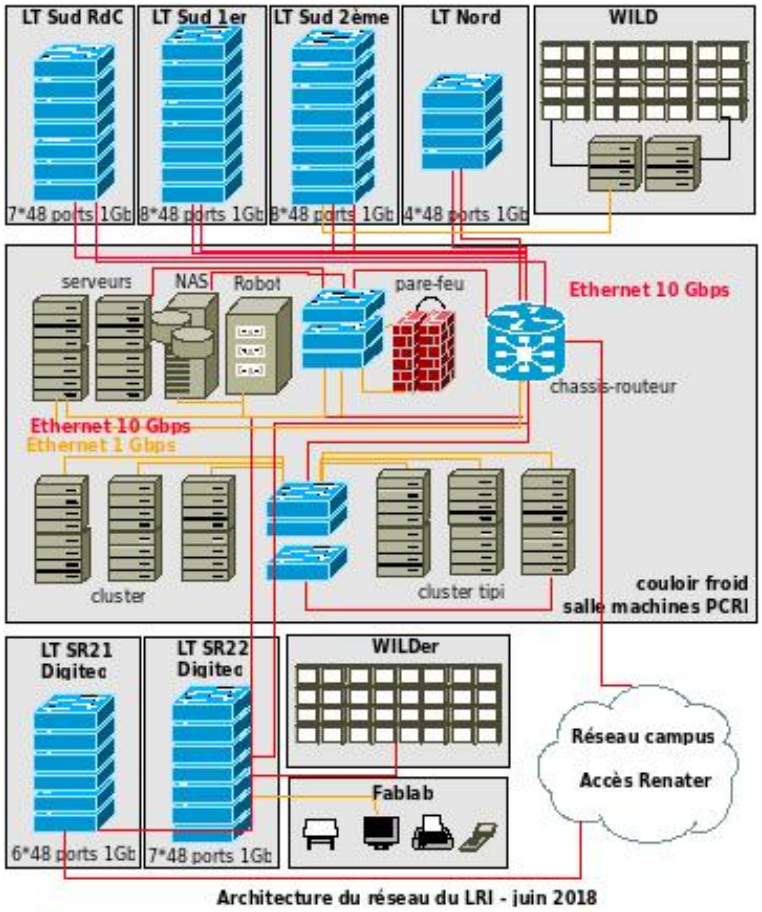
Au cours de la période, 2 statutaires ont quitté le laboratoire: une mutation interne par NOEMI en septembre 2015 (Jean-Roch Liebgott, IE CNRS vers le LPT à Marseille) et un départ à la retraite en mars 2017 (François Zimmermann, IR CNRS). Ces départs de permanents ont été en partie compensés par l'arrivée d'une ingénieur CDD d'un an en mai 2018 recrutée par le laboratoire sur ses fonds propres. L'équipe a aussi accueilli un apprenti en alternance (licence PRISM d'Orsay) de septembre 2016 à août 2017.

Evénements majeurs

Restructuration de l'équipe technique Après un diagnostic organisationnel effectué par le CNRS en 2016, une nouvelle organisation des services administratifs et techniques s'est mise en place début 2017. L'ancien pôle 'système et réseau' de l'équipe technique est devenu, après l'ajout des fonctions 'systèmes d'informations et développement web', le 'service informatique' directement rattaché à la direction du laboratoire.

Participation à la mise en place d'une plate-forme GPU sur Paris Saclay Une plateforme mutualisée de calcul sur GPU, initialement financé dans le cadre d'un CDS, s'est mise en place fin 2016 sur l'Université Paris Saclay. Cette plateforme d'expérimentation en Sciences des données est hébergée à l'IDRIS et administrée par un collectif d'ingénieurs issus des laboratoires impliqués dans le projet (LIMSI et LRI initialement). Un nouveau financement de 350 k€(région, CNRS, Université Paris Sud) va permettre d'étendre notablement la plateforme et d'inclure de nouveaux laboratoires (Centrale-Supelec, Telecom ParisTech, Telecom SudParis ...) dès l'été 2018.

Mise en place d'une plate-forme matériel pour le projet Codalab Codalab, projet porté par un chercheur de l'équipe A&O, est une plateforme permettant d'organiser des compétitions en ligne pour résoudre des problèmes de science des données. Une plateforme d'enseignement a été déployée par un ingénieur de l'équipe fin 2016 sur l'infrastructure matérielle du LRI. La plateforme de compétitions, initialement sponsorisée par Microsoft Research et hébergée sur Azure, sera elle aussi déployée au LRI en 2018.



Architecture du réseau du LRI - juin 2018

Web des données En recherche et développement, un projet actuel, auquel participe un membre de l'équipe, est l'export des données scientifiques du laboratoire vers le web des données. Une première application référence ces données dans Wikipedia au travers de Wikidata et d'une base RDF implémentée au LRI.

Missions de l'équipe

Environnement informatique

Le LRI possède un réseau informatique performant dont le cœur, en 10 Gbps, forme un des nœuds du réseau informatique du plateau du Moulon de l'Université Paris-Sud. Il est installé dans la salle machines du bâtiment Ada Lovelace qui abrite aussi la plupart des ressources informatiques du laboratoire : serveurs, baies de stockage, pare-feu, clusters de calcul ... Les locaux techniques des deux bâtiments abritent de nombreux switchs Ethernet connectés en 10 Gbps au cœur de réseau et qui comprennent au total plus de 1500 ports permettant de dédier des liens 1 Gbps à tous les équipements informatiques courants (postes de travail, téléphones, imprimantes, etc.). Certains de ces équipements, comme les clusters de calcul et les murs d'images WILD et WILDer, sont utilisés directement pour les travaux de recherche.

Le cluster de calcul, composé de 48 serveurs de calcul, pour un total de 320 cœurs, est très largement utilisé par la plupart des équipes du laboratoire. Le principe d'utilisation le rend accessible à toute personne disposant d'un compte informatique au LRI. Un ingénieur est chargé de suivre et de répondre aux besoins spécifiques de ces utilisateurs, en installant ou adaptant les logiciels et bibliothèques, ainsi qu'en répondant aux besoins éventuels de sécurité et de confidentialité.

Le service informatique du LRI gère ce réseau, les équipements qui y sont connectés (dont les nombreux postes de travail fonctionnant sur des systèmes d'exploitation très divers) et les services qui y tournent (web, mail, dns, dhcp, ldap, etc.). Il fournit les ressources matérielles et logicielles (machines virtuelles dédiées, bases de données, serveurs web virtuels, etc.) sollicitées par les chercheurs en s'attachant à maintenir un niveau de sécurité élevé. Il fait en sorte que cet environnement informatique soit opérationnel 7 jours sur 7 et 24 heures sur 24 pour tous les membres du laboratoire quelle que soit leur appartenance (Université, CNRS, Inria ou CentraleSupelec). Pour cela, les ingénieurs de l'équipe ont mis en place

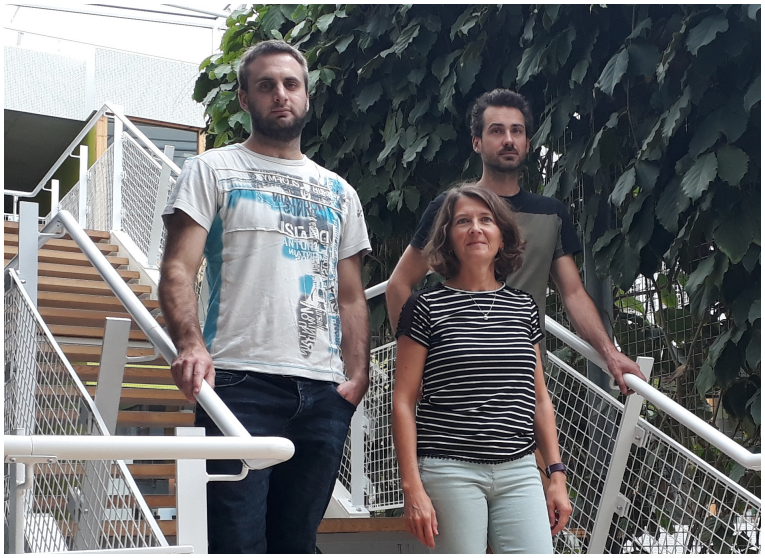
et maintiennent une architecture réseau robuste, des serveurs virtualisés redondants et des services en haute disponibilité. Cela implique de travailler de concert avec la direction informatique de l'Université qui gère le réseau du campus et avec le staff technique d'Inria installé à Digiteo Palaiseau.

Système d'Information et développement web

Le système d'information du LRI est principalement constituée autour d'une base de données riche et complexe. Un ingénieur du service informatique l'administre et en assure la maintenance et les évolutions. Il exploite et développe le site Web institutionnel du LRI qui repose largement sur ce système d'information. Il garantit la robustesse de l'architecture Web du laboratoire : évolutivité, sécurité, pérennité. Plus largement, il développe et maintient tous les outils web hébergés au LRI et utiles à la communauté : scientifiques, direction du laboratoire, support technique, administration et enseignement.

1/ Présentation de l'unité

Développement logiciel



Le service développement assure pour l'ensemble du personnel du LRI hébergé dans les bâtiments voisins 650 et 660 la mission 'développement logiciel': il s'agit de l'accompagnement de la production de logiciels scientifiques et la gestion des problématiques associées.

Membres de l'équipe

Permanent Members (June 1st, 2018)				
Name	*First name*	*Position*	*Institution*	*Remarks*
LETOURNEL	Anne-Catherine	IR	CNRS	
SOUPLET	Jean-Christophe	IR	CNRS	parti en juillet 2016

Non Permanent Members (June 1st, 2018)				
Name	*First name*	*Position*	*Institution*	*Remarks*
VANZO	Daniel	IE	CNRS	
RENAULT	Jonas	IR	CNRS	arrivé en juin 2018
FAUGIER	Thomas	Stagiaire	UPSUD	2014-06 – 2014-06
HIRWA	Fabienne	Stagiaire	UPSUD	2014-04 – 2014-09
LE TORRIELLEC	Dimitri	Stagiaire	UPSUD	2013-01 – 2013-07
SAHLI	Sabrina	Stagiaire	UPSUD	2015-04 – 2015-09
SARHAN	Mohamed	Apprenti	CNRS	2013-09 – 2014-09
VAN DALEN	Alexander	Stagiaire	UPSUD	2015-04 – 2015-07

Evolution des effectifs

Au cours de la période, un agent statutaire a quitté le laboratoire: Jean-Christophe Souplet, CNRS, IR vers le CRMBM de l'université de Marseille. Il n'a pas été remplacé. L'activité développement logiciel a été fortement restructurée (cf infra). Aujourd'hui, en plus de la responsable, un CDD est en poste depuis novembre 2017 (Daniel Vanzo, CNRS, IE) et un second CDD démarre un contrat de 18 mois courant juin 2018.

Evénements majeurs

Restructuration de l'équipe technique: Après un diagnostic organisationel effectué par le CNRS en 2016, une nouvelle organisation des services adminitratif et technique s'est mise en place début 2017. L'ancien pôle 'développement' de l'équipe technique est devenu le Service d'Appui au Développement Logiciel, directement rattaché à la direction du laboratoire. Le lancement de l'activité a été amorcé par un appel à projet auprès du conseil scientifique du LRI. Deux projets ont été selectionnés par la direction en raison de critères comme la forte ré-utilisabilité des compétences en ingénierie dans d'autres projets ou l'implication de plusieurs équipes favorisant les échanges scientifiques inter-équipes ou encore la forte valeur ajoutée pour la visibilité et la promotion de thématiques développées au LRI.

L'INS2I a pourvu deux supports de postes pour réaliser ces projets. L'avancement de ces projets sert de preuve de concept au fonctionnement du service en construction. En effet, le projet de service doit être pérénnisé à terme en définissant un périmètre technique, un pool de ressources et une méthodologie de fonctionnement pour atteindre un régime continu stable.

Promotion du laboratoire vers l'extérieur: Durant cette première année de fonctionnement, la responsable, en accord ou à la demande de la direction, a assuré un certain nombre d'activités visant à assoir la visibilité du laboratoire dans son environnement. Le service est l'interlocuteur de la SATT pour le projet Plugin Labs présentant le LRI sur le plateau de Saclay. Par ailleurs, le suivi des dossiers APP du LRI est assuré auprès du SAIC. Ensuite, le service est présent dans toute rencontre de prospection avec des entreprises et facilite ou organise les contacts avec les équipes intéressées afin de détecter toute possibilité de collaboration. Enfin, la responsable a animé une journée thématique au conseil scientifique INS2I sur la question de la production logicielle dans les laboratoires.

Missions de l'équipe

Les projets en cours:

Les missions de l'équipe s'articulent autour des projets selectionnés concernant aujourd'hui 4 des 9 équipes scientifiques. La feuille de route établie au moment de la sélection du projet est ajustée au fur et à mesure du déroulement de la période prévue et les retombées attendues sont régulièrement évaluées: en terme de collaborations avec des personnes extérieures à l'unité ou encore en terme d'avancées techniques dans des domaines exploratoires.

Les périmètres thématiques qui sont aujourd'hui couverts sont la programmation sur GPU d'une part et les applications web temps réel de visualisation de grandes masses de données d'autre part.

Soutien aux logiciels scientifiques:

Des actions au niveau du LRI sont mises en place pour répondre aux besoins des équipes: on peut distinguer les actions de détection des besoins (comme la réalisation d'un sondage sur les besoins en GPU) des actions de réponses à un besoin (comme des ateliers d'échange de bonnes pratiques, en préparation).

A la demande de la direction et selon l'agenda du conseil scientifique du LRI, une des missions du service est de participer à toute discussion concernant la politique du laboratoire sur les logiciels scientifiques. Concernant la production logicielle, sur la centaine de logiciels actifs sur la période d'évaluation depuis 2013, une vingtaine bénéficient d'une protection par preuve de date auprès de l'agence de protection des programmes (APP). De nouveaux dépôts peuvent être soumis avec l'aide de l'équipe mais les délais de traitements par le SAIC des derniers dossiers se sont révélés extrêmement longs.

Veille technologique:

Une veille technologique auprès des réseaux métiers et des projets DevOps locaux (Mésocentre U-Psud...) est assurée.

Perspectives

L'existence du service est encore fragile à cause du faible effectif mais les objectifs d'aujourd'hui sont clairement appuyés sur la réponse à des besoins exprimés par les équipes. C'est ce qui garantit l'enracinement de l'activité.

Ainsi, il est aujourd'hui envisagé de pérenniser l'expertise en programmation sur GPU par une demande de poste permanent. Concernant le 2ème axe (expertise visualisation web), il est un peu trop tôt pour se prononcer aujourd'hui car le projet vient de commencer. Le projet Cartolabe a été choisi dans un premier temps pour en bénéficier. Il est certain que plusieurs autres projets du LRI seraient intéressés par ces technologies. Il est prévu courant 2019 de faire émerger un 3ème axe de compétences (bases de données, réalité virtuelle, génie logiciel, deep learning...) à partir d'un nouvel appel à projet auprès des équipes. A terme, il apparait raisonnable de couvrir un large spectre d'ingénierie logicielle pour répondre à la plus grande partie des besoins des équipes du LRI avec 3 axes d'expertise dans le service, reposant sur deux permanents et un CDD.

1/ Présentation de l'unité

Auto-évaluation de l'unité de recherche

Cette partie contient d'une part l'auto-évaluation du laboratoire, et d'autre part le détail des actions engagées pour prendre en compte les recommandations du précédent rapport HCERES (2013).

Analyse SWOT

Forces. Le LRI a une longue tradition d'excellence scientifique, et ses réalisations récentes telles qu'attestées par exemple par les indicateurs tels qu'ERC, IUF ou médailles du CNRS s'inscrivent dans cette tradition. Cette excellence se situe aussi bien au niveau des recherches fondamentales qu'appliquées. Par leur taille et la diversité de leurs expertises, les équipes sont à même de réaliser des avancées fondamentales et appliquées dans leurs domaines de recherche, d'établir les dialogues avec l'environnement académique et industriel permettant de nourrir une vision stratégique. Cette qualité scientifique constitue un attracteur, ainsi que le démontrent les candidatures internationales sur les postes de Professeur et l'arrivée au laboratoire de permanents venant d'autres laboratoires voisins.
Une seconde force concerne la diversité des champs disciplinaires du LRI, enracinée dans la tradition aussi bien que dans la volonté d'offrir un enseignement au meilleur niveau. Cette diversité permet, dans un contexte où les innovations se font aux frontières des domaines, de trouver facilement des interlocuteurs experts. L'activité aux frontières disciplinaires a été encouragée par la politique scientifique du laboratoire, favorisant la flexibilité. Cette flexibilité se manifeste par la mobilité des membres entre équipes ainsi que par l'évolution des thèmes de recherche de chaque équipe. La vitesse d'évolution de notre champ disciplinaire est un lieu commun ; il est d'autant plus important de noter que les équipes s'adaptent rapidement à ces évolutions.
Une troisième force du LRI est d'être porté par l'environnement de l'Université Paris-Saclay, maintenant la nécessité d'une vision stratégique et scientifique à long terme.

Faiblesses. En contrepartie, les permanents du LRI sont extrêmement sollicités pour l'animation et l'encadrement d'initiatives foisonnantes au niveau de l'Université Paris-Saclay. Du point de vue de l'animation, le LRI fournit une part importante des cadres de l'Université Paris-Saclay et de l'Université Paris-Sud en informatique (responsables du Département STIC, responsable de l'Ecole Doctorale STIC, doyen de la Faculté des Sciences, vice-président Enseignement de Paris-Sud). La séparation entre l'Université Paris-Saclay et NewUni, remettant en cause une partie des structures nouvellement définies (Masters, Ecole Doctorale, stratégie scientifique) et acquises au prix de réunions innombrables, a donné une impression de gachis d'énergie, tout en augmentant les demandes des structures.
Du point de vue des projets de recherche, la lisibilité modérée des programmes existants, la lourdeur administrative du montage des projets (en particulier Européens), font qu'une partie significative du temps est investie pour identifier les opportunités les plus profitables, ce qui entraine également une déperdition d'énergie.

Opportunités. Les opportunités sont liées à l'environnement. Au cours de la période 2013-2018, le LRI a su agilement se saisir des Programmes d'Investissement d'Avenir pour proposer et faire avancer des pri-

orités scientifiques, avec les partenaires, les moyens et les équipements idoines[4]. La période 2018-2022 offre de nouvelles opportunités, tel l'appel 3IA consacré aux Instituts Interdisciplinaires d'Intelligence Artificielle. La décision de l'Université Paris-Saclay et de NewUni de faire une réponse jointe pour définir un Pole IA d'envergure internationale sur la région Ile de France, est une opportunité pour le LRI d'augmenter l'ambition des objectifs définis conjointement dans DataIA, et de se concentrer sur leur réalisation.
Du point de vue du transfert, les liens établis avec l'IRT System'X et les entreprises, le dépot de deux brevets, l'existence de plateformes visibles à l'échelle internationale, et le nombre de thèses Cifre, témoignent des opportunités de transfert offertes au LRI, de sa capacité à s'en saisir, et de sa grande visibilité dans le monde industriel.

Menaces. Les menaces sont également liées à l'environnement : industriel, académique et enfin, institutionnel. Dans certains domaines de recherche, la pression exercée par l'industrie attire les permanents seniors par des offres qu'il est difficile de refuser, ce qui peut contribuer à l'asséchement du champ (certains modules de Master sont fermés ici ou là en France en raison de l'hémorragie des chercheurs et enseignants chercheurs en apprentissage machine). L'environnement académique multiplie les offres et les demandes, mais ne réduit pas, voire augmente, la complexité des processus, les contraintes et les constantes de temps (les règles limitant le nombre de PhD par HdR peuvent entrainer un goulet d'étranglement dans les champs sous pression industrielle). Ainsi que nous l'avons dit, la complexité administrative croissante est très sensible au niveau des services support (diversité des statuts, gestion de contrats, propriété intellectuelle, multiples systèmes de gestion des budgets récurrents).
Enfin, dans l'objectif de créer un paysage d'excellence lisible dans le cadre de l'Université Paris-Saclay, les tutelles ont proposé aux laboratoires informatique LRI, LIMSI et LSV de se concerter pour établir une recomposition unifiée des thèmes d'activité tirant parti au mieux des complémentarités et des coopérations existantes. Le LRI est en majorité favorable à cette recomposition, dans le respect des différences de culture entre les laboratoires. Cependant, il faut noter que cette recomposition fait suite à la recomposition institutionnelle effectuée par le LRI en 2013 (passant de 13 à 8 équipes), à la recomposition liée aux interactions avec CentraleSupélec (création d'une 9e équipe) et enfin, que son extension pour prendre en compte d'autres laboratoires voisins et amis (L2S, IBIS, DAVID, Li-Parad entre autres) est probable à court terme. Cette hyper-activité institutionnelle et la déperdition d'énergie entrainée au niveau humain, pénalise la paix mentale des membres du LRI, nécessaire pour conduire une recherche au niveau mondial, excellente, sereine, stratégique et non tactique.

Recommandations du rapport HCERES 2013, prise en compte et évolution

Complexité de l'environnement. Il ne fait pas de doute que la complexité s'est accrue depuis le rapport 2013, en raison de l'accumulation des structures apparues avec les investissements d'avenir (Labex, Equipex, IRT, SATT, Idex, Institut de Convergence), le montage de l'Université Paris-Saclay, puis la décision de créer les deux établissements séparés (UPSaclay et NewUni), et au niveau plus local, l'augmentation de la diversité des statuts des membres du Laboratoire (U. Paris-Sud, CNRS, INRIA, CentraleSupélec). Comme nous l'avons montré, le LRI s'est adapté avec volontarisme et succès à cette complexité pour en tirer parti et répondre aux besoins.
Cependant l'évolution prévue par les tutelles, concernant la création d'un Pole Méthodes Formelles unissant le LSV et l'équipe VALS du LRI, et la recomposition du reste des équipes du LRI avec les équipes du LIMSI (sans préjuger des évolutions futures probables) ne permet pas d'espérer un sentiment d'apaisement de la complexité à court terme. Aux difficultés de refondation et de Yalta thématique s'ajoutent les problèmes quotidiens (pauvreté des transports, omniprésence des chantiers et du bruit, éloignement de la cantine, limitation des plages horaires d'accessibilité des bureaux).
Dans ce contexte, des efforts soutenus ont été faits pour améliorer la convivialité du laboratoire (petits déjeuners mensuels, journée d'accueil), dont la plus appréciée est l'aménagement du local bibliothèque en espace de détente (billard, babyfoot, canapés).

Frais de fonctionnement. La direction du LRI a pris des mesures drastiques concernant la gestion budgétaire, les frais[5] passant de 200K€ en 2012 à 30 K€ en 2018. Les économies réalisées ont été mises à profit pour financer des mesures incitatives de recherche : mise à disposition d'un budget de fonctionnement pour chaque équipe (missions, gratification de stages, invitations) ; appel à projets finançant des projets inter-équipes ; accompagnement des doctorants (subvention des écoles d'été et de la soutenance de thèse) ; augmentation des investissements en termes de matériel et sécurité informatique.

[4] RTRA Digiteo; Equipex Digiscope; Labex DigiCosme; Lidexes Center for Data Science et Institut de la Société Numérique; Initiatives de Recherche Stratégiques CDS.2, IMSV, Nutriperso, B5GS; Institut de Convergence DataIA.

[5] Les frais incluent imprimantes, téléphonie, consommables ... Il convient aussi de tenir compte de la diminution des frais liés à l'arrivée et la mise en fonctionnement des batiments 650 et 660.

Clarification des périmètres des équipes du LRI et des EPC Inria. Si les interactions et les collaborations entre enseignants chercheurs sont excellentes, ainsi que les interactions entre équipes du LRI, EPC et équipe propre INRIA telle AViz, la convention entre CNRS, Université Paris-Sud et INRIA, qui était appelée par le rapport HCRES 2013, n'a pu être signée dans le cours du quinquenat 2013-2018 malgré les efforts répétés de la direction du LRI. Cependant, les modes de création d'EPC ont été clarifiés au niveau national par des accords cadre ; chaque partie a appris à connaitre les modes de fonctionnement des autres parties, et la transmission des informations se fait désormais de manière transparente.

Le danger possible, le sentiment d'un laboratoire à deux vitesses (entre EPC et équipes non-EPC) alimenté par la souplesse additionnelle offerte aux EPC en termes de gestion de contrats ou d'accès aux moyens humains (assistantes de projet, ingénieurs), a été jugulé par l'attention rigoureuse apportée par la direction du LRI à l'égalité de traitement, de participation aux instances de gouvernance, des droits et devoirs des membres, indépendamment des statuts. Les critères scientifiques d'excellence, de reproductibilité et d'éthique sont les mêmes, aucune tension interne n'est donc perceptible à ce niveau. En résumé chaque équipe ayant fait le choix d'être ou non une EPC est satisfaite de son statut.

Le souhait d'un accord cadre entre ParisSud-CNRS-Inria-CentraleSupélec demeure très vif, officialisant l'implication des deux partenaires privilégiés du LRI que sont Inria et CentraleSupélec.

Projets européens. Plusieurs efforts ont été faits au niveau de l'Université Paris-Sud et au niveau du LRI, pour faciliter le dépot de projets Européens ; la direction du LRI a notamment nommé un chargé de mission en interne pour informer les chercheurs des appels à projets et les accompagner dans leur démarches. Pour les raisons mentionnées précédemment liées à la sélectivité des appels européens et de lourdeur d'investissement, d'une part, et les opportunités offertes par les Programmes d'Investissement d'Avenir d'autre part, les membres du LRI participent présentement à trois projets européens seulement (outre les ERC).

Postes de soutien. Le rapport précédent a souligné le fait que l'équipe administrative est *numériquement trop faible, croule sous la tâche et n'est pas promue*. La situation est restée identique (voir Table 1.3), voire s'est empirée dans la mesure où 5 postes CDI ont été remplacés par des CDD. Certains CDDs ont été financés grâce au soutien de l'INS2I ; cependant le non-remplacement des CDI (promus, mutés, partis en retraite, en détachement Paris-Sud) est cruellement senti en raison i) de l'accroissement des tâches administratives (augmentation de la diversité des statuts, du nombre des contrats, des logiciels de gestion) et logistiques (liées au batiment) ; ii) du périmètre d'action élargi du service technique (suppléant l'absence de support de proximité d'Inria ; administrant un nombre croissant de plateformes, dont la plate-forme GPU localisée à l'IDRIS à l'usage de nombreux partenaires de Paris-Saclay) ; de la création d'un service d'aide au développement logiciel à la suite du diagnostic organisationnel de 2016. Dans ce contexte, le LRI a dû financer sur ses propres ressources le gardiennage 24/24 heures du bâtiment Claude Shannon aka Digiteo Moulon, pour un coût de 55 kE/an. Il a aussi financé durant toute la période entre un et deux adjoints administratifs en CDD par an pour la gestion des contrats. En 2018 le LRI finance également un CDD pour le service systèmes et réseaux.

Le LRI demande instamment à Paris-Sud un poste permanent de gestionnaire pour l'équipe administrative, répétant la demande faite chaque année depuis 4 ans.

Aspects valorisation. Des avancées notables ont été effectuées en terme de simplification des circuits décisionnels : la valorisation des résultats obtenus par les personnes sur statuts Paris-Sud ou CNRS (respectivement, INRIA ou Supélec) est confiée à la DARI de Paris-Sud (respectivement, est confiée au service SRIV d'Inria ou un service de CentraleSupélec, sous réserve de l'accord de la DARI).

La création du service d'aide au développement logiciel (SADL) sous la direction d'un IR CNRS, ainsi que la nomination d'un membre senior du LRI comme référent valorisation et partenariat et relations industrielles, vont également dans le sens d'une valorisation effective et efficace. Le SADL est soutenu par l'INS2I, par deux postes en CDD respectivement d'un an et de 18 mois. La difficulté concerne ici les grilles de salaires, ne permettant pas l'embauche d'ingénieurs expérimentés au prix du marché.

Concrètement, trois start-up ont été fondées par des membres du LRI dans les dernières années : Green Communications (équipe ROCS); Numscale (équipe PARSYS), Nukkai (équipe A & O).

Attraction et suivi des doctorants. Le LRI travaille en étroite concertation avec l'Ecole doctorale pour le suivi et le devenir des doctorants. Le sujet de préoccupation majeure reste la chute du nombre des

doctorants (d'un tiers depuis les années 2010), attribuée à la forte demande des étudiants par le secteur privé et au montant des rémunérations. Toutefois, l'augmentation récente des effectifs des Masters, liée à la structuration des maquettes et au vivier des grandes écoles partenaires de Paris-Saclay, devrait en principe permettre d'y remédier. Une des initiatives de la direction du LRI a été de mettre à la disposition des équipes une enveloppe financière dédiée à la gratification de stages (d'un montant total correspondant à 80 mois de stage) dans le but d'attirer de bons stagiaires au niveau M2, et de pouvoir les retenir en thèse.
La plupart des jeunes docteurs trouvent un poste soit presqu'immédiatement dans l'industrie, soit après un post-doctorat de un à deux ans avec mobilité, si possible à l'étranger ; dans ce dernier cas, les encadrants de thèse guident les doctorants et facilitent leur contact par leur réseau.

Cohésion du LRI et animation transverse. Dans les dernières années, la priorité ressentie était celle d'établir ou de renforcer les liens avec les équipes des autres laboratoires STIC de Saclay travaillant dans le même domaine, ce qui a été fait avec grand succès notamment dans le cadre de groupes de travail et appels à projets Digiteo puis DigiCosme. Depuis 2014 environ, la direction du LRI a cherché à faciliter les interactions entre équipes, à l'aide d'un appel à projet interne. Une première preuve de succès peut en être vue dans les projets inter-équipes qui ont été élaborés depuis Jan. 2018 (voir Perspectives).

Qualité de vie. Une progression a été observée depuis 2013, notamment en ce qui concerne la qualité de la restauration. Sur d'autres points (transports RER; bus; chantiers et nuisances des chantiers tels que bruits et accidents), les marges de progression restent très importantes.

Projet Scientifique à cinq ans

La réflexion scientifique conduite à partir de Décembre 2017 à l'initiative des tutelles[6] a conduit à un premier document de proposition élaboré par les membres des laboratoires à la suite de nombreuses réunions. Ce document[7] a appelé une réponse des tutelles préconisant la formation de deux UMR[8]. Cette proposition soumise au vote des membres du LRI (resp. du LIMSI) a recueilli en Juin 2018 un assentiment modeste[9] des membres du LRI (resp. un avis fortement négatif des membres du LIMSI).

Dans ce contexte, début Juillet 2018, le LRI s'est adressé à ses tutelles, ainsi qu'à l'Ecole Normale Supérieure de Saclay, pour demander une relaxation synchrone du calendrier conduisant des trois unités actuelles aux deux UMR visées par les tutelles ; l'argumentation avancée est qu'une évolution – se limitant dans l'immédiat au départ de VALS du LRI pour former un pôle *Méthodes Formelles* avec le LSV – ne remplit pas l'objectif de recomposition du paysage informatique de l'Université Paris-Saclay et augmente l'entropie générale.

Cette demande de relaxation synchrone a été approuvée sur le principe par les tutelles et par l'Ecole Normale Supérieure de Saclay, tout en fixant un délai pour la constitution des deux pôles cibles visés. Dans cet esprit, les réunions de concertation LIMSI et LRI - VALS se sont poursuivies de manière intensive tout au long de Septembre 2018 et ont permis d'établir un texte commun. Il convient de noter que ce texte commun, contrairement au souhait du LRI, ne comporte aucun engagement sur le résultat attendu[10] ; le texte a recueilli l'assentiment des personnels des deux laboratoires. En même temps, en termes d'engagement concret vers la restructuration LIMSI et LRI – VALS, au terme du vote du 12 octobre 2018, la réponse du LIMSI est négative[11].

[6] Annexe A: La lettre de mission des tutelles appelait les Laboratoires LRI, LIMSI et LSV à se concerter pour proposer une recomposition du paysage de l'informatique à l'Université Paris-Saclay.

[7] Annexe B: Eléments de projet scientifique LIMSI, LRI et LSV, 26 Avril 2018.

[8] Annexe C : Décision de restructuration en deux UMR, un pôle *Méthodes Formelles* unissant le LSV et l'équipe VALS du LRI, et un pôle pluridisciplinaire unissant le LIMSI et le LRI moins l'équipe VALS, 30 Mai 2018.

[9] Sur 110 votants, 45 oui; 35 non; 18 abstentions; 12 blancs.

[10] Annexe E: *"....les deux laboratoires souhaitent se donner le temps pour mener la réflexion sur l'opportunité et les modalités de la création éventuelle d'une telle unité, sans écarter l'hypothèse d'un constat d'échec qui rendrait cette opération inopportune, ou l'émergence de propositions alternatives...."*.

[11] La question *Le texte soumis au vote laisse la porte ouverte à une restructuration des deux ensembles LRI (sans VALS) et LIMSI en une seule UMR. Etes-vous aujourd'hui favorable à une telle restructuration ?* recueille 45 non, 14 oui, 14 blancs et 16 votes nuls.

En conséquence, le projet du LRI s'inscrit dans la perspective d'un renouvellement à l'identique du laboratoire, ouvert à la restructuration dès qu'un calendrier synchrone pourra être défini.

Dans ce contexte incertain et dans la perspective d'une recomposition du paysage informatique de l'Université Paris-Saclay qui ne saurait manquer d'être réalisée à terme, le LRI oriente donc sa stratégie de recherche vers une structure ambitieuse permettant de réaliser cette recomposition, d'en établir une matrice accueillante et visionnaire, facilitant l'adhésion des chercheurs et enseignants chercheurs à des buts scientifiques préalables à leur instanciation organisationnelle.

Dans l'objectif de créer un esprit de recherche commun, sans meurtrir les sentiments d'appartenance des personnes aux structures existantes, la proposition de *Perspectives à 5 ans* définit des pôles au sein du LRI, dans le but de décloisonner les équipes actuelles, et de permettre à leurs membres de travailler aux interfaces. La liste des pôles, en cours de consolidation, comprend certaines composantes majeures de l'informatique du XXIe siècle : *Intelligence Artificielle*; *Interfaces Humains Machines*; *Informatique Théorique*.

Ces pôles constitueront *de facto* des axes d'intégration pour les informaticiens de Paris-Saclay souhaitant rejoindre un laboratoire dont l'excellence scientifique, la masse critique et la tolérance disciplinaire, assureront le rayonnement au niveau national et international. Ces axes ne forment pas une partition des équipes, ni des objets scientifiques ; ils ont vocation à évoluer en fonction des opportunités, se prêtant *by design* à la jonction souhaitée avec le LIMSI. Leur priorité est d'unir chercheurs et enseignants chercheurs et de leur permettre d'atteindre des objectifs théoriques, algorithmiques et applicatifs dont l'ambition dépasse celle accessible au niveau d'une équipe.

Perspectives à cinq ans

Cette section présente les perspectives scientifiques globales de l'unité pour le quinquennal 2020-2025, se fondant sur l'auto-évaluation des actions du LRI durant la période 2013-2018, dans le cadre de la mise en place de la future université Paris-Saclay.

Du point de vue de la localisation du LRI, la phase immobilière initiée lors de la période 2008-2012 est achevée, le LRI se trouve regroupé géographiquement dans un même ensemble de bâtiments (batiments mitoyens 650 et 660), lui assurant la place disponible pour son expansion prévisible durant la durée du prochain quinquennal.

Du point de vue du soutien et du support de la recherche, le LRI demande l'aide de ses tutelles : i) du point de vue humain, pour pérenniser le CDD de gestionnaire administratif et le CDD d'ingénieur systèmes et réseaux actuellement financés sur les ressources propres du LRI, ainsi que pour transformer les deux CDD CNRS accordés au Service d'Aide au Développement Logiciel, en un poste permanent à brève échéance ; ii) du point de vue financier, pour que le soutien de base des tutelles permette de continuer à faire face aux frais d'exploitation du bâtiment Digiteo Moulon.

Recrutements. Depuis 2013, la politique de recrutement du LRI est de la responsabilité du Conseil Scientifique, planifiant les profils des postes sur une base pluriannuelle. Pour les postes de MdC, un fléchage sur un nombre restreint d'équipes avec priorités bien définies est effectué (le nombre de postes ouverts liés aux pr omotions et aux départs le permet). Pour les postes de Professeur, plusieurs postes seront disponibles dans les prochaines années compte tenu des départs en retraite, ce qui permettra également de faire des choix focalisés. De manière générale, les choix se fondent sur la définition des thèmes à renforcer ou à faire émerger, en préservant l'équilibre entre recherche fondamentale et appliquée.

Dans le cadre de la programmation pluriannuelle sur les postes, plusieurs priorités sont identifiées pour la période 2018-2022 :
Le thème *Internet of Things*, au confluent des équipes LAHDAK et ROCS, sera soutenu par un poste de Professeur. Ce thème pose des problèmes d'optimisation (utilisation des ressources et performance des outils) dont la résolution peut/doit être guidée par le contenu (données et connaissances). Les problèmes de communication, de stockage et de traitement des données font intervenir des socles fondamentaux : combinatoire, programmation mathématique, satisfaction de contraintes, programmation par contraintes, inférence. Cet axe, qui fait intervenir trois expertises complémentaires du LRI, est ainsi identifié comme une perspective stratégique.

Le thème *High Performance Computing* dans l'équipe PARSYS sera renforcé par un poste de Professeur (après le recrutement d'un MdC, d'un CR CNRS et l'affiliation d'un professeur CentraleSupélec en 2018). Cet axe est considéré comme une priorité stratégique en tant que goulet d'étranglement des appli-

cations de l'informatique. L'algorithmique quantique HPC et ses aspects formels font partie des pistes explorées en collaboration avec d'autres chercheurs du LRI et des partenaires industriels.

Le thème *Bio-informatique*, en liaison avec les initiatives pluridisciplinaires de l'Université Paris-Saclay, sera renforcé à court terme par des recrutements MdC. L'ambition ici est de créer un collectif fort et visible à Paris-Saclay en Informatique sur l'étude des systèmes biologiques, capable de profiter des nombreuses opportunités de collaboration avec des biologistes du campus Paris-Saclay (I2BC, INRA, AgroParisTech) et d'être une force d'attraction pour d'autres chercheurs et équipes voisines (équipe Lifeware Inria, IBISC), en bénéficiant de nos collaborations actives avec de nombreux instituts et universités aux niveaux national et international.

Le pôle *Intelligence Artificielle*, au confluent des équipes A&O / TAU, LAHDAK et BIOINFO sera également renforcé par un poste de Professeur, en lien avec l'axe DataSense du Labex, l'institut de convergence DataIA; les Initiatives de Recherche Stratégique *Center for Data Sciences* et *Nutriperso*; et enfin le futur Pôle 3IA proposé par l'Université Paris-Saclay et NewUni. D'autres postes de professeur, MdC et Chaires viendront renforcer ce pôle à moyen terme.

Le pôle *Interaction Humain-Machine* (HCC / EXSITU/ILDA) doit aussi être renforcé, en particulier, par un poste de professeur, pour répondre a des besoins importants pour l'organisation des masters recherches. En terme de recherche nous souhaitons renforcer les thèmes à l'intersection de l'IA et de l'IHM (partenariat humain-machine), et à l'intersection du web des données, de la visualisations et de l'IHM.

Enfin, le pôle *Informatique Théorique* sera également renforcé, en soulignant qu'il s'agit d'un axe d'expertise historique du LRI (médaille de bronze CNRS 2018, 2 IUF, projet H2020 OPENDREAMKIT), qui doit être préservé et conforté dans l'intérêt de la solidité et de la visibilité de l'informatique dans le cadre de l'Université Paris-Saclay, en bonne intelligence et complémentarité avec d'autres thématiques du domaine présentes à Upsay comme les *Méthodes Formelles*. Des domaines qui se trouvent au carrefour du pôle, comme par exemple, l'optimisation, seront privilégiés.

Lien avec les organismes de recherche. Le LRI poursuivra sa politique volontariste de recrutement de chercheurs CNRS en essayant en particulier de renforcer le potentiel de recherche de ses équipes ayant un faible ratio chercheur/ enseignants-chercheurs.

Les liens avec INRIA et la création de nouvelles équipes INRIA au LRI (notamment en calcul haute performance et IOT) feront également l'objet de tous nos efforts, pour remédier à la diminution du nombre des EPC dans le dernier quinquennal. La signature d'un accord cadre UPSud – CNRS – INRIA – CentraleSupélec reste notre priorité et nous espérons que la situation pourra se débloquer en lien avec la consolidation du paysage informatique de Paris-Saclay.

Projets européens. La présence du LRI au niveau des projets européens se réduit à quelques points phares (2 ERC, le KIC ICT Labs de l'EIT et enfin OpenDreamKit). L'investissement dans le KIC est remarquable, tant en recherche qu'en enseignement, et il va être poursuivi. A part ces résultats, les membres du LRI ont préféré se tourner vers les PIA, en raison de la sélectivité des programmes Européens et la lourdeur de leur montage. Une initiative de la direction consistera à nommer un chargé de recherche à l'Europe et à l'international en étroite interaction avec la direction des relations internationales de l'université (DRI). On cherchera à s'inspirer ce qui a été réalisé pour le volet formation à l'international au niveau du département d'informatique, dont est en charge un membre du LRI en étroite concertation avec les directions du LRI et du LIMSI, et qui fonctionne très bien.

Une autre action prioritaire au niveau européen est de motiver des candidatures à l'ERC parmi les membres du laboratoire. Outre l'aide fournie par Paris-Sud, et la DARI, et le CNRS, le directeur se propose de procéder par entretiens individuels.

Etudiants. Ainsi que dit précédemment, la baisse du nombre de doctorants est préocupante. Les actions en cours au niveau de la licence ou du Master comprennent la refondation de la maquette, la chasse aux redondances, l'élaboration de parcours Maths-Info. Nous espérons que l'ensemble de ces actions, dans lesquelles le LRI joue un rôle moteur, et la dynamique impulsée par la création de l'université Paris-Saclay à l'horizon 2020 vont avoir un effet d'entraînement et permettre d'enrayer la baisse des doctorants (qui n'est pas due à une insuffisance de financements, allocations ou contrats) et d'inverser la tendance durant le prochain quinquennal.

Animation Paris-Saclay. Il est certain que le défi principal ouvert au LRI concerne la place des STIC dans l'Université Paris-Saclay. Le LRI, qui s'est impliqué dès le début dans tous les appels à projets des investissements d'avenir et dans les groupes de travail et structures de gouvernance de l'Idex Paris-Saclay, est de fait parfaitement à même de relever avec succès ce défi, d'abord en consolidant les acquis. Les projets existants (dans le cadre de DigiScope, de DigiCosme, de CDS, de DataIA) seront menés à bonne fin et permettront de définir les prochains objectifs. De même, les liens existants avec *l'Institut Programme Gaspard Monge pour l'Optimisation et la recherche opérationnelle* (PGMO), la *Fondation Mathématique Jacques Hadamard* (FMJH) et l'*EDF* seront resserrés.

Consolidation des STIC. Le LRI est majoritairement favorable à la recomposition et l'unification du paysage STIC dans le contexte de l'Université Paris-Saclay ; nous avons rappelé l'investissement et le dévouement des permanents du LRI pour l'animation et la politique scientifique des structures STIC dans ce cadre.

Dans cet esprit, le LRI reste particulièrement attentif à l'évolution des contours du Département STIC et des contours des UMR à l'ordre du jour pour le prochain quinquennal. L'objectif est de contribuer à la définition de réorganisations et changements de périmètres qui assurent la lisibilité et l'envergure globale des projets scientifiques, dans le respect du rôle et de la visibilité de toutes les catégories de personnels (enseignants chercheurs, chercheurs, administratifs, logistiques et techniques) sans oublier les étudiants. La méthode retenue devra éviter la démoralisation liée aux restructurations brusquées et *ad hoc*, comme la démoralisation liée à l'enlisement.

Pour finir : la création d'un grand Institut STIC et Interfaces à Saclay nous parait seule à même de garantir la force et la visibilité de l'informatique et des STIC dans le cadre de l'Université Paris-Saclay. Le fait que cette création doive être réalisée par étapes pour surmonter les blocages semble probable. Cependant, la mise en route du processus demande : i) une vision suffisamment claire de la trajectoire globale, et en particulier des engagements sur l'échéancier et l'accompagnement du processus ; ii) la cohérence et la synchronisation des étapes intermédiaires, assurant que les avancées réalisées dans une composante ne le sont pas aux dépens d'une autre composante.

Annexe A. 15 décembre 2017, Message des tutelles

Message des tutelles Université Paris-Sud, ENS Paris-Saclay, et CNRS INS2I au LRI, LIMSI et LSV.

Chers Collègues,

Dans le cadre du projet d'Université Paris-Saclay en cours de construction, les tutelles du LSV, du LIMSI et du LRI souhaitent voir émerger un pôle fort et structuré en sciences de l'information et sont prêtes à l'accompagner.

Dans ces disciplines, la nouvelle université a le potentiel pour devenir l'un des principaux centres scientifiques français. Ses forces tiennent au nombre de ses (enseignants-)chercheurs, à la qualité de ses recherches mais aussi à son large spectre scientifique qui lui permet d'affronter les nombreux défis et les nouvelles questions que soulève la transformation numérique de la société et des pratiques scientifiques.

En revanche, l'organisation actuelle ne paraît plus optimale : il y a des recouvrements thématiques entre les trois unités de recherche, ce qui nuit à la visibilité des axes de recherche et la concurrence dans l'allocation des ressources ne permettra pas de développer une stratégie scientifique concertée.

Sans préjuger de la structure cible (pour être bien clair, une ou plusieurs unités de recherche à l'horizon 2020), l'Université Paris-Sud, l'ENS Paris-Saclay et l'INS2I-CNRS en tant que tutelles souhaitent que les « conseils scientifiques » des trois unités LSV, LIMSI et LRI travaillent à l'élaboration d'un projet scientifique global fort et cohérent faisant ressortir les thématiques phares, la manière dont elles s'articulent les unes aux autres et les axes de développement envisagés. Une fois ce projet scientifique élaboré, il conviendra de définir s'il doit être porté par une seule ou plusieurs unités de recherche. Les tutelles ne font à ce stade aucune recommandation à cet égard, si ce n'est que l'organisation actuelle doit nécessairement évoluer.

Les tutelles sont conscientes des différences de culture du LSV, du LRI et du LIMSI mais insistent sur l'importance de regrouper les forces de recherche autour d'un projet commun. L'évaluation par l'HCERES fixe une échéance : il faut que les bilans des unités et les grandes lignes du nouveau projet soient prêts à l'été 2018. Le nouveau projet devra se mettre en place en 2020 et se tourner résolument vers l'avenir. Pour l'évaluation, les tutelles demanderont qu'un seul comité soit chargé d'évaluer les trois unités. Chacune des trois unités impliquées dans cette réorganisation devra élaborer son propre bilan mais c'est une vision globale qui sera présentée avec une proposition concertée d'organisation.

Les tutelles sont prêtes à accompagner les unités de recherche dans l'élaboration de ce projet. Elles proposent de rencontrer les conseils scientifiques (ou les équipes de direction élargies aux responsables d'équipe) courant janvier pour faire un premier point d'avancement et échanger sur la manière dont cette réflexion collective se met en place.

Sylvie Retailleau, Présidente de l'Université Paris-Sud
Pierre-Paul Zalio, Président de l'ENS Paris-Saclay
Michel Bidoit, Directeur de l'INS2I - CNRS

Annexe B. 26 avril 2018, Eléments de projet scientifique LIMSI, LRI et LSV

Eléments de réflexion pour un projet scientifique

impliquant les membres du LIMSI, du LRI et du LSV

suite à la lettre de mission du 15 décembre 2017

(26 avril 2018)

Introduction

Contexte et méthode

Dans le cadre du projet d'Université Paris-Saclay, les tutelles du LIMSI (CNRS), du LRI (Univ. Paris-Sud et CNRS) et du LSV (ENS Paris-Saclay) ont exprimé leur souhait de voir émerger un pôle fort et structuré autour d'un projet commun. Cet objectif a été inscrit dans la lettre de mission du 15 décembre 2017 qui est reproduite en annexe A. Ainsi, l'Université Paris-Sud, l'ENS Paris-Saclay et l'INS2I-CNRS ont demandé aux conseils scientifiques des trois unités de travailler à l'élaboration d'un projet scientifique global qui mette en avant les thématiques principales de ce périmètre et les axes de développement envisagés.
Les conseils scientifiques du LIMSI, du LRI et du LSV se sont réunis le lundi 05 février au LIMSI, le vendredi 09 mars au LRI et le jeudi 05 avril au LIMSI (cf. les comptes-rendus en annexe B, C et D) afin d'élaborer collectivement ce projet global. Au terme de ces 3 réunions, 7 thématiques scientifiques se sont dégagées:

- *Algorithmic Intelligence: Learning, Optimization and Graphs.*
- *Big Data and IoT.*
- Interaction Humain-Machine.
- Mécanique des Fluides, Modélisation et Simulation Numérique Intensive.
- Méthodes Formelles et Systèmes Biologiques.
- *Parallel and Distributed Systems.*
- Traitement Automatique des Langues.

Pour chaque thème, des rédacteurs ont été identifiés et un document a été rédigé qui décrit les forces en présence et les ébauches d'un projet scientifique. Les documents décrivant ces 7 thèmes sont présentés dans la suite du document, à raison d'un chapitre par thème. Il est important de noter qu'en dépit de recommandations pour que les présentations suivent un canevas relativement homogène, une grande liberté a finalement été laissée sur la forme, sur le fond et sur les équipes impliquées par ces thèmes. Par ailleurs, une évolution a pu être observée quant aux thèmes finalement retenus, avec par exemple plusieurs regroupements qui progressivement ont émergé au cours de la réflexion.

Comme indiqué dans la lettre de mission du 15 décembre, l'évaluation par l'HCERES fixe une échéance et notre réflexion a dû aussi s'effectuer dans un calendrier resserré, en rassemblant des chercheurs

issus de laboratoires ayant des cultures diverses. En dépit de ces fortes contraintes temporelles, nous avons pu réunir les conseils scientifiques des trois unités à plusieurs reprises, et les rédacteurs des documents décrivant chacun des thèmes ont participé à plusieurs réunions pour travailler sur le document. Ceci sans compter les réunions en comité de direction dans chaque laboratoire et les échanges nombreux entre les directions des laboratoires. En dépit de l'urgence de leur préparation, les textes rassemblés ci-après sont le fruit d'une réflexion scientifique approfondie.

Dans la lettre de mission du 15 décembre, les tutelles se sont proposées de visiter les laboratoires en janvier 2018 pour prendre connaissance de l'état d'avancement de la réflexion et clarifier les attendus. Ainsi, les visites suivantes ont été effectuées:

- Jamal Daafouz, Olivier Cappé et Adeline Nazarenko, représentant le CNRS-INS2I, ont rencontré la direction et les responsables d'équipes du LIMSI le 31 janvier 2018; Etienne Augé, Christine Paulin et Sylvie Retailleau pour l'Université Paris Sud en ont fait de même le 6 février 2018.
- Christine Paulin (Doyenne de la faculté des sciences) et Sylvie Retailleau (Présidente de l'Université Paris-Sud) ont rencontré le conseil scientifique du LRI le 11 janvier 2018.
- Adeline Nazarenko (CNRS-INS2I) et Keitaro Nakatani (VPR, ENS Paris-Saclay) ont rencontré les membres du LSV le vendredi 16 mars 2018. Pierre-Paul Zalio (Président de l'ENS Paris-Saclay) et Keitaro Nakatani ont aussi rencontré les membres du LSV le vendredi 06 avril 2018.

Guide de lecture

Comme rappelé ci-dessus, la réflexion des laboratoires LIMSI, LRI et LSV a permis de faire émerger de manière ascendante sept thèmes construits sur la base d'affinités scientifiques, rassemblant des équipes d'un ou deux labos. Aucun thème ne traverse les trois laboratoires, ni ne redécoupe les équipes actuelles des laboratoires. Ces thèmes, dont les forces sont sensiblement comparables (à part deux : l'un nettement plus gros, l'autre nettement plus petit), sont brièvement présentés ci-dessous avec leurs motivations. Une présentation plus détaillée de chacun des thèmes figure dans la suite du document.

- *Algorithmic Intelligence: Learning, Optimization and Graphs.*
- *Big Data and IoT.*
- Interaction Humain-Machine.
- Mécanique des Fluides, Modélisation et Simulation Numérique Intensive.
- Méthodes Formelles et Systèmes Biologiques.
- *Parallel and Distributed Systems.*
- Traitement Automatique des Langues.

Le thème ``***Algorithmic Intelligence:, Learning, Optimization and Graphs***'' (AI-Log) regroupe les équipes GALAC (``Graphes, algorithmes et combinatoire'') et A&O (``Apprentissage et Optimisation'') du LRI, dans le but d'allier les compétences en mathématiques et informatique des deux équipes pour attaquer les défis de l'Intelligence Artificielle. La nécessité d'une approche fondamentale et pluri-disciplinaire est soulignée, en s'appuyant sur les liens existants avec les équipes des Laboratoires de

Maths (LMO), de Physique (LAL), du Traitement de Signal (L2S) ou avec les équipes du LIX et du CMAP.

Le thème ``***Big Data and IoT***'' regroupe l'équipe ROCS (``Réseaux et Optimisation Combinatoire et Stochastique'') et l'équipe LaDHAK (``Données et connaissances massives et hétérogènes'') du LRI, pour aborder de front les interactions des agents communicants (internet des objets et architectures de type cloud). Les expertises complémentaires des équipes visent une approche unifiée des problèmes de communication d'information et de construction de connaissances décentralisées, leur optimisation et leur mise en oeuvre e.g. pour des applications liées aux véhicules électriques.

Le thème ``**Interaction Humain-Machine**'' aggrège un ensemble homogène et cohérent de chercheurs et enseignants-chercheurs actuellement répartis au LIMSI (groupes AMI, CPU et VENISE) , au LRI (HCC et les EPC ex-Situ et Ilda), ainsi qu'au centre INRIA Paris-Saclay (EP AVIZ), constituant un des principaux pôles européens sur ces thématiques. Les équipes de ce thème explorent de multiples formes d'interaction, telles que l'interaction visuelle, la visualisation interactive d'information et l'analyse d'image pour l'interaction ; l'interaction tangible; l'interaction gestuelle; l'interaction immersive, ou encore l'interaction multimodale, avec un focus particulier sur les questions soulevées par l'interaction collaborative. Ils disposent pour ce faire d'un réseau d'équipements exceptionnel, développé notamment au travers de l'Equipex Digiscope.

Le thème ``**Mécanique des Fluides, Modélisation et Simulation Numérique Intensive**'' recouvre exactement le périmètre actuel du département de "Mécanique Energétique" du LIMSI, aggrégeant les forces des trois équipes AERO, ETCM et TSF. S'appuyant sur des compétences bien identifiées en matières de méthodes numériques et de simulations intensives, de modélisation des écoulements (instabilités, transition), des transferts de masse et de chaleur (convection, diphasique) et des couplages multi-physiques (magnéto-hydrodynamiques), le projet de ce thème se développe autour d'objectifs bien identifiés: compréhension des phénomènes physiques, maîtrise de la turbulence, contrôle des écoulements, qui engagent à investir en permanence dans les nouvelles méthodes et architectures de calcul intensif.

Le thème ``**Méthodes Formelles et Systèmes Biologiques**'' regroupe les chercheurs du LSV, ainsi que les équipes Bioinfo et VALS du LRI, avec la volonté de joindre leurs forces pour développer des activités de recherche sur les méthodes formelles d'une part, la bio-informatique d'autre part, et leurs interfaces en troisième lieu. Les équipes concernées ont noué des liens étroits dans les dernières années, et le processus de réflexion globale a permis de faire émerger ce thème et de proposer un projet scientifique pour l'avenir.

Le thème ``**Parallel and Distributed Systems**'' regroupe l'équipe ParSys du LRI et quelques enseignants-chercheurs et chercheurs à CentraleSupélec, au LSV et dans l'équipe VALS au LRI. Il regroupe des activités autour de la conception et l'amélioration d'algorithmes parallèles et distribués ainsi que dans la programmation et l'utilisation des architectures matérielles les plus récentes. Les principaux domaines de recherche sont le calcul scientifique haute-performance (HPC), les algorithmes distribués, les algorithmes pour les ordinateurs quantiques, les protocoles de population ou encore les circuits microbiologiques. Il est important de noter que les thématiques de ce thème se trouvent clairement à la croisée de plusieurs disciplines (informatique, physique quantique, microbiologie, par exemple).

Le thème ``**Traitement Automatique des Langues**'' s'inscrit dans la continuité des activités développées de longue date au sein des groupes ILES et TLP du LIMSI. Ces équipes s'appuient sur une

forte culture pluridisciplinaire, ainsi que sur une longue expertise en matière d'annotation et d'exploitation de corpus linguistiques. Prenant acte des rapides évolutions du domaine de la linguistique informatique, dont les principales applications diffusent rapidement et massivement auprès du grand public, ce thème propose un programme de travail s'articulant autour de trois axes : outiller la linguistique de corpus ; progresser dans la compréhension de l'apprentissage des langues (par des humains comme par des machines) ; poursuivre les travaux en cours sur les grandes applications du domaine.

Conclusion

Nous récapitulons les positionnements des sept thèmes dans l'Université Paris-Saclay.

Le thème ``Algorithmic Intelligence: Learning, Optimization and Graphs'' s'inscrit dans le cadre de l'Intelligence Artificielle et de l'apprentissage statistique, où les algorithmes et les modèles sont inférés à partir de données selon la théorie de l'information, par opposition aux approches classiques fondées sur les spécifications formelles et la déduction automatique. Les expertises complémentaires du nouveau groupe AI-LOG et la visibilité internationale de ses membres, offrent un cadre unique à la croisée des mathématiques et de l'informatique, pour relever les défis de l'IA dans l'environnement de l'Université Paris-Saclay.

Le thème ``Big Data and IoT'' offre une vision ambitieuse et novatrice autour du Big Data et de l'Internet des objets, avec un fort impact socio-économique et technologique. Le défi scientifique consiste à allier les compétences fortes et complémentaires des membres de ce thème pour attaquer les objectifs identifiés, et définir un pôle Big Data cohérent et spécifique dans l'Université Paris-Saclay.

Comme nous l'avons rappelé ci-dessus, le thème ``Interaction Humain-Machine'' constitue un ensemble homogène de membres répartis entre le LIMSI, le LRI et le centre Inria Paris-Saclay. La collaboration entre équipes de ce thème existe d'ores et déjà, au travers de projets communs, de co-encadrements de thèse, et d'équipements communs. Ce thème, dont l'objectif général est de créer des systèmes interactifs adaptés aux capacités humaines, forme d'ores et déjà l'un des pôles européens les plus importants sur cette thématique.

Le thème "Mécanique des Fluides, Modélisation et Simulation Numérique Intensive" est bien reconnu pour ses compétences en développement de méthodes numériques , en simulations intensives (HPC), en maîtrise des écoulements, en transferts de masse et de chaleur et en couplages multi-physiques. Développant des recherches aussi bien théoriques qu'expérimentales et numériques, les chercheurs de ce thème sont engagés dans des collaborations pluridisciplinaires très variées , allant des mathématiques appliquées (contrôle, optimisation, UQ) et de l'informatique (IHM, apprentissage artificiel, calcul intensif) jusqu'à la modélisation fine de phénomènes physiques. Cette activité protéiforme présente une forte propension à s'ouvrir à d'autres communautés, mais également requiert de disposer des moyens appropriés tant humains que matériels pour maintenir d'une part des plateformes expérimentales académiques instrumentées avec de la métrologie de pointe et, d'autre part, des plateformes logicielles capitalisant le savoir-faire et des moyens de calcul de développement.

Le thème ``Méthodes Formelles et Systèmes Biologiques'' se place à la croisée de deux domaines, la bioinformatique et les méthodes formelles ; ces dernières ont toujours eu une place privilégiée en bioinformatique, par exemple en biologie des systèmes et en biologie synthétique. Le projet

scientifique de ce thème ambitionne de défricher de nouveaux champs à la croisée de ces deux domaines, comme par exemple l'étude des processus d'analyse bioinformatiques. Parmi ses points forts, on peut citer l'alliance de groupes reconnus et la volonté de créer une dynamique nouvelle, des axes de recherche bien identifiés avec des enjeux scientifiques majeurs. Il y a aussi la volonté d'attirer de nouveaux membres extérieurs et de s'ouvrir davantage vers d'autres disciplines scientifiques.

Le thème ``Parallel and Distributed Systems'' qui couvre à la fois le calcul scientifique haute performance, l'informatique quantique et l'analyse d'algorithmes distribués se trouve interagir avec des nombreux autres champs disciplinaires, par exemple en robotique, en science des données, avec les simulations numériques en physique, ou encore avec les problématiques des circuits microbiologiques. Non seulement, les problématiques de ce thème s'attaquent à des défis identifiés par de nombreuses agences de recherche (ANR, H2020) mais aussi ce thème implique des participants au LRI, au LIMSI et au LSV et dans d'autres structures de l'Université Paris-Saclay, comme à CentraleSupélec.

Le thème "Traitement Automatique des Langues" étudie des questions fondamentales relatives aux systèmes linguistiques, en exploitant de larges corpus collectés, annotés et enrichis de manière automatique et semi-automatique. L'exploitation de ces corpus par les outils d'apprentissage statistique mobilise des moyens de calculs importants; il demande également des développements méthodologiques spécifiques qui permettent parfois de progresser dans l'étude de l'apprentissage humain des langues. Egalement mobilisé sur les grandes applications du traitement des langues : reconnaissance vocale, recherche d'information, agents conversationnels, traduction automatique, le thème langue couvre un large spectre, des recherches les plus fondamentales aux plus appliquées, dans toutes les modalités (écrit, parole et signe), et sur une grande variété de supports. certains mêlant d'ailleurs ces différentes modalités. Ces recherches pluridisciplinaires rassemblent des communautés diverses au sein du LIMSI, et impliquent des collaborations multiples, au sein des trois laboratoires comme plus largement dans le périmètre Paris-Saclay et au-delà.

Suit une cinquantaine de pages composée d'annexes, et de descriptions plus détaillées des thèmes de recherche.

Annexe C. 30 mai 2018. Décision des tutelles de restructuration en 2 UMR

Message au LSV, LRI, LIMSI

Le 29 mai 2018, les tutelles, Université Paris-Sud, ENS Paris Saclay et CNRS/INS2I ont rencontré les équipes de direction du LSV, du LRI et du LIMSI pour leur faire une proposition de restructuration des 3 UMR sur la base du document "Eléments de réflexion pour un projet scientifique émanant des chercheurs des trois laboratoires".

Les tutelles ont pris connaissance de ce rapport et de la proposition d'organisation en sept pôles scientifiques. Elles saluent l'effort entrepris dans un délai très contraint. Cette proposition fait ressortir des thématiques importantes et prend en compte les recommandations des tutelles concernant les recouvrements thématiques. Les tutelles ont conscience que les différents projets des pôles n'ont pas le même niveau de maturité à ce stade, mais ces projets vont certainement se préciser dans les mois et années à venir.

Dans la perspective de la prochaine évaluation par l'Hcéres, il est à présent nécessaire de statuer sur la structuration des forces scientifiques des 3 UMR. Après examen des différentes options possibles, les trois tutelles ont pris acte que la constitution d'une seule UMR n'est pas envisageable à court terme et souhaitent donc une structuration à l'horizon 2020 en 2 UMR :

- Une UMR CNRS/ENS PS/UPSUD centrée sur les méthodes formelles (LSV + équipe VALS du LRI),
- Une UMR CNRS/UPSUD regroupant les autres thématiques (les autres équipes du LRI + LIMSI), structurée en thèmes ou pôles.

Dans cette perspective de restructuration en 2 UMR, il est rappelé que:

- Les noms des UMR doivent évoluer pour refléter la reconfiguration scientifique en cours ;
- L'organisation interne et les objectifs propres de chacun des pôles pourront être précisés progressivement ;

- Il n'est pas demandé à court terme aux équipes ou à leurs membres de déménager d'un bâtiment à l'autre (en dehors du LSV dont le déménagement à Paris-Saclay est prévu pour 2019) ;
- Un travail important sera à faire pour réorganiser les services de laboratoires et un accompagnement RH spécifique sera prévu à cette fin ;
- Les directeurs d'unités actuels sont responsables de présenter le bilan de leur unité et les nouveaux projets des deux futures UMR, en attendant la désignation des prochains directeurs d'unité.

Les DUs sont invités à partager ces recommandations avec les membres de leurs unités et les tutelles proposent d'échanger avec les membres des conseils de laboratoires qui le souhaitent.
Les tutelles réaffirment qu'elles vont accompagner les unités dans toutes les dimensions des évolutions à conduire, d'ici au 1er janvier 2020 puis durant toute la durée du quinquennal 2020-2024.

Sylvie Retailleau, Présidente de l'Université Paris-Sud
Pierre-Paul Zalio, Président de l'ENS Paris-Saclay
Michel Bidoit, Directeur de l'INS2I – CNRS.

Annexe D: 21 juin 2018. Demande du LRI de détente synchrone du processus

Message à l'Université Paris-Sud et au CNRS
Chers collègues,
A la suite de la lettre de mission des tutelles du LRI du 15 décembre 2017, et de la lettre de résolution des tutelles du 30 mai 2018, j'ai conduit un processus de concertation au sein du LRI : 2 réunions du conseil scientifique, 1 réunion du conseil de laboratoire, 1 AG et consultation par vote de l'ensemble des membres permanents. Ce vote établit :

- L'entière adhésion du LRI à une structure unique, dans le but de garantir la force et la visibilité de l'informatique et des STIC dans le cadre de l'Univ. Paris-Saclay - solution qui n'a pas été retenue par les tutelles ;
- L'avis modestement positif des membres du LRI sur l'agrégation à horizon 2020 du LRI moins VALS plus LIMSI, solution proposée par les tutelles.

Cette solution se heurte toutefois à la réticence massive des membres du LIMSI. Dans le but de débloquer la situation, nous proposons la constitution dans les meilleurs délais de groupes de travail, animés par un binôme LRI-LIMSI, dédiés aux divers points de blocage (entre autres, le nom du futur laboratoire ; sort des ITA; la pluri-disciplinarité; l'application des dispositions ZRR) en vue de remédier à ces réticences et de nous permettre d'atteindre dans un calendrier plus détendu l'agrégation retenue par nos tutelles.
L'établissement et la conduite de ces groupes de travail seront facilités par la réponse des tutelles aux questions stratégiques suivantes :

- Accompagnement du processus (modalités et personnalité du chargé de mission) ;
- Adossement de l'entité nouvelle aux autres partenaires de l'Université Paris-Saclay (ENS, Centrale-Supélec, INRIA : signature d'accord de partenariat ou de tutelle)
- Mesures de renforcement du LRI pendant la période transitoire nous séparant de la création de l'entité visée, dans l'hypothèse où le LRI se trouverait diminué à effet immédiat des 26 chercheurs et enseignants-chercheurs rejoignant l'ENS-Saclay ; en particulier, mesures de soutien des disciplines de l'Informatique Théorique (hors VALS) et de la BioInformatique, qui sont les plus affaiblies de fait par la diminution ci-dessus et la création en parallèle de l'Unité LSV+Vals ;
- Échéancier de discussion visant l'émergence à terme d'une structure unifiée des laboratoires liés aux STIC sur l'Université Paris-Saclay.

Veuillez, chers collègues, croire à notre ferme engagement de contribuer à une vision forte et unifiée des STIC et de ses interfaces sur le plateau de Saclay, prenant en considération tous les membres des labos concernés.

Bien cordialement,
Yannis Manoussakis
Directeur du LRI

Annexe E: Texte commun LRI moins Vals et Limsi

texte approuvé par les deux laboratoire LRI et Limsi le 12 Octobre 2018

Comme indiqué dans les rapports scientifiques des deux laboratoires, le CNRS, l'Université Paris-Sud et l'ENS Paris-Saclay ont demandé, par un courrier daté du 17 décembre 2017, que *les "trois unités LSV, LIMSI et LRI travaillent à l'élaboration d'un projet scientifique global fort et cohérent faisant ressortir les thématiques phares, la manière dont elles s'articulent les unes aux autres et les axes de développement envisagés. Une fois ce projet scientifique élaboré, il conviendra de définir s'il doit être porté par une seule ou plusieurs unités de recherche. Les tutelles ne font à ce stade aucune recommandation à cet égard, si ce n'est que l'organisation actuelle doit nécessairement évoluer."*

Les trois unités ont produit un rapport qui a été transmis aux tutelles le 26 Avril 2018, présentant une cartographie des activités scientifiques en sept thématiques. Le 31 mai 2018, les tutelles ont informé les trois unités qu'elles souhaitaient désormais "une structuration à l'horizon 2020 en 2 UMR :

- Une UMR CNRS/ENS PS/U-PSud centrée sur les méthodes formelles (LSV + équipe VALS du LRI),
- Une UMR CNRS/U-PSud regroupant les autres thématiques (les autres équipes du LRI + LIMSI), structurée en thèmes ou pôles."

La création d'une unité rassemblant le LRI sans VALS et le LIMSI serait une opération complexe compte-tenu de la taille des laboratoires, de leurs spécificités et de leur histoire. Les personnels doivent s'approprier un projet dont ils ne comprennent pas toujours la justification, la portée ou la pertinence. Réfléchir sur la structure organisationnelle, les modes de fonctionnement, l'organisation de la vie d'une telle unité demande un travail de fond qui est incompatible avec une mise en œuvre au 1er janvier 2020. Les incertitudes qui subsistent concernant les évolutions de l'Université Paris-Saclay (périmètres des Graduate Schools, EUR) sont un autre frein à une recomposition pérenne des unités de recherche. Aussi les deux laboratoires souhaitent se donner le temps pour mener la réflexion sur l'opportunité et les modalités de la création éventuelle d'une telle unité, sans écarter l'hypothèse d'un constat d'échec qui rendrait cette opération inopportune, ou l'émergence de propositions alternatives.

Les directions et conseils scientifiques des deux laboratoires LRI et LIMSI, après échanges avec les tutelles, ont convenu de mettre en place 4 groupes de travail qui commenceront à se réunir à partir du mois d'octobre 2018, avec l'objectif de rendre leur analyse et leurs propositions dans le courant de l'année 2019. Ces groupes de travail et leurs objectifs sont décrits à la fin de ce document. Toutefois, pour coordonner la réflexion des laboratoires autour de cette possible refondation des unités, l'identification rapide d'un chef de projet apparaît comme un préalable indispensable.

A ce stade de la réflexion, les équipes actuelles du LRI (sans VALS) et du LIMSI sont conservées et leurs projets scientifiques, décrits dans leurs rapports respectifs, restent d'actualité. Le reste de ce document reprend les thématiques identifiées dans le document du mois d'avril, ajustées pour prendre en compte le projet parallèle d'unité LSV+VALS, ainsi que d'autres évolutions intervenues depuis à la faveur des réflexions des équipes. Ces thématiques peuvent évoluer et ne préjugent pas d'une possible réorganisation en "pôles" ou "départements", laquelle reste à définir.

En capitalisant sur les acquis et la reconnaissance internationale des deux unités dans leurs domaines respectifs, l'évolution envisagée vise à aboutir à un centre de recherche interdisciplinaire d'envergure, qui aura vocation à terme à agréger d'autres équipes ou unités dans son périmètre thématique. Ce centre couvre un large spectre de recherches fondamentales et appliquées dans les domaines des Sciences de l'Information et des Sciences de l'Ingénieur. Il inclut à la fois les domaines cœurs de l'informatique (algorithmes, données, connaissances, systèmes, réseaux, ...) et de la mécanique des fluides et de l'énergétique, et des domaines aux dimensions interdisciplinaires comme l'intelligence artificielle, l'interaction humain-machine, le traitement automatique des langues ou la bioinformatique. Il rassemble donc des chercheurs et enseignants-chercheurs de cultures et d'horizons divers, relevant des Sciences de l'Information et des Sciences de l'Ingénieur, mais aussi des Sciences Humaines et Sociales, et entretient des liens étroits avec les autres disciplines de son environnement proche (mathématiques, physique, biologie). bf Etat courant des thématiques scientifiques

- Le thème "Algorithmic Intelligence: Learning, Optimization and Graphs" (AI-Log) regroupe princi-

palement les équipes GALAC ("Graphes, ALgorithmes et Combinatoire") et A&O ("Apprentissage et Optimisation") du LRI, dans le but d'allier les compétences en mathématiques et informatique des deux équipes pour attaquer les défis de l'Intelligence Artificielle et de l'Algorithmique. L'optimisation, l'algorithmique et l'apprentissage sont de plus en plus entrelacés : l'optimisation et l'algorithmique portent principalement sur la qualité, l'efficacité et la robustesse des calculs, tandis que l'apprentissage se concentre sur l'efficacité via des formulations simples sur le plan informatique et évolutives pour une classe bien définie d'instances. L'apprentissage développe de nouvelles approches en combinant un large éventail de formulations issues non seulement de l'optimisation, mais aussi des statistiques et des probabilités, de la physique théorique et du génie électrique. L'expertise établie de GALAC en mathématiques discrètes, en combinatoire algébrique et en optimisation discrète, continue et stochastique contribuera à renforcer encore l'expertise d'A&O dans les algorithmes dédiés aux formulations d'apprentissage. La nécessité d'une approche fondamentale et pluridisciplinaire est soulignée, en s'appuyant sur les liens existants avec les équipes des Laboratoires de Maths (LMO), de Physique (LAL), du Traitement de Signal (L2S) et avec les équipes du LIX et du CMAP.

- Le thème "Big Data et IoT" concerne principalement les équipes ROCS ("Réseaux et Optimisation Combinatoire et Stochastique") et LaDHAK ("Données et connaissances massives et hétérogènes") du LRI. Sur les aspects données massives et connaissances, en s'appuyant sur les compétences en bases de données et en IA de l'équipe LaHDAK, les recherches de ce thème porteront sur la découverte de connaissances, la représentation des données/connaissances, l'optimisation en Big Data, le requêtage, le raisonnement, la fouille et l'analyse de données, la qualité et la confidentialité des données. Sur les aspects réseaux de nouvelle génération, l'équipe ROCS s'intéressera en particulier au développement de nouvelles solutions intégrant la programmation mathématique (non linéaire) en variables mixtes déterministe et incertaine et des algorithmes et protocoles optimisées pour les futurs réseaux (5G, LP-WAN, Edge Cloud Computing, etc.), tout en concentrant l'effort sur l'adaptation des modèles et approches mathématiques aux spécificités pratiques des systèmes réseaux de nouvelle génération. Les deux équipes regroupées dans ce thème sont aussi animées par des objectifs communs, liés aux problématiques de communication, stockage et traitement des données issues de l'IoT, dont notamment : le développement de mécanismes optimisés de communication afin d'offrir une connectivité ciblée et adaptée aux différentes spécificités et contraintes des applications IoT ; la gestion des différentes étapes du processus "KDD" pour des données massives et complexes (données incomplètes, incertaines, sémantiques, évolutives, en streaming, séries temporelles) issues de domaines variés (dont bien sûr l'IoT, mais aussi en santé, environnement, transports, smart cities, finance, etc) ; et la recherche de solutions efficaces en termes de communication, gestion de données et de connaissances pour le mise en œuvre d'applications à forte valeur ajoutée dans le domaine de l'IoT.
- Le thème "Interaction Humain-Machine" agrège un ensemble homogène complémentaire et cohérent de chercheurs et enseignants-chercheurs actuellement répartis au LIMSI (groupes AMI, CPU et VENISE) et au LRI (HCC, constitué des équipes-projets communes Paris-Sud–CNRS–Inria EX-SITU et ILDA), auxquels pourrait s'ajouter l'équipe-projet propre Inria AVIZ présente sur le site et qui souhaite devenir équipe-projet commune. Cet ensemble constituerait l'un des principaux pôles européens sur ces thématiques. Les équipes de ce thème explorent de multiples formes d'interaction, telles que l'interaction visuelle et non visuelle, la visualisation interactive d'information et l'analyse d'image pour l'interaction, l'interaction tangible, l'interaction gestuelle, l'interaction immersive multi-sensorimotrice (visuelle, audio, haptique...) dans des mondes virtuels ou augmentés, ou encore l'interaction multimodale (i.e. la gestion "intelligente" de différents modes d'interaction) et les interactions affectives et sociales, avec un focus particulier sur les questions soulevées par l'interaction collaborative tant co-localisée que distante. Ces équipes disposent pour ce faire d'un réseau d'équipements exceptionnel, développé notamment au travers de l'Equipex Digiscope. Au-delà de leurs activités de recherche complémentaires, elles contribuent ensemble à l'animation de deux Masters d'audience internationale dans leur domaine d'expertise.
- Le thème "Mécanique des Fluides, Energétique" recouvre exactement le périmètre actuel du département de "Mécanique Énergétique" du LIMSI, agrégeant les forces des trois équipes AERO, ETCM et TSF. Notre objectif est de développer conjointement et de partager des méthodes spécifiques, à la fois numériques et expérimentales. Nos recherches se situent sur deux plans, d'une part à un niveau méthodologique, dans lequel nous contribuons au développement de méthodes de pointe aussi bien numériques, pour accroitre les performances des outils de simulation, qu'expérimentales pour faire progresser les techniques d'analyse et mieux appréhender la dynamique des écoulements et des transferts. Nos travaux s'inscrivent, d'autre part, à un niveau phénoménologique afin de progresser dans la connaissance des phénomènes de base intervenant dans les systèmes fluidiques.
- Le thème "Bioinformatique" regroupe les chercheurs de l'équipe Bioinfo du LRI. L'objectif de ce thème est de concevoir et de développer de nouvelles approches informatiques pour répondre à de véri-

tables questions biologiques et bioinformatiques. Les membres de ce thème s'appuient sur leur forte culture pluridisciplinaire pour non seulement comprendre les problèmes posés par l'étude des systèmes biologiques depuis l'échelle moléculaire jusqu'à celle des cellules et des populations, mais aussi concevoir des solutions impliquant des compétences issues de domaines très variés : algorithmique, combinatoire, bases de données, représentation des connaissances, analyse de données (statistiques) et apprentissage automatique, méthodes formelles et simulation.

- Le thème "Parallel and Distributed Systems" regroupe l'équipe ParSys du LRI et quelques enseignants-chercheurs de CentraleSupélec. Il regroupe des activités autour de la conception et l'amélioration d'algorithmes parallèles et distribués ainsi que la programmation et les systèmes d'exécutions pour les architectures massivement parallèles les plus récentes. Parmi les objectifs communs partagés par les chercheurs impliqués dans ce thème se trouvent la performance des algorithmes et leur passage à l'échelle, la tolérance aux défaillances, et la minimisation de l'énergie. Les principaux domaines de recherche sont le calcul haute-performance (HPC) pour le calcul scientifique et le big data, les algorithmes distribués (protocoles de population, algorithmes de la nature et circuits biologiques...) et les algorithmes pour les futurs ordinateurs quantiques. Il est important de noter que les domaines étudiés dans ce thèmes se trouvent à la croisée de plusieurs disciplines (informatique, mathématiques appliquées, physique quantique, microbiologie, par exemple).
- Le thème "Traitement Automatique des Langues" s'inscrit dans la continuité des activités développées de longue date au sein des groupes ILES et TLP du LIMSI. Ces équipes s'appuient sur une forte culture interdisciplinaire, ainsi que sur une longue expertise en matière d'annotation et d'exploitation de corpus linguistiques. Prenant acte des rapides évolutions du domaine de la linguistique informatique, dont les principales applications diffusent rapidement et massivement auprès du grand public, ce thème propose un programme de travail s'articulant autour de trois axes : outiller la linguistique de corpus pour mieux traiter toutes les langues, de France ou du monde ; progresser dans la compréhension de l'apprentissage des langues (par des humains comme par des machines) ; poursuivre les travaux sur la compréhension de la langue, des couches basses de la perception du signal jusqu'au sens, pour s'attaquer aux verrous qui sous-tendent les applications fondées sur la langue ou l'utilisant comme moyen de communication.

Description des Groupes de Travail. L'objectif des groupes de travail est de faire un état des lieux des pratiques, en identifiant ce qui fonctionne bien ou pas dans chaque laboratoire et en notant les souhaits d'évolution. Une fois identifiés et analysés les verrous éventuels à la construction d'une future unité, chaque GT s'emploiera à étudier si et comment ils pourraient être levés. Enfin chaque GT fera des propositions d'organisation et des mesures d'accompagnement jugées nécessaires, et proposera un calendrier de mise en œuvre. Les GTs devront travailler en étroite collaboration afin que les propositions finales affichent une cohérence d'ensemble propre à satisfaire les personnels et garantir un bon fonctionnement d'ensemble.

- Le GT Science est en charge du volet scientifique et a pour mission d'identifier les atouts scientifiques de l'ensemble formé par les deux laboratoires (compétences, lignes de force, nouvelles synergies), d'imaginer une organisation en « pôles », « thèmes », axes transverses et/ou autres, et de définir une possible identité scientifique à partir de ces lignes de forces.
- Le GT Valeurs et Vie de Laboratoire est en charge d'échanger sur les valeurs essentielles auxquelles sont attachés les personnels des deux laboratoires (solidarité entre équipes, collégialité, respect, inclusion, convivialité) et leurs implications en terme d'organisation.
- Le GT Gouvernance et Moyens pour la Recherche est en charge de croiser les pratiques en terme de gestion des moyens pour la recherche et de proposer des modes de gouvernance en mesure de préserver la cohérence, la transparence de l'accès à ces moyens, en particulier :
  - gestion des plateformes ;
  - répartition des crédits récurrents/contrats ;
  - actions de recherche portées par le centre ;
  - fonctionnement des services de soutien à la recherche ;
  - organisation géographique ;
  - structure de gouvernance et modalités de prise de décision (profils de postes, etc.).
- Le GT Organisation des Services est en charge de faire un état des lieux des pratiques des services des deux laboratoires (il pourra travailler en deux sous-groupes, pour les aspects administratifs et techniques), d'identifier les points communs et les différences. Il devra ensuite travailler en lien étroit avec le GT Moyens afin d'identifier les évolutions de service à imaginer et proposer des scénarios d'organisation. Il pourra bénéficier d'un accompagnement par les services RH des établissements.

Annexe 3 : Équipements, plateformes

Les Cluster TIPI du LRI

Ce cluster de calcul est accessible à l'ensemble des équipes du laboratoire. Il se compose actuellement de 40 serveurs de calcul (machines tipixx), pour un total de 288 cœurs. Le cluster abrite 3 générations de serveurs qui sont accessibles directement par ssh avec son compte LRI :

- 8 machines (Dell R630, 08/2017) Intel Xeon E5-2623 v4 2.6GHz, 4 coeurs, 64 Go, Ubuntu 16.10;
- 16 machines (Dell R620, 05/2014) bi-pro Intel® Xeon® E5-2609v2 2.5GHz ,8 coeurs, 64 Go, CentOS 64 bits;
- 16 machines (Dell R610, 04/2011) bi-pro Intel Xeon, 8 cœurs 24 Go, Ubuntu 16.10;

Les machines sont sous distribution Ubuntu ou CentOS. Certains nœuds peuvent être réservés pour des expérimentations ponctuelles. Cette grappe de calcul est massivement utilisée par plusieurs équipes du laboratoire. Son taux de charge, ramené en temps de calcul par coeur, est de l'ordre de 90%.

Serveur GPU kepler

Configuration de kepler:

- configuration physique:
  - Dell PowerEdge R720
  - 2 cartes GPU Nvidia K40M au format PCI-E 16x
  - 2 processeurs Intel E5-2620v2 à 2,1GHz 6 cœurs, 15M Cache, 7.2GT/s
  - 64Go 1600 Mhz RDIM
- système : Ubuntu Server 14.10.
- réseau : @IP : 129.175.28.33; nom : kepler; vlan : 278
- gestionnaire : Torque (client)
- logiciels/bibliothèques : C, C++, fortran, CUDA, MAGMA

La machine kepler peut être utilisée pour faire du développement ou pour faire du calcul. Elle est accessible directement par ssh par tous les membres du LRI pour faire des expérimentations sur matériel GPU. Un ingénieur du service soutien au développement logiciel assure les mises à jour des logiciels et des drivers GPU, le développement d'outils de surveillance et d'analyse des performances ainsi que d'outils d'environnement facilitant l'utilisation par des développeurs de communautés variées: HPC, machine learning, bioinformatique... Les outils de monitoring montrent qu'il est très sollicité. Il est adapté à la fois pour faire du développement ainsi que pour lancer des calculs plus importants. Les principaux utilisateurs en 2018 étaient les équipes A&O et ParSys.

Un sondage récent réalisé auprès des membres du laboratoire a montré l'intérêt croissant parmi toutes les équipes du LRI pour ce type de matériel de proximité. Il présente l'avantage d'être très souple d'utilisation avec une expertise locale pour aider à l'utiliser. Une fois les premiers tests de type 'développement' réalisés avec succès, les développeurs peuvent partir à la recherche de plateformes de plus grande envergure (comme le cluster DSP@Saclay ci-dessous).

La generation 'Kepler' étant maintenant largement dépassée par les nouvelles performances de GPU, une étude est en cours pour remplacer ce serveur afin d'investir dans un serveur similaire équipé de la dernière génération de cartes à GPU (Volta).

Le cluster GPU DSP@Saclay

L'objectif du projet DSP@Saclay est d'offrir à la communauté des chercheurs en sciences des données, une plateforme d'exécution à distance d'algorithmes tels que les réseaux de neurones profonds ou les architectures conventionnelles et récurrentes, pour permettre le prototypage rapide de systèmes et l'exploration de nouveaux modèles. Cette plateforme, hébergée à l'IDRIS et administrée par le LIMSI et le LRI, a une action à la fois nationale et locale.

- 5 serveurs GPU Dell PE 730
  - PowerEdge R730/xd Carte mère, MLK
  - 2*Intel Xeon E5-2620 v4 (2,1GHz, 8C/16T, 20Mo de mémoire cache, 8GT/s QPI, 85W, Turbo, HT)
  - 8*16Go RDIMM, 2400MT/s, Dual Rank

  - 2*NVIDIA Tesla K80 GPU
- 2 serveurs de service Dell PE 630
  - PowerEdge R630 Carte mère, MLK
  - 2*Intel Xeon E5-2620 v4 (2,1GHz, 8C/16T, 20Mo de mémoire cache, 8GT/s QPI, 85W, Turbo, HT)
  - 4*8Go RDIMM, 2400MT/s, Single Rank
- 1 baie de stockage Dell Storage MD1400
  - 12*Disque dur Hot Plug 4To NL-SAS 12Gbit/s 512n 7200tr/min 3,5"
- Un switch Dell Networking N4064F
  - 48 ports SFP+ 10GbE
  - 2 ports QSFP+ 40GbE

Cette plateforme est actuellement utilisée à pleine capacité par les chercheurs des laboratoires partenaires. Elle sera étendue au dernier trimestre 2018 avec l'ajout de nouveaux serveurs GPU grâce à un financement de 350 k€ dans le cadre d'un projet SESAME.

Équipement D'excellence Digiscope

Digiscope est un réseau de plateformes pour la visualisation interactive de grandes quantités de données et de calculs complexes. Installées au sein de l'Université Paris-Saclay, les dix salles de Digiscope sont interconnectées par un réseau de téléprésence permettant la collaboration distante. Les applications visées sont la recherche scientifique, la conception industrielle, l'aide à la décision et la formation. **http://www.digiscope.fr/**.

Le responsable scientifique de Digiscope est M. Beaudouin-Lafon membre du LRI, et l'un des deux responsables techniques, C. Fleury, est membre du LRI. Les platformes Digiscome, en particulier celles localisées au LRI sont utilisées quotidiennement par des membres du LRI, et tout particulièrement par les membres de l'équipes HCC.

Trois platformes Digiscope sont présentes dans les locaux du LRI (ou des locaux attenant), et sont directement accessible aux membres du LRI:

- Le mur WILD (LRI). WILD (Wall-sized Interaction with Large Datasets) est un mur d'écrans à ultra-haute-résolution muni d'un système de suivi de mouvements 3D, un tableau interactif et divers dispositifs interactifs (tablettes, souris gyroscopique, Wiimote, etc.). Affichage: 32 (8x4) écrans de 30" Apple Cinema Display, 2560x1980 pixels chacun; Taille : 5m50 x 1m80 (9.9 m2); Résolution: 20480 x 6400 = 131,072,000 pixels; Cluster: 16 ordinateurs, 3.2 GHz quad core Apple Mac Pro avec 2 cartes graphiques Nvidia 8800GT chacun; Suivi de mouvements: Système de suivi de mouvement VICON à 10 caméras (précision .5mm); Audio: Son spatialité avec 7 haut-parleurs, micros d'ambience, micros-cravate et écouteurs pour son 3D; Tableau interactif: un Microsoft Surface Hub de 55 pouces, deux écrans tactiles 4K liyama de 65 pouces avec pied ajustable en hauteur et orientation.

- Le mur WILDER (Inria). WILDER est constitué d'une mosaïque de 75 écrans à bords ultra-fins et d'un cadre multitactile rendant l'ensemble de la surface interactive. Il est complété par un système de suivi de mouvements et un tableau interactif. Affichage: 75 (15x5) dalles PLANAR 20", 960 x 960 pixels chacun, avec bords ultra-fins (espace entre images < 7 mm); Taille: 5m90 x 2m = 11,8m; Résolution: 14 400 x 4 800 = 69 120 000 pixels; Tactile: Cadre multitactile 32 points PQLabs; Cluster: 10 PCs 3.7GHz quad core Intel Xeon PCs aver une carte graphique NVIDIA Quadro K5000 graphics chacun; Suivi de mouvements: Système 3D VICON à 6 caméras; Audio: Son spatialisé avec 8-hauts-parleurs, micros d'ambience, micros-cravate et écouteurs pour son 3D; Tableau interactif: un Microsoft Surface Hub de 55 pouces, deux écrans tactiles 4K liyama de 65 pouces avec pied ajustable en hauteur et orientation;

- Le Fablab Digiscope (mutualisé). Fablab Digiscope est un Laboratoire de Fabrication Numérique de 100 m^2, ouvert à tous les publics et comprenant 15 machines contrôlées numériquement. Découpe laser: Epilog Fusion M2+ 40" (75 watts Laser au CO2 + 30 watts Laser Fibre Optique); Découpe laser: Epilog mini 24" (40 watts); Impression 3D FDM: 2x Ultimaker 2+, 2x Ultimaker 3 (standard et extended); Impression 3D SLA: 2x Form2; Fraisage: Roland Modela MDX40A (fraisage de pcb); Fraisage: Shopbot Desktop 2418 (fraisage 3 axes); Fraisage : NC Pocket (fraisage 5 axes); Découpe vinyl: KNK MAXX Air; Couture/Broderie: Pfaff Creative 3.0; QPCR: Chai Technology; Autre: Banc électronique, Arduini, Raspberry Pi, Atmel, etc.

CodaLab

CodaLab est une plateforme open-source qui fournit un écosystème pour mener des recherches informatiques de manière plus efficace, reproductible et collaborative. Il y a deux aspects de CodaLab: les feuilles de travail et les concours.

Les feuilles de travail vous permettent de capturer des pipelines de recherche complexes de manière reproductible et de créer des "documents exécutables". Utilisez n'importe quel format de données ou langage de programmation - idéal pour les utilisateurs expérimentés!

Les compétitions rassemblent toute la communauté pour s'attaquer aux problèmes de données et de calcul les plus complexes aujourd'hui. Vous pouvez gagner des prix et créer votre propre compétition.

Isabelle Guyon, membre du LRI (équipe A&O) est responsable de cette plateforme. Une instance de Codalab, destinée à l'enseignement, a été installée fin 2016 par le service informatique sur l'infrastructure du LRI. La plateforme principale, actuellement hébergée sur Azure, le cloud Microsoft, sera bientôt déplacée sur une nouvelle infrastructure dédiée mis en place par le service informatique du LRI.

2/ A & O

Learning and Optimization

équipe
Apprentissage & Optimisation

Responsable: Michèle Sebag, Marc Schoenauer

L'équipe Apprentissage & Optimisation (A & O) est une équipe commune LRI, CNRS et INRIA-Saclay fondée en 2004, focalisée sur l'apprentissage statistique et l'optimisation stochastique. Nos activités de recherche sont structurées en cinq groupes (SIGs) ; ces cinq SIGs ne forment pas une partition de A & O et chaque permanent appartient à plusieurs SIGs. Cette organisation nous permet de maintenir le cap global en nous adaptant aux évolutions de la recherche internationale et de nos intérêts scientifiques.

Les deux SIGs **Décision Optimale en Contexte Incertain** et **Optimisation Stochastique Continue** sont les SIGs historiques de A & O, respectivement dédiés à l'apprentissage pour la décision, avec applications aux domaines des jeux et de la gestion de l'énergie, et à l'optimisation boite-noire.

Le SIG **Auto-ML & Challenges** s'intéresse à la sélection et à la calibration automatique d'algorithmes (en apprentissage, mais aussi en optimisation et en satisfaction de contraintes), dans l'objectif du transfert des algorithmes vers les autres disciplines scientifiques et l'industrie. Ce SIG a particulièrement bénéficié de l'arrivée en 2015 d'Isabelle Guyon, sur la Chaire d'Excellence en Big Data et e-Science de l'Université Paris-Saclay (chaire UPSud et INRIA).

Le SIG **Apprentissage Profond et Théorie de l'Information** s'attaque aux défis posés par l'apprentissage de modèles à grande échelle tels les réseaux profonds et examine comment la théorie de l'information permet de répondre aux questions de conception d'architecture neuronale et d'optimisation des paramètres.

Enfin, le SIG **Sciences Sociales Computationnelles** s'intéresse aux questions éthiques liées à la science des données et l'intelligence artificielle ; il s'inscrit dans le cadre de l'Institut de Convergence DataIA et a bénéficié de l'arrivée de Paola Tubaro sur un poste de chargée de recherche CNRS en sociologie dans un laboratoire d'informatique.



Learning and Optimization

Head: Michèle Sebag, Marc Schoenauer

Apprentissage & Optimisation (A & O), a joint research group from LRI, CNRS and INRIA-Saclay created in 2004, aims at the cross-fertilisation of Machine Learning and Optimization. Our research activities are structured along five Special Interest Groups (SIGs): SIGs are not a partition of A & O, and permanent members belong to several SIGs; this organization allows us to preserve our global focus while swiftly adapting to the evolution of the scientific landscape.

The **Optimal Decision Making Under Uncertainty** and **Stochastic Optimization** SIGs, the primary two pillars of A & O, are respectively devoted to Learning and Decision Making with applications to Games and Energy Management, and to Black-Box Optimization.

The **Auto*** **and Challenges** SIG addresses the challenge of delivering algorithms outside the (computer science) research labs (mostly in Machine Learning but also in Black-Box Optimization and Constraint Programming), with the additional perspective of acculturation of scientists from other domains. This SIG particularly benefitted from I. Guyon's arrival as Professor on the Chaire of Excellence in Big Data for e-Science of Université Paris-Saclay (chaire UPSud-INRIA)

In the 2013-2018 period, the **Deep Learning and Information Theory** SIG has emerged to take into account the large scale of Big Data, and investigate approaches to deep neural nets design (architecture and optimization) rooted in Information Theory.

Finally, the **Computational Social Sciences** SIG, within the framework of the DataIA Institut de Convergence and benefitting from P. Tubaro's arrival as CNRS associate researcher in sociology, aims to address the ethical challenges and caveats of New Artificial Intelligence.

Scientific Output

Head of A & O: Michèle Sebag (deputy: Marc Schoenauer)

Members of the group
As of January, 2013, the group had 12 permanent members, 3 university faculty (1 Pr, 2 MC), 3 CNRS researchers (1 DR, 2 CR), 5 INRIA researchers (1 DR, 4 CR), 1 emeritus Pr.

As of June 30, 2018, the group includes 11 permanent members, 4 university faculty (2 PR, 2 MC), 3 CNRS researchers (1 DR, 2 CR), 3 INRIA researchers (1 DR, 2 CR), 1 emeritus Pr.

As writing this report the team also includes 15 Ph.D. students, 2 post-doctoral students and 3 engineers.

Permanent members who left the group
Jamal Atif (MdC) left in September 2014 to join Univ. Paris-Dauphine as Professor; Olivier Teytaud (CR1 INRIA) left in May 2016 to join Google Zurich; Yann Ollivier (CR1 CNRS) left in April 2017 to join Facebook AI Research Paris; Anne Auger (CR1 INRIA) and Nikolaus Hansen (DR2 INRIA) left in January 2017 to found the new INRIA RANDOPT team at Center for Applied Maths, Ecole Polytechnique; Véronique Ventos (MdC) left in May 2018 to co-found start-up Nukkai.

Permanent members who joined the group
Aurélien Decelle, PhD Univ. Orsay (LPTMS), joined in September 2014 as assistant professor; Guillaume Charpiat, CR INRIA Sophia, joined in Jan. 2015; Paola Tubaro, Reader at Univ. of Greenwich (UK), joined in Jan. 2016 as CR1 CNRS; Véronique Ventos, MdC LRI (team LAHDAK), joined in June 2015; Isabelle Guyon, adjunct professor Univ. Berkeley, joined in Jan 2015 as Full Professor, Chaire d'Excellence Big Data Univ. Paris-Sud & INRIA.

Scientific production

1. The general scheme of optimization by natural gradient in distribution spaces was formalized, with the prominent Covariance-Matrix-Adaptation Evolution Strategy black-box continuous optimization algorithm as particular case for Gaussian distributions (11, 37);
2. The HIGGS BOSON MACHINE LEARNING challenge was co-organized by C. Germain and **I. Guyon** (coll. CERN, Imperial College, UPSud, INRIA) on Kaggle, and attracted circa 1700 participants worldwide (2014-2016); a follow-up challenge, Tracking ML, organized by same partners and aimed at tracking the Large Hadron Collider's particle trajectories, is advertised by Nature (May 2018)[1];
3. Several results were obtained in the Deep Learning field: the No-Backtrack algorithm achieves approximate unbiased linear training for recurrent networks; time invariance was used to derive from first principles the long known and complex Long-Short-Term Memory architecture (**?**); a finer-grained batch-based criterion was defined to train Generative Adversarial Networks (62);
4. The research in *Automatic Algorithm Selection and Calibration* yielded 1 honourable prize (2016) and one 1st and 2nd prizes (2017, (72)) in international challenges in SAT and CSP; and the first prize in black-box optimization (2017, (46)).

Quantitative data
- Papers in major international reviews: 41
- Papers in major international conferences: 100
- Books edited: 5
- Book chapters: 12

Major publications

- (11) presents the Information Geometric Optimization framework (Section 2.4.1), a major theoretical result, unifying several known derivative-free optimization algorithms into one framework, and paving the way for more.
- (23) proposes a well-grounded approximate Belief Propagation inference algorithm for the inverse Ising problem in the case of loopy graphs.
- (10) extends Collaborative Filtering to the Algorithm Selection problem (Section 2.4.4), and shows how this approach enables to independently assess the quality of the benchmark data and the quality of the meta-features.

[1] https://www.nature.com/articles/d41586-018-05084-2

- (**?**) introduces the first approach to learn causal models using generative adversarial networks (Section 2.4.5).
- (**?**) and (**?**) are both dealing with the "no-backtrack" approach for training recurrent neural networks (Section 2.4.3).

Major softwares and documents

- The CODALAB Challenge platform, created in 2013 as a joint venture between Microsoft and Stanford University, has been migrated and is now managed at Univ. Paris-Sud. In 2016/2017, 88 new challenges were launched, including the international challenge launched by the SEE.4C European project (2 million Euro prize of the EU): https://codalab.lri.fr/.
- The CARTOLABE platform, funded by INRIA (2015-2017) and CNRS (2018-2020), offers a visual search engine of the scientific landscape automatically built from scientific publications (HAL): https://cartolabe.lri.fr/
- The IO.DATASCIENCE, achieved within the Center for Data Science (Lidex CDS, Univ. Paris-Saclay), hosts public datasets, gathered and shared by Labs in Univ. Paris-Saclay; https://io.datascience-paris-saclay.fr;
- CMA-ES (Covariance Matrix Adaptation-Evolution Strategy), developed by N. Hansen et al. since 2011, is acknowledged a prominent black-box optimization algorithm, used and cited by 100+ papers in sciences and industry;
- The project Amiqap (Lidex ISN, Univ. Paris-Saclay) led to a general audience publication, published by les Presses des Mines: D. Kalainathan, O. Goudet, P. Caillou, P. Tubaro, T. Weil, E. Bourdu, *Portraits de travailleurs: Comprendre la qualité de vie au travail*, Presses des Mines - La Fabrique de l'Industrie, 2017

Visibility and attractivity

- **I. Guyon** was hired (2015) as full Professor on one of the 3 Chaires d'Excellence of the Univ. Paris-Saclay (Big Data for e-Science);
- **I. Guyon** was general chair of the Neural Information Processing Systems conference (2017; 8000 attendees);
- **M. Schoenauer** was elected Chair of the SIGEVO (ACM-Computing);
- C. Villani and **M. Schoenauer** were responsible for the Report *For a Meaningful Artificial Intelligence* (2017-2018);
- **M. Sebag** was elected Chair of the European Steering Committee for Machine Learning and Knowledge Discovery from Databases (2015);
- **M. Sebag** was elected at Académie des Technologies (2017);
- Startup MYNDBLUE became A& O Associate Corporate (2017);
- First prize (2017) at the BBComp Challenge: **N. Belkhim**, J. Dreo, P. Savéant, and **M. Schoenauer** ;
- First prize (2017) at the Algorithm Selection Challenge: **F. Gonard, M. Schoenauer, M. Sebag**;
- Best Paper Awards: Parallel Problem Solving from Nature (PPSN) 2014; Genetic and Evolutionary Computation Conference (GECCO) 2015; runner-up GECCO 2017; Geometric Science of Information 2017;
- Test of time Award: ACM-SIGEVO Impact Award 2018 for Adaptive operator selection with dynamic multi-armed bandits published at GECCO 2008, Alvaro Fialho, Luis Da Costa, **Marc Schoenauer, Michèle Sebag**.

Socio-economic / cultural interactions

- **Y. Ollivier** was coordinator, with IHP, of numerous activitives for the centenary of Claude Shannon, including a public exhibition at the Musee des Arts et Metiers, a cycle of public conferences, a contest for teachers on the best IT class project, and a workshop on the current state of information theory.
- Interview Le Monde, **I. Guyon** (2 pages, 2018);
- Interview Usine Nouvelle, **I. Guyon** (15 gurus of big data, 2017);
- Interview TV France 2, **M. Sebag** (2017);
- **V. Ventos** co-founded the Nukkai start-up in 2018.
- 7 PhD Cifres (PhD grants from industry): Orange (2); Dassault (1); Thalès (3); RTE (1);
- **O. Teytaud** was hired by Google Zurich (May 2016);
- **Y. Ollivier** was hired by Facebook AI Research in Paris (Apr. 2017).

Education

- **I. Guyon** launched the Challenge-based educational activity at University Paris-Sud (Master and Under-grads): Master students prepare challenges for the undergrads.
- Master AIC (Computer Science): **Anne Auger** (12h); M. Sebag (24 h); **O.A Maillard** (6h);
- Centrale Supélec: **G. Charpiat** (34h);
- Ecole des Hautes Etudes en Sciences Sociales: **P. Tubaro** (24h);
- Collège de France: **Y. Ollivier** gave one course in Yann Le Cun' series.

Research Group Members and evolution since 2013

2/ A & O

Research Group Members

Permanent Members (October 1st, 2018)				
Name	*First name*	*Position*	*Institution*	*Remarks*
ATIF	Jamal	MCF	IUT Orsay	until Sept. 14
CAILLOU	Philippe	MCF	IUT Sceaux	
CHARPIAT	Guillaume	CR1	INRIA	joined in Jan. 15
DECELLE	Aurélien	MCF	PARIS SUD	joined in Sept. 14
FURTLEHNER	Cyril	CR1	INRIA	
FONTANA	Laurence	Assistant	INRIA	
FRANOVA	Martha	CR1	CNRS	
GERMAIN	Cécile	PE	PARIS SUD	
GUYON	Isabelle	PR Chaire	PARIS SUD	joined in Jan. 16
MAILLARD	Odalric-Ambrym	CR2	INRIA	joined in Jan. 15; until June 16
OLLIVIER	Yann	CR1	CNRS	until Apr. 17
SPYRATOS	Nicolas	PR émérite	PARIS SUD	
TEYTAUD	Olivier	CR	INRIA	until May 16
TUBARO	Paola	CR1	CNRS	joined in Jan. 16
VENTOS	Véronique	MCF	PARIS SUD	joined in June 15; until Sept. 18

Doctoral Students (October 1st, 2018)				
Name	*First name*	*Position*	*Institution*	*Remarks*
Alami	Reda	CIFRE	Orange	
Bartenlian	Eléonore	MENRT	PARIS SUD	
Blier	Léonard	CIFRE	Facebook	
Berger	Victor	NEXT	PARIS SUD	
Doquet	Guillaume	MENRT	PARIS SUD	
Donon	Balthazar	CIFRE	RTE	
Donnot	Benjamin	CIFRE	RTE	
Estrade	Victor	MENRT	PARIS SUD	
Fissore	Giancarlo	MENRT	PARIS SUD	
Kalainathan	Diviyan	Chaire	PARIS SUD	
Liu	Zhengying	AMX	PARIS SUD	
Makdoud	Nizam	CIFRE	Thalès	
Nabhan	Marc	CIFRE	Renault	
Pol	Adrian		CERN	
Rakotoarison	Herilalaina	NEXT	PARIS SUD	
Sanchez	Théophile	MENRT	PARIS SUD	
Sun	Lisheng	Chaire	PARIS SUD	
Tallec	Corentin	AMX	PARIS SUD	
Wolinski	Corentin	MENRT	PARIS SUD	

Temporary Personnel (October 1st, 2018)				
Name	*First name*	*Position*	*Institution*	*Remarks*
BATU	Berna	Post-doc	INRIA	project NEXT
BOUZBIBA	Yasmina	engineer	INRIA	project TIMCO
BRAME	Etienne	engineer	INRIA	project ADAMME
JAISWAL	Raphael	engineer	INRIA	contract, Renault

Group evolution

- Jamal Atif left in September 2014 to join Univ. Dauphine as professor
- Aurélien Decelle joined in September 2014 as assistant professor;
- Guillaume Charpiat joined in January 2015 as CR1 INRIA;
- Odalric-Ambrym Maillard joined in January 2015 as CR2 INRIA, and left in June 2016 to join INRIA-Lille;
- Véronique Ventos joined in June 2015 (moving from Lahdak LRI) and left in June 2018 to co-found start-up Nukkai;
- Isabelle Guyon joined in Jan. 2016 as Full Professor (Chaire d'Excellence Big Data for e-Science);
- Paola Tubaro joined in Jan. 2016 as CR1 CNRS (sociology);
- Olivier Teytaud left in May 2016 to join Google Zurich;
- Anne AUGER and Nikolaus HANSEN left in January 2017 to found the new INRIA RANDOPT team at Center for Applied Maths, Ecole Polytechnique;
- Yann Ollivier left in April 2017 to join Facebook AI Research Paris;
- An Inria administrative assistant supports the group: Olga Mwana Mobulakani (until May 2017) and Laurence Fontana (since January 2018).

2/ A & O

Research Description

This section details the activities of the five Special Interest Groups forming the joint CNRS-INRIA-LRI Apprentissage & Optimisation team.

Stochastic Optimization

Our strengths in Stochastic Optimization have been maintained and extended, addressing the ever increasing needs for black-box optimization from industry and extending the abilities of the prominent Covariance Matrix Adaptation-Evolution Strategy (CMA-ES) algorithm. Joint efforts have yielded a major theoretical result in developing the Information Geometric Optimization (IGO) framework (11), establishing in particular the well-foundedness of CMA-ES as achieving natural-gradient optimization in the space of Gaussian distributions on the search space. Major results in the 2013-2018 period concern the scalability w.r.t. the dimensionality of the search space (36, 36), the handling of noisy objectives (41, 2, 40, 49, 48), and multi-objective optimization.

CMA-ES and Beyond. Main theoretical contributions regard the linear convergence of Adaptive Stochastic Algorithms, based on studying the stability of Markov chains underlying the algorithms. This framework exploits invariance properties of the algorithms and holds on scaling-invariant functions (3). This framework has been notably applied to analyze one algorithm on a linearly constrained problem where constraints are handled via rejection (5). Additionally, we have investigated augmented Lagrangian approaches to handle constraints and proven sufficient conditions for linear convergence for a (1+1)-ES algorithm (42, 43).
Novel algorithms have been designed for large-scale black-box optimization, breaking the intrinsic quadratic complexity of the powerful CMA-ES while preserving its properties as much as possible. We have been working on scalable variants of CMA-ES, defining and updating a restricted covariance matrix (36, 36).

Benchmarking platforms. The need for benchmarking Black-Box Optimization algorithms is all the more important as the theory has long been lagging behind the practice, notably in industry. Two benchmarking platforms have been proposed, with different sets of functions (large-scale, expensive, constrained, multi-objective), enabling to compare in detail the algorithmic results. The *Comparing Continuous Optimizers* (COCO) platform developed within A & O since end 2007 has been extended to multi-objective optimization and the performance assessment procedure has correspondingly been adapted (47), making use of different indicators. We have organized the first Black-Box Optimization Benchmarking (BBOB) multi-objective workshop at the ACM-GECCO conference. We have also defined a large-scale testbed, based on an original methodology to construct non-trivial but scalable test functions (33).

Noisy Optimization. Some upper bounds on noisy optimization in discrete domains have been obtained (1). Regarding continuous noisy optimization, we applied Sieves methods in noisy optimization (A84), paired optimization (A168), and combining various policies (A152). The notion of *regret*, at the core of the multi-armed bandit literature, can also be used in the framework of optimization algorithms. Experimental results on the noisy sphere function show that the Approximate Simple Regret, currently used in some optimization testbeds, fails to estimate the Simple Regret convergence rate. We proposed the Robust Simple Regret, analyzed different regrets and their rates (41, 2), and proved some lower bounds (40). Along similar lines, (49, 48) obtain fast noisy rates, showing that fast rates (simple regret $O(1/budget)$, with $budget$ the number of iterations) can be achieved for derivative free noisy optimization with comparison-based methods. This work shows in particular that the notions of recommended arm (arm that best approximate the optimum) and most explored arm are distinct: it is necessary to explore far from the current estimate of the optimum to achieve an optimal rate, and noisy optimization testbeds must necessarily be able to distinguish among both. Very practical rules were also derived for reaching simple regret $O(1/\sqrt{budget})$ with existing algorithms (A165), and optimal rates for portfolios of noisy optimization solvers (**?**).

Evolution Strategies offer simplicity and convenience advantages compared to other derivative-free optimization algorithms, at the cost of a slower convergence. We proved another advantage, the resilience when facing useless variables in high dimensions (A153). We also combined ES with cutting plane approaches, getting the best of both worlds, i.e. fast rates from cutting planes and nice parallel speed-up from ES (A171). We showed that the use of quasi-random (instead of pseudo-random) numbers improves evolution strategies, showing that it is beneficial even in simple cases it is beneficial (A240), and yields large improvements in highly multimodal cases (A132). While portfolio methods are usual in combinatorial optimization and some works exist in the continuous case, we developed the first approach in the noisy case (19).

Other Results include:
Multi-objective ATC: Our original formulation using Bayesian Networks for the problem of Air Trafic Control led to a general approach to uncertainty handling in Multi-Objective Evolutionary Algorithms (Gaëtan Marceau's CIFRE PhD at Thalès (110, 63)).
Multi-objective AI Planning: Since the end of the DESCARWIN ANR project in 2013, we proposed some new benchmarks in the ZENOTRAVEL domain together with an exact solver ensuring the knowledge of the true Pareto front (**?**, A222).
Symbolic Backpropagation: The idea of backpropagation was successfully ported to Genetic Programming for Symbolic Regression problems and received the Best Paper Award at ACM-GECO - GP track, 2015 (54).
Anomaly detection: The E-Lucid project with Thalès TERESIS deals with anomaly detection in network trafic. A new approach using a representation based on Voronoi diagrams was proposed (A244, **?**), and led to an original method to handle many-objective problems, where the objectives are gradually introduced (64) (runner-up for the Best Paper Award – GECCO 2017). The collaboration with TERESIS is on-going, though now oriented toward Deep Reinforcement Learning for testing the reliability of system security (Nizam Makdoud CIFRE PhD under Marc Schoenauer's supervision).

Optimal Decision Making Under Uncertainty

The *Optimal Decision Making under Uncertainty* SIG continued the very successful game playing activity launched in the 2008-2013 period, where the MoGo performances at the game of Go were reported even in generalist media. We switched to the game of bridge, thanks to Véronique Ventos' arrival, and won the World Computer-Bridge Championship in 2016 and 2017 (32). This SIG has seen many moves: Odalric-Ambrym Maillard arrived in Jan. 15 and left for INRIA-Lille in Nov. 16; Olivier Teytaud left for Google in Jul. 16; finally, Véronique Ventos left (délégation) to co-found the Nukkai start-up.
Our priviledged links with the domain of energy have been continued, with I. Guyon taking in charge the extensive links with Artelys and RTE (POST and NEXT contracts).

Optimal Decision Making and Bandits Algorithms. The original *Programming by Feedback* paradigm was developed in R. Akrour's PhD (38, 89); the user is sequentially proposed a series of behaviors and is only asked "Hot-or-Cold" questions. This paradigm has initiated a general way to allow non-digitally-proficient users to nevertheless control the behavior of software-based agents (it is well cited in OpenAI paper[2] for instance). The anti-imitation reinforcement learning approach directly learns the value function using rank-based learning (A218, A268, 67), based on counter-demonstrations generated using prior

[2]Paul F. Christiano, Jan Leike, Tom Brown, Miljan Martic, Shane Legg, and Dario Amodei. Deep reinforce- ment learning from human preferences. In Isabelle Guyon et al., editor, Advances in Neural Information Processing Systems 30, pages 4302–4310, 2017

knowledge. Active learning for the identification of biological dynamical systems has been tackled using Multi-Armed Bandit algorithms (58). Weijia Wang's PhD (115) summarizes the work done in TAO regarding Multi-objective Reinforcement Learning with Monte-Carlo Tree Search algorithm.
Concentration inequalities quantify the deviation of a random variable from a fixed value. In (**?**), we first improve on the fundamental result of Serfling (1974), and further extend it to obtain a Bernstein concentration bound for sampling without replacement. We then derive an empirical version of our bound that does not require the variance to be known to the user.

We studied the task of maximizing rewards from recommending items (actions) to users sequentially interacting with a recommender system. The user identity is the only contextual information available to the learner. A low-rank structure is assumed on the matrix of expected rewards. We provide the first rigorous regret analysis for the two-sided uncertainty.

R. Allesiardo's PhD (CIFRE Orange; defended in 2015 (90)) considered a variant of the stochastic multi-armed bandit with K arms where the rewards are generated by a non-stationary stochastic process (15). For both the unique best arm and the general switching best arm settings, we provide sampling complexity and cumulative regret bounds. In a different context, we show that differential evolution can be applied as an alternative to solve non-stationary Bandit problems (A232).

Games. During this evaluation period, and departing from Go, the team mostly worked on games with partial information: Phantom-Go, Bridge, Game of War, Cheat game, Guess Who.
High-dimensional adversarial bandits lead to two main drawbacks: (i) computation time; (ii) highly mixed nature of the results. We proposed a provably consistent approach that focuses on sparse solutions, is faster when the Nash equilibrium is sparse, and provides highly sparse solutions (**?**).
The principle of the seed method is to randomly generate deterministic policies, and select the best ones. This can be applied for games and any control problem where stochastic policies are available. This method works well when nothing else works, in particular when opening moves are critical and difficult, or when there is a lot of hidden information (70, A163). We obtained a computationally faster algorithm using bandits (A228). This approach was also applied to Computer Bridge and boosted Wbridge5, Yves Costel's computer bridge program that won the **World Computer Bridge competition** in 2016 and 2017 (32). It also proved successful for the 10x10 world computer Draughts competition.

Other works on games include theoretical analyses, such as (A162). We proposed a method that dynamically adapts the probability distribution for specific positions (A233), addressing the MCTS scalability limitations and opening many perspectives for further research.

Energy Management. The collaboration with SME Artelys during the evaluation period continued to be very fruitful, with the project POST (2012-2017) about long-term investments in power systems, and the project NEXT (2017-2021) about the optimization of local grids (at the city or region level), both funded by ADEME BIA. The collaboration with RTE addresses the online maintenance of Power Grids.

The project POST has focused on the combination of reinforcement learning tools, offering anytime behavior and asymptotic guarantees, with existing fast approximate algorithms, taking into account non-linearities, often neglected in power systems due to the huge computational cost. We have also studied various error models, e.g. biases due to finite samples or linearization, and proposed corrections thereof.

In the context of Capacity Expansion Planning, we supported the need for rigorous cross-validation (A161) and provided evidence about the overfitting impacts. Basically, many methods (such as simple model predictive control) applied and tested without cross-validation significantly underestimate the value of assets (long distance connection & storage) aimed at reducing the risk. Indeed, special care must be exercized to avoid overfitting when considering investment decisions of hundred million euros. Along this line, we proposed model predictive control with noisy optimization methods for avoiding the above biases (A274, A169), and various methods for improving the noisy optimization part, e.g. in terms of variance, were proposed (A168). The combination between neural networks and traditional model predictive control is theoretically sound (**?**) and provably combines the efficiency of traditional window-based control and the unbiased nature of non-parametric control.

We also proposed meta-learning in this context (A209), combining evolution strategies (specifically Gaussian mutations) and cutting plane methods within a new memetic algorithm (49). Also Vincent Berthier obtained surprising experimental comparative results on some power system optimization problems (A294), and used these problems to extend the well-known continuous optimization benchmarks.

The NEXT project continues the POST project (Victor Berger's PhD; Herilalaina Rakotoarison's PhD, started

Nov. 2017) also in relation with the Auto-∗ & Challeges line of research.

The RTE setting implies modeling hundreds of different network topologies with a simulator that is far too slow; the challenge is to learn a single model for all topologies. Guided Dropout was proposed, using the topology to determine which connections to drop. The first results on a small grid (118 nodes) outperform the classical DC approximation while providing a significant speedup in calculations (A174, **?**).

Several other energy-related works are on-going (A175), including the organization of a large scale challenge funded by the EU, which was endowed with 2 million euros in prizes (Isabelle Guyon co-organizer), in the context of the EU project SEE.4C. The participants are asked to predict the power flow on the entire French territory over several years.

Deep Learning and Information Theory

This SIG serendipitously appeared in 2015, benefitting from G. Charpiat's arrival to work with Y. Ollivier in Jan. 15, and it turned out to be a most fruitful playground for research in the perspective of information theory on the one hand, and statistical physics on the other hand – with A. Decelle's arrival as Research Assistant in Sept. 14. The heavy computational resources notoriously required by deep learning have been made at least partly available, thanks to ADAMME and NEXT contracts. Significant algorithmic results have been obtained, to the extent that Y. Ollivier was offered a position at Facebook Paris and left in June 2017.

An Information Theory perspective. The non-linear lossy compression criterion of Auto-Encoders is formalized using Minimum Description Length (MDL); this criterion can be interpreted in terms of denoising reconstruction, enabling to determine an optimal noise level. Information geometry is used to devise *Riemannian gradient descent*, invariant under affine transformations of the activation functions or shuffling of the inputs. The approach is based on practical and well-grounded approximations for computing the Fisher metric and are valid for any class of statistical models (TIMCO contract, Gaëtan Marceau-Caron's post-doc). The algorithms have been released in Torch (2016), with good empirical performances. Criteria from information geometry are used to guide the construction and selection of network architectures themselves, a major problem given the current trend towards highly complex, hand-built model architectures (P. Wolinski's PhD under Y. Ollivier and G. Charpiat's supervision). The No-Backtrack algorithm achieves the training of recurrent networks in an online manner, by maintaining at each time step a stochastic 1-D search direction in parameter space (C. Tallec's PhD under Y. Ollivier's supervision; (**?**)), providing an unbiased random estimate of the gradient and avoiding the large computational and memory cost of the backpropagation through time. The full convergence proofs for this algorithm (first of their kind) have been obtained in 2016.

Bayesian learning. We prove that, for any exponential family of distributions, arbitrary Bayesian predictors can be approximated by taking the average of the maximum likelihood predictor and the sequential normalized maximum likelihood predictor from information theory, which generalizes Laplace's rule (used to avoid zero probabilities in frequentist learning). This result makes it possible to approximate Bayesian predictors without the cost of integrating or sampling in parameter space (76). Bayesian principles suggest the merit of adding some very specific amount of noise during neural training as a protection against overfitting, following the Langevin dynamics in relation with the Fisher information metric (77) (Best paper award at GSI17). The Bayesian viewpoint can also help select the right size for each layer in a neural network. A comparison to a theoretical model of an infinitely large network suggests ways to adapt learning rates and criteria to select or deselect neurons or even layers (P. Wolinski's PhD).

Computer vision. A learnable computer vision process is designed, motivated by the analysis of high-resolution multispectral satellite images. Convolutional Deep Networks have been used to avoid artifacts from patch-based approaches (75). A staged training process, first considering imprecise ground truth data (available in large amounts), and refining the approach using precise but scarce ground truth data, is proposed in (A13). The output of convolutional networks is polished by training a recurrent neural network to implement the unblurring partial differential equation (PDE). Finally, a new neural architecture is designed to achieve multi-resolution processing and exchange information among the different resolution scales. The algorithm and a benchmark were made public (as there is lack of those in the remote sensing community) (A14).
In relation with the Looking at People (LaP) series of challenges (Section 2.4.4; (**?**, **?**)), we investigated deep-learning methods (A247, A143), showed that deep residual networks can attain state-of-the art performances on these challenges (24, A139, 73, 24), and lend themselves well to identifying which parts of the image is responsible for the final decision (interpretability).

Statistical physics perspective. Markov Random Field (MRF) design is tackled in the Ising model framework, motivated by applications to large scale traffic prediction. The main two issues regard the design of the MRF *per se*, and its use for tractable inference through e.g. belief propagation algorithms. Both issues have been considered together, through inversion of a Gaussian Markov random field subject to topological and spectral constraints, well suited to subsequent use of belief propagation (65, 26, 30) (V. Martin's PhD under C. Furtlehner's co-supervision (112)).
The inverse Ising problem has been considered with respect to approximate inference in the case of loopy graphs (23); in the dynamic case, a new L_0 regularized method based on a maximum likelihood maximization has been proposed (21). The impact of the training data on the MRF learning has been examined (**?**), characterizing the data properties governing the learned static (**?**) or dynamical (20) Ising models.
The average-case analysis of generative model training has been considered in the Restricted Boltzman Machine (RBM) framework (G. Fissore's PhD under A. Decelle and C. Furtlehner's supervision), focusing on the dynamics of the order parameters along the learning trajectory, depending on the learning hyper-parameters. The information contents of an RBM has been characterized from its spectral properties; a phenomenological equation of the learning process was derived by means of the spectral dynamics of the weight matrix (**?**). The learning dynamics has been analyzed in both linear and non-linear regimes, investigating the impact of the input data.

Structures and learning dynamics. Pierre-Yves Massé's PhD (under Y. Ollivier's supervision) obtained the very first rigorous results of convergence for online training of recurrent neural networks, by viewing them from the viewpoint of dynamical systems. C. Tallec showed that the LSTM structure can be derived from first principles in a very simple axiomatic setting, by requiring that the model be invariant under arbitrary time deformationsin the data.
(**?**) has shown that the natural gradient in optimization is mathematically fully identical to the Kalman filter, for all probabilistic machine learning models. The result extends to the non-iid setting (recurrent neural networks).
Applications to genetic data and specifically population genetics require the ability to handle varying size data (e.g. one demographic history instance involves a varying number of individuals and a varying number of genes). New flexible architectures are being investigated, invariant by permutations (Th. Sanchez's PhD under F. Jay and G. Charpiat's supervision; (A112)).

Auto* and Challenges

Auto* is concerned with the automatic delivery of peak performance from algorithm portfolio by selecting and calibrating the algorithm best suited to the problem instance at hand. It is acknowledged a bottleneck for algorithmic transfer in black-box optimization, SAT and CSP, or ML for over 3 decades[3] Being purely experimental, Auto* results are best validated through competitions and challenges, viewed as crowdsourcing, benchmarking, and communication tools.

Online Algorithm Selection and Configuration As said, CMA-ES, invariant w.r.t. affine transformation of the search space and monotonous transformation of the optimization objective, is among the most "parameter-less" algorithms in black-box optimization. An original mechanism achieving the online adaptation of the CMA-ES hyper-parameters that control the covariance matrix adaptation itself was proposed in (60) (Best Paper Award at PPSN'14; Ilya Loshchilov's PhD), maximizing the likelihood of the selected sample at time t to adapt the hyperparameters at time $t-1$. Another original, low-cost strategy for step-size adaptation in SGD has been proposed in P.-Y. Massé's PhD under Yann Ollivier's supervision (defended in 2017), by performing a gradient descent on the step-size itself.

Offline Algorithm Selection and Configuration The most common approach is concerned with offline Auto*. When there exists no appropriate features describing the problem instances, the dominant approach relies on Bayesian optimization a.k.a. sequential model-based optimization, building a surrogate model of algorithm/hyper-parameters performances on the instance at hand and using it to select a new algorithm/hyper-parameter setting [4]. Our first original contribution is to consider the problem as a Collaborative Filtering problem (10), after Stern et al.[5] (M. Misir's ERCIM post-doc). Nacim Belkhir's CIFRE PhD

[3] P. Brazdil, C. Giraud Carrier, C. Soares, and R. Vilalta. Metalearning: Applications to Data Mining. Springer Verlag, 2009.
J. Bergstra, R. Bardenet, Y. Bengio, and B. Kègl. Algorithms for Hyper-Parameter Optimization. In Neural Information Processing Systems (NIPS 2011).

[4] C. Thornton, F. Hutter, H. H. Hoos, and K. Leyton-Brown. Auto-WEKA: Combined selection and hyper- parameter optimization of classification algorithms. In Knowledge Discovery from Databases (KDD-2013), pages 847–855, 2013.

[5] David H. Stern, Horst Samulowitz, Ralf Herbrich, Thore Graepel, Luca Pulina, and Armando Tacchella. Collaborative expert portfolio management. In 24th AAAI Conference on Artificial Intelligence, AAAI 2010. AAAI Press, 2010.

with Thalès (94) was centered on Per Instance Algorithm Configuration (PIAC) in the context of continuous optimization, focusing on the dependency of the PIAC results on the size of the sample on which they are computed. The rationale is that the cost of feature computation must be taken into account when solving a new instance. He demonstrated that PIAC based on very small sample sets (down to 50 times the dimension) can nevertheless help improving the overall results of the optimization procedure (46); this work was awarded as he won the single-objective track of the GECCO 2017 Black Box Competition (BBComp). François Gonard proposed ASAP, an Algorithm Selection algorithm that combines a global pre-scheduler and a per instance algorithm selector, to take advantage of the diversity of the problem instances on one hand and of the algorithms on the other hand. ASAP obtained a *Special Mention* for its originality (and obtained excellent results on half of the problems) at the 2016 ICON challenge (A253) ; and it won the 2017 OASC challenge (72).

Challenges C. Germain and I. Guyon were among the organizers of the Higgs boson Machine Learning challenge (2014-2015; coll. CERN & Imperial College), best ever attended Kaggle challenge[6], that attracted over 1700 participants from physics, computer science, and mathematics, with a large coverage both in the social networks and in the media. Our team thus pioneered the opening of the traditionally very closed High Energy Physics (HEP) community to ML research, which has rapidly expanded (A277, **?**, A105, A226, **?**, **?**) and organized the HEPML workshop at NIPS14[7] to report on the challenge results and methods. The dataset and a software toolkit are available from the CERN Data Portal.[8]

In collaboration with the University of Barcelona, I. Guyon organized the series of Looking at People (LaP) challenges (A178), sponsored by DARPA, NSF, Microsoft, Google, Facebook, NVIDIA, and others. The LaP challenges were organized to achieve gesture recognition (**?**, A133) to detect personality traits from a few seconds of video (first impressions), identify apparent age (A97) and personality trait estimation. We showed that deep residual networks can attain state-of-the art performances on these challenges (24, **?**, 73), and lend themselves well to identifying which parts of the image is responsible for the final decision (interpretability). Other LaP challenges are concerned with Job Candidate Screening Coopetition (A177), in conjunction with IJCNN 2017 workshop on explainability in machine learning, LAP Real Versus Fake Expressed Emotion Challenge (ICCV 2017) (73), Large-scale Continuous Gesture Recognition Challenge (ICCV 2017) (81), and Large-scale Isolated Gesture Recognition Challenge (ICCV 2017).

We also organized two rounds of a completely new recognition on personality trait evaluation from short video clips (A123, A90). The purpose of this study is to evaluate whether human first impression judgments are consistent and reproducible. Such research could lead to device coaching curricula to help job applicants present themselve better and hiring managers to overcome unsubstantiated negative biases. A demonstration was presented at the NIPS 2016 conference.[9] A & O also co-organized local events (hackathons), as "rehearsals" of international competitions in preparation:

- Spatio-temporal time series challenges for the European See.4C challenge about Energy Management (Paris, 14/2/2017, and Toulon, 22/4/2017). Book with Springer in preparation.
- Track ML: tracking particles in high energy physics (Orsay, 21/3/2017) (A142).

The open source Codalab challenge platform, originally designed within Microsoft Research with Isabelle Guyon as one of the PIs, has now been migrated to U. Paris-Sud. This platform supports the organization and management of international academic or industrial challenges in Machine Learning. Part of its development is supported by Isabelle Guyon's Paris-Saclay chaire of Excellence (co-funded by INRIA). Codalab's user base has been steadily growing. At the end of 2017, we now have over 10'000 users. There was a major upgrade of Codalab in 2017, enabling its wide use for challenges for experimental sciences (480 as of 2017, with 145 being public) and as an innovative pedagogical tool with Master students designing challenges for undergrad students.

From challenges in HEP to new questions The experiments at the Large Hadron Collider are at the forefront of Data Science and ML is increasingly integrated in experiment analyses and discovery pipelines. The fact that predictors are typically trained on simulations raises new scientific questions about how to assess scientific discoveries (A138, **?**). Additionally, the interplay of simulations, modelling and observations raises the question of how to best *invert* the generative chain or *replace* it. V. Estrade's PhD (under C. Germain's and I. Guyon's supervision) takes inspiration from the adversarial generative models and domain

[6] **https://www.kaggle.com/c/higgs-boson**
[7] **http://nips.cc/Conferences/2014/Program/event.php?ID=4292**
[8] **http://opendata.cern.ch**
[9] **https://nips.cc/Conferences/2016/Schedule?showEvent=6314**

adaptation literature to close the gap between simulations and real data, by learning representations insensitive to the effects of the "known unknowns" in simulation (A275, **?**).

A follow-up of the Higgs boson challenge is the Tracking Machine Learning challenge (TrackML) (**?**, A283), set up for 2018. Current particle tracking methods do not scale up to the advances of detector apparatus and the associated combinatorial explosion. The LAL and the TAU team have designed the TrackML challenge to renew the physicist processing toolkit and prepare for the next generation of particle detectors (A142); a 100GB dataset has been built by the Atlas and CMS collaborations specifically for this challenge.

The topic of anomaly detection in detectors and triggers, following a previous work on fault management (D. Feng's PhD under C. Germain's supervision (103, A182, 22)) is tackled in A. Pol's PhD (under C. Germain's supervision; coll. CERN).

Computational Social Sciences

The impacts of Artificial Intelligence at large, and Machine Learning in particular, on our lives and societies call for a joint vision of the scientific, technological and sociological questions at the crossroad of Data Sciences and Social Sciences. A joint proposal of Université Paris-Saclay and NewUni, the DataIA Institute of Convergence has been launched in 2017, with the goal of building a pluridisciplinary 10-year research and education programme at the crossroad of machine learning and statistics on the one hand, and social, economic and legal sciences on the other hand.

Social Networks An early collaboration with the **Augure** start-up (2014-2015) aimed at identifying leaders in social media (Modyrum contract, funding Marco Bressan's Post-doc). This joint work on the discovery of influencers from tweets allowed the Augure SME to raise 15 millions euros, as they themselves claimed in the media[10]. The breakthrough is to show that social influence must be viewed as a (weakly) supervised ranking problem; the network structure around influencers in domains such as e.g., high-tech, fashion, politics, is significantly different, suggesting that content-agnostic features are insufficient to uncover true influencers. Note that the same approaches can be applied to leaders in business as well as in politics (invited talk at DGA, Ecole Militaire, Jul. 2017). Note that there was no publication on these results (Augure's model pivoted and their interests changed; data were not public; the topic is in-between knowledge discovery and machine learning and papers should have been submitted to other conferences).

Causality The Amiqap project (funded by the Lidex Institut de la Société Numérique & La Fabrique de l'Industrie; cooperation with the Faculté Jean-Monnet at Univ. Paris-Sud, SES at Telecom Paristech, La Fabrique de l'Industrie) aimed to assess whether there exists a causal relationship between the quality of life at work and the performance of enterprises. In a first phase, the data recorded by the Ministry of Labor (DARES, survey 2013) about the quality of life at work, were exploited to identify workers' profiles with respect to their situations and their perception of their situation. The results were disseminated to a large public by the French-language book (85) (D. Kalainathan's Master, now in PhD). A similar study was conducted for profiling the enterprises based on their economic performances. The next step (D. Kalainathan's PhD, under I. Guyon and M. Sebag's supervision; O. Goudet's postdoc; both being funded by I. Guyon's Chaire of Excellence) tackles the fundamental aspects of learning causal models (collaboration with Facebook Research; (**?**)). The originality is to propose an end-to-end approach to causal modeling (i.e. from the discovery of the causal graph to the structural equation models) based on the optimization of a generative adversarial neural net (code available on GitHub).

Collaborative Filtering and Frictional Unemployment The Collaborative Hiring project (Thomas Schmitt's PhD under P. Caillou, J.P. Nadal from EHESS and M. Sebag's supervision; funded by the Lidex Institut de la Société Numérique) concerns the use of collaborative filtering to recommend job positions to job seekers. Extensive data have been obtained from the Qapa Web interim agency (blue collar job sector) and from the Association Bernard Gregory (PhDs in industry). Among the main lessons learned are the fact that job seekers and recruiters speak different languages; a Siamese network approach has been proposed to define a "translator" between both languages (Th. Schmitt's PhD, defended in 2018; (A128, 80)).

Other Results include: Projects related to nutrition and health: Paola Tubaro worked on the online and face-to-face social networks of persons with eating disorders, the so-called "pro-ana" websites, and how they reveal gaps in the health-care system (**?**, **?**, **?**). An IRS project, Nutriperso, aims at uncovering the relationships between nutrition and health, with focus on the Type-II diabetes. The RESTO project investigates

[10] Cap Digital and BPI France web sites.

the effects of restaurants-booking and rating platforms on both diners' experience and industry's business models (P. Caillou and P. Tubaro). Another research direction, related to the semantic exploitation of archives, was explored by G. Grefenstette (H2020 EHRI-II project on holocaust archives; Personal Semantics project); and C. Germain-Renaud (Gregorius project on church history). The semantic interpretation of the logs of multi-agent behavioral economics models was tackled by P. Caillou ((**?**, A176); coll. IRD). Finally, the Cartolabe project (ADT INRIA) is concerned with the visualization and visual querying of a scientific network, based on their bibliography (HAL; F. Louistisserand's engineer internship, under P. Caillou's supervision).

2/ A & O

Team Organisation

As said, the decision was taken very early, in 2006, to structure our research activities in Special Interest Groups, preserving a shared culture in Machine Learning and Optimization while offering opportunities to discuss in depth some acute scientific issues.

Except for the primary two SIGs devoted to Optimal Decision Making and Stochastic Optimization, other SIGs have been evolving to reflect the arrivals and departures of permanent members, their interests and skills. The SIG creation procedure is light: when someone feels that a new SIG deserves being created, and convince a few other permanent members and students, the SIG is created.

The Apprentissage & Optimisation group has a weekly seminar, mostly with external speakers; the talks are recorded and remain available on our website (protected by a password if needed). Reading groups are organized on a regular basis by students.

The computational resources needed to conduct research in Machine Learning and specifically in Deep Learning are notoriously intensive. Several contracts (POST, NEXT, ADEME; TIMCO, ADAMME FUI) have been instrumental in allowing us to have a GPU cluster and to acquire know-how, thanks to tutorials organized by the most knowledgeable students for all team members. All in all, we now have a productive and most appreciated environment.

Significant attention is paid to team building activities; permanent members organize a joint lunch at least once a trimester, to informally share their thoughts and priorities.

2/ A & O

Self Assessment

Strengths: Stochastic Optimization: the A & O members are now recognized in the more traditional Applied Maths community at large (e.g., publication in SIAM Optimization (3) and invited talk at the Derivative-free and Simulation-based Optimization cluster of the 2016 ICCOPT Conference, Japan).
Decision Making: Our activities in the domain of games have been very visible in this period again (winning the World Computer Bridge competition in 2016 and 2017); the long established links with main actors in the domain of Energy enable us to participate in large-scale scientific and industrial proposals, gaining access to data and addressing advanced demands.
Deep Learning is among the most powerful and strategic approaches of the moment in ML, attracting many excellent students and acute industrial attention. The strong A & O expertise, supported by a rigorous technical know-how and good computational resources, relies on first principles approaches (information geometry on the one hand and statistical physics on the other hand).
Auto*& Challenges: A & O has an international expertise in the organization of challenges: I. Guyon used to organize international challenges for over a decade; The Microsoft Codalab challenge platform was migrated at Univ. Paris-Sud by I. Guyon. C. Germain and I. Guyon, after the Higgs boson challenge (2014-2016), will launch the Track ML challenge (coll. CERN).
Computational Social Sciences: Our research goals are aligned with those of DataIA, one among the 10 French Institutes of Convergence launched in 2017; incidentally, we actively participated in the DataIA proposal.

Weaknesses: The departure of Anne Auger and Nikolaus Hansen to found a new team at CMAP certainly decreases our visibility in the domain of black-box optimization. Nevertheless the links remain strong and the cooperation centered on the integration of ML within CMA-ES is still alive. The departure of Yann Ollivier and Olivier Teytaud, now both at Facebook AI Research in Paris also weakened our group, though they keep a strong link with our team through one Cifre contract and co-supervised students.

Opportunities: The Villani report on AI spells out some requirements for an AI endowed with a sense of *common decency*, which are well aligned with our research priorities. The industrial demand for Deep Learning expertise also offers a favorable context to select the most interesting applications to participate in, only subject to our supervision capacities.
Algorithm Selection and Configuration (Auto*) has been identified a key issue in both ML (see footnotes 2 and 3), all the more so as both the complexity of ML/Optimization toolboxes and the shortage of data scientists increase. A follow-up of the most visible Higgs boson challenge, the Track-ML challenge (coll. CERN) is launched and advertised on Nature[11]. A challenge on Auto-Deep Learning, aimed at the automatic neural architecture design in Deep Learning, will be launched by I. Guyon in collaboration with Google Zurich in 2018.

Threats: The difficulties of recruiting and keeping excellent researchers in the domain of Machine Learning due to the GAFAM pressure, acknowledged by all French academic institutions, have also been witnessed in our group. The recruitment of good PhD students or post-docs also raises difficulties. In 2015, two PhD students left after one year and joined some private companies. This had clearly a negative impact on some research topics. The recruitement of engineers also suffers from monetary and administrative constraints; we ask for relaxing one or the other type of constraints. Last but not least, the efforts needed to create the Univ. Paris-Saclay exert a heavy toll on the seniors' time and scientific production.

2/ A & O

Strategy and five-year project

As said, A & O was launched in 2004 as a joint CNRS-LRI and INRIA team. This INRIA team ended up in Dec. 2016 to give rise to two INRIA teams: RANDOPT, that continues and extends A & O expertise in Evolutionary Computation around Anne Auger and Nikolaus Hansen (at Ecole Polytechnique, Center of Applied Maths, since Jan. 2017), and TAU, involving all other members of A & O. The A & O-TAU team thus continues as a joint CNRS-LRI and INRIA team, with the goal of *TAckling the Under-specified* challenges at the core of the Fair Artificial Intelligence (FAI) trend.

FAI is a mixture of disciplines, technologies and resources, which has already modified the fabric of our lives, the ways we travel, maintain and establish our social links. Its impacts on the fabric of our society (our values, the economy and the jobs, and eventually the politics) are underway. While the Machine Learning and Optimization (ML & O) disciplines are at the forefront of the FAI wave, they are by no way the only ones, neither should they be the dominant ones: the FAI revolution spells out that new scientific principles are required to account for the fact that the algorithms we do today will set up laws for the majority of the people at the end of the day, and that these laws are not voted[12].

Overall, the FAI disruptivity is present-day commonplace, with its ability to bring in a Brave New World in all positive and negative dimensions. How to face all bright and dystopic consequences of Machine Learning and Optimization is the scientific question at the core of the A & O five-year project, and also at the core of the DataIA Paris-Saclay Institute of Convergence, created in 2017. This high-level scientifc question is declined below along four fundamental issues, to be confronted to, and validated on, three application fields.

FAI **input**. The credo of the Big Data era is that (sufficiently) big data can to some extent compensate for virtually anything. After C. Anderson (2008), *the data deluge made the scientific method obsolete*. There are severe obstacles to this questionable claim. Firstly, the data about the thing is not the thing; it is filtered by the sensors and reflect the priorities of the data acquisition designers at that time. Secondly, and especially in value-sensitive domains (e.g., security, hiring), data reflect human practices; we certainly do

[11] https://www.nature.com/articles/d41586-018-05084-2
[12] Weapons of Math Destruction, C. O'Neill, 2016

not want to perpetuate their biases and prejudices through the models learned from these data. In most cases, the data are biased in unknown and potentially bad ways. Some cover for the bias impacts must be offered, leading to redefine the statistical learning criteria[13]. Thirdly, more data cannot be the unique answer to all problems, unless we want to be dwarfed forever by the GAFAM. In order to train data-hungry models we thus need to tackle data augmentation in a principled way and identify the operators of invariance in the application domains.

FAI **output**. A FAI system is not expected to be "finished" at some point, in contrast with the software produced along the mainstream computer science methodology. It is embedded in a – generally non-stationary – environment, and its lifelong learning is required to deal with open environments and users with diverse profiles. While users learn about the system and their requirements evolve, the system must accordingly adapt to, and anticipate, the evolution of the users/environment. A FAI system thus is a dynamic process, whose behavior will depend in a cumulative way upon its interactions and environments. The question regards the control of a lifelong learning system from a performance and robustness viewpoint. The system must thus monitor itself and characterize its behavioral changes.

Harnessing FAI. Besides the matters of instantaneous and lifelong performance, FAI researchers must consider the social acceptability and the control of a lifelong learning system from an ethical viewpoint, and the feedback loops made possible by FAI systems (e.g. regarding the use of predictive systems for police or justice). As said, there is little doubt that Big Data can pave the way for Big Brother; the social contract can be ruined through modeling benefits and costs at the individual level, e.g. when designing insurance policies. *Fair, Accountable and Transparent* AI raises a mixture of ethical, legal and technical questions. Undesirable behaviors can be defined and castigated by law; but unless some measurable and objective evidence can be provided (about the fact that an undesirable behavior has actually taken place), such laws can hardly be enforced. Tight interdisciplinary research at the crossroad of sociology, philosophy, law, economy, ML&O, thus is required to seamlessly define i) what we don't want to take place now, or at some point in the future; ii) how this can be characterized in legal terms; iii) how some characterization thereof can be assessed along a computational objective procedure, based on sound principles. Note that the problem is taken one level higher if we consider not an individual AI, but an ensemble of AIs.

Unleashing FAI. Already at the core of TAO, a last question concerns the transfer of the algorithms outside the research labs, toward other sciences, industry, or citizens. The transfer is tackled at the meta-learning level of algorithm selection and calibration called META-$*$. Specifically, META-$*$ addresses the choice of the algorithm and the optimization of the hyper-parameters of the chosen algorithm, needed to achieve peak performances from some algorithm portfolio (e.g. Scikit-learn) on the problem at hand. An instance of META-$*$ problem concerns the choice of the neural architecture most appropriate to a classification problem, depending on the dataset. A main difficulty for META-$*$ in Machine Learning is the lack of appropriate meta-features to describe a dataset (as opposed e.g. to the meta-features designed in the field of Satisfiability and Constraint Satisfaction). For these reasons, the current dominant approaches (footnotes 2 and 3) are based on sequential model-based optimisation, a.k.a. Bayesian Optimization. Still, the design of predictive meta-features amounts to better understanding the landscape of ML & O problems, and the competence map of the diverse algorithms developed so far. Most interestingly, current approaches in architecture design rely on structured stochastic optimization[14], at the core of A & O expertise.

The above questions will be investigated along four *Special Interest Groups* (SIGs):

- The Input and Structure (I&S) group is concerned with how to take into account the structure of the input data (if known), how to discover them (otherwise) with the grail of being able to achieve data augmentation and learn from few data. PhD Th. Sanchez; M. Nabhan (Cifre Renault); new PhD on JOBAGILE (FUI, coll. EHESS and SMEs Qapa and Dataiku).
- The Learning Criteria (LC) group is concerned with designing criteria and procedures to assess data (e.g., the presence of biases) and models (fair models, robustness w.r.t. adversarial examples). PhDs D. Kalainathan, V. Estrade, A. Pol (CERN), V. Berger (NEXT), M. Nabban (Cifre Renault), N. Makdoud (Cifre Thalès).
- The Information Theory and Statistical Physics (IT&SP) group is concerned with characterizing *a priori*

[13] See e.g. Fairness Without Demographics in Repeated Loss Minimization, T. Hashimoto, M. Srivastava, H. Namkoong, P. Liang ; Int. Conf. on Machine Learning, PMLR 80:1934-1943, 2018.

[14] Understanding and Simplifying One-Shot Architecture Search. G. Bender, P.-J. Kindermans, B. Zoph, V. Vasudevan, Q. Le; Int. Conf. on Machine Learning, PMLR 80:549-558, 2018.

the feasibility regions for learning, and examining the compatibility of learning architectures in terms of formal properties. PhDs C. Tallec, G. Fissore, L. Blier (Cifre Facebook, starting Sep. 2018).

- The META-∗ group, continuing the current META-∗ SIG, is concerned with meta-learning and optimization. PhDs: G. Doquet; L. Sun; Z. Liu; H. Rakotoarison (NEXT); P. Wolinski.

The first two SIGs will establish a strong scientific cooperation with the Galac LRI team, forming an *Algorithmic Intelligence* pole at the core of the future Univ. Paris-Saclay AI Institute.
These SIGs will take inspiration and find their validation in three main application domains, in which we already have some expertise, and on-going collaborations:

- Energy management: Artelys (NEXT), PhDs V. Berger, H. Rakotoarison, Post-doc Berna Batu; RTE, PhDs Benjamin Donnot, B. Donon (new RTE Cifre, starting Sept. 2018).
- Computational social sciences and economics: VADORE (Dataia, coll. ENSAE);NUTRIPERSO (IRS, coll. INRA, INSERM, AgroParisTech); AMIQAP, PhD D. Kalainathan (coll. Ministry of Labor, La Fabrique de l'Industrie, TelecomParisTech).
- Data-driven design: CERN, PhD V. Estrade, A.Pol; Renault, PhD Marc Nabhan; engineer R. Jaiswal; Thalès TERESIS, PhD N. Makdoud; Bio-Info, PhD Th. Sanchez.

2/ A & O

Annex 4

Collaborations

Participation to national and international collaborative research projects

International projects

EGI-Inspire FP7, e-Infrastructure (CP-CSA)
Objectif: Integrated Sustainable Pan-European Infrastructure for Researchers in Europe Duration: May 2010 - April 2014
Coordinator: EGI.eu foundation Partner: Université Paris XI (France) Inria contact: Cécile Germain-Renaud Abstract: To support European science and innovation, a longer lasting operational model is now needed – both for coordinating the infrastructure itself and for delivering integrated services that cross national borders.The EGI-InSPIRE project will support the transition from a project-based system to a sustainable pan-European infrastructure.

CitInES FP7, ICT for a low carbon economy (STREP)
Objectif: ICT systems for energy efficiency Duration: October 2011 - March 2014
Coordinator: Artelys Partners: Artelys (SME, France), Inria (Tao), AIT (Austria), Tupras (4 refineries, Turkey), Cesena (City, Italy), Ervet (Italy), Inesc-Porto (Portugal), Armines (France), Bologna (City, Italy) Inria contact: Olivier Teytaud Abstract: Design of a decision support tool for sustainable, reliable and cost-effective energy strategies in cities and industrial complexes

EHRI-II 2015-2019 (7 969 k€). European Holcaust Research Infrastructure, H2020, Coordinator NIOD, Amsterdam. Digital Humanities.
Participants: Gregory Grefenstette

See.4C 2016-2017 (700 k€). SpatiotEmporal ForEcasting : Coopetition to meet Current Crossmodal Challenges
Coordinator: Fraunshofer München
Participants: Isabelle Guyon
web site: **http://www.fabiodisconzi.com/open-h2020/projects/199868/index.html#**

National projects

SIMINOLE - 2010-2014 (250 k€). Large-scale simulation-based probabilistic inference, optimization, and discriminative learning with applications in experimental physics, ANR project, Coordinator B. Kégl (CNRS LAL).
Participants: : Balázs Kégl, Nikolaus Hansen, Emmanuel Benazera, Michèle Sebag, Cécile Germain-Renaud

TIMCO (Technology for In Memory Computing applications) FUI Project – 2012-2015 (432 k€)
Coordinator: Bull SA
Participants: Cécile GERMAIN (WP Algorithm adaptation: the paradigm shif coordinator)

LOGIMA – 2012-2016 (136 k€). Logics, structural representations, mathematical morphology and uncertainty for semantic interpretation of images and videos, ANR project, Coordinator Céline Hudelot, MAS-ECP. Other partners: TAO , LTCI-Telecom ParisTech Local
Coordinator: Jamal Atif

NUMBBO – 2012-2017 (290 k€). Analysis, Improvement and Evaluation of Numerical Blackbox Optimizers, ANR project,

Coordinator Anne Auger, Inria. Other partners: Dolphin, Inria Lille, Ecole des Mines de Saint-Etienne, TU Dortmund
Participants: : Anne Auger, Nikolaus Hansen, Marc Schoenauer, Ouassim Ait ElHara

MAJORE A Collaborative Filtering Approach to Matching Job Openings and Job Seekers, 2013-2016 (105 k€) Thomas Schmitt's PhD (funded by ISN).
Participants: : Philippe Caillou, Michèle Sebag, Thomas Schmitt (PhD)

ROM Model Reduction and Multiphysics Optimization 2014-2016 (50 K€)
Coordinator: IRT System X
Participants: Marc Schoenauer, Michèle Sebag, François Gonard (PhD)

E-LUCID 2014-2017 (194 k€)
Coordinator: Thales Communications & Security S.A.S
Participants: : Marc Schoenauer, Cyril Furtlehner, Luis Marti

POST ADEME 2012-2017 (1,220 M€, including 500 k€for a 'private' cluster). Platform for the optimization and simulation of trans-continental grids
Coordinator: ARTELYS
Participants: Olivier Teytaud, Marc Schoenauer, Marie-Liesse Cauwet, Jérémie Decock, Sandra Cecilia Astete Morales, David L. Saint-Pierre, J. Decock

ACTEUR – 2014-2018 (236 k€). Cognitive agent development for urban simulations, ANR project, Coordinator P. Taillandier (IDEES, Univ Rouen).
Participants: : Philippe Caillou

ReMODeL Rewarded Multimodal Online Deep Learning 2015-2016 (31,5 k€)
Participants: Michèle Sebag, Mathieu Lefort, Alexander Gepperth

AMIQAP 2015-2017 (50 k€, 12 months of Postdoc). Project funded by ISN Partners: Mines-Telecom SES, RITM (Univ. Paris Sud) and La Fabrique de l'Industrie. Extended for 6 months in 2018 via a donation from La Fabrique de l'Industrie (30k€)
Participants: Philippe Caillou, Olivier Goudet, Isabelle Guyon, Michèle Sebag, Paola Tubaro, Diviyan Kalainathan (2016 intern, 2017 PhD)

CNES contract 2015-2017 (70 k€)
Coordinator: Manuel Grizonnet (CNES) and Yuliya Tarabalka (Inria Sophia-Antipolis, Titane team)
Participants: Guillaume Charpiat

PIA ADAMME 2015-2018 (258 k€)
Coordinator: Bull SAS
Participants: : Marc Schoenauer, Yann Ollivier, Gaetan Marceau Caron, Guillaume Charpiat, Cécile Germain-Renaud, Michèle Sebag

NUMBBER 2016-2018 (PGMO, 60 k€)
Coordinator: FMJH (Fondation mathématiques Jacques Hadamard - Paris Saclay)
Participants: Anne Auger, Nikolaus Hansen

BRAINTIME 2017 (7 k€) Défi exploratoire interdisciplinaire de l'appel INFINITE (CNRS) concerning the functional connectome dynamics of the brain.
Coordinator: Andrea Brovelli (CNRS), Institut de Neurosciences de la Timone (INT)
Participants: Aurélien Decelle, Cyril Furtlehner

Nutriperso 2017-2018, 37 k€. Personalized recommendations toward healthier eating practices. U. Paris-Saclay IRS (Initiative de Recherche Stratégique)
Partners: INRA (coordinator), INSERM, Agro Paristech, Mines Telecom
Participants: Philippe Caillou, Flora Jay, Michèle Sebag, Paola Tubaro

EPITOME 2017-2020 (225k€). Efficient rePresentatIon TO structure large-scale satellite iMagEs,
Coordinator: Yuliya Tarabalka (Titane team, Inria Sophia-Antipolis)
Participant: Guillaume Charpiat

NEXT 2017-2021 (675 k€). Simulation, calibration, and optimization of regional or urban power grids ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie)
Coordinator: ARTELYS
Participants: Isabelle Guyon, Marc Schoenauer, Michèle Sebag, Victor Berger (PhD), Herilalaina Rakotoarison (PhD), Berna Bakir Batu (Post-doc)

International collaborations

INDEMA Intelligent Decision Making Mechanisms with Hidden Information, and Application to Electricity Generation.
International Partner: NUTN (TAIWAN)
Duration: 2012 - 2014
See also: http://www.lri.fr/ teytaud/indema.html
The objective of the project is three-fold:
Objective 1: Designing anytime consistent iterative realistic algorithms for partially observable 1-player or 2-player games. Consistent algorithms (provably, asymptotically optimal in the computation time).
Objective 2: Apply them to impressive visible applications, e.g. applications in games or puzzles, such as Minesweeper, Chinese Dark Chess, Kriegspiel, Phantom-Go, or card games. Games and puzzles offer nice frameworks to assess and make our research highly visible.
Objective 3: Work on a real-size industrial applications the field of energy generation: i) it is close from our expertise

(thus reducing the warm-up time), yet with the new challenge of partial observability; ii) in real applications, many problems are simplified so that they boil down to fully observable problems; iii) we already have contact with industry.

CIADM Computational intelligence and Decision making
International Partner: NUTN (Taiwan) - Multimedia Informatics Lab - Chang-Shing Lee
Duration: 2015-2017
See also: http://www.lri.fr/ teytaud/indema.html
The associate team works on computational intelligence for decision making, with different application fields for the various partners: - power systems (Tao) - eLearning (Oase) - games (Ailab)

S3-BBO Threefold Scalability in Any-objective Black-Box Optimization
International Partner: Shinshu (Japan) - Tanaka-Hernan-Akimoto Laboratory - Hernan Aguirre
Duration: 2015-2017
See also: http://francejapan.gforge.inria.fr/doku.php?id=associateteam
This associate team brings together researchers from the TAO and Dolphin Inria teams with researchers from Shinshu university in Japan.The common interest is on black-box single and multi-objective optimization with complementary expertises ranging from theoretical and fundamental aspects over algorithm design to solving industrial applications. The work that we want to pursue in the context of the associate team is focused on black-box optimization of problems with a large number of decision variables and one or several functions to evaluate solutions, employing distributed and parallel computing resources. The objective is to theoretically derive, analyze, design, and develop scalable black-box stochastic algorithms including evolutionary algorithms for large-scale optimization considering three different axes of scalability: (i) decision space, (ii) objective space, and (iii) availability of distributed and parallel computing resources.

MDG-TAO Data-driven simulations for Space Weather predictions International Partner (Institution - Laboratory - Researcher): CWI (Netherlands) - Multiscale Dynamics Group - Enrico Camporeale Team TAU Start year : 2017 See also: https://www.cwi.nl/research-groups/Multiscale-Dynamics We propose an innovative approach to Space Weather modeling: the synergetic use of state-of-the-art simulations with Machine Learning and Data Assimilation techniques, in order to adjust for errors due to non-modeled physical processes, and parameter uncertainties. We envision a truly multidisciplinary collaboration between experts in Computational Science and Data assimilation techniques on one side (CWI), and experts in Machine Learning and Data Mining on the other (Inria).

National collaborations

Cartolabe
Contact: Philippe Caillou
Duration: Jan 2016 – Jan 2018
URL: http://cartolabe.lri.fr/
The goal of Cartolabe is to build a visual map representing the scientific activity of an institution/university/domain from published articles and reports (authors and full text of the articles). Using the HAL Database and building upon the AnHALytics processing chain, Cartolabe provides the user with a query-able map of the thematics, authors and articles. It has been developed in collaboration with the AVIZ Inria team, at the crossroad of machine learning (dimensionality reduction, topic identification, clustering) and data analytics (visualization and navigation).

Visiting professors and students (more than one week)

- Daria La Rocca (PhD Univ. from Roma Tre, Oct 2013-Sept 2014)
- Luigi Malago (Univ. Shinshu, Japan, from Sep 2014 until Sep 2015)
- Aditya Gopalan (Indian Institute of Science, Bengalore, Apr 2015 - May 2015)
- Youhei Akimoto (Univ. Tsukuba, Japan, Aug - Sep 2015)
- Chaouki Boufenar (PhD Student from Univ. Oran, Algerie, Sep 2015 - Aug 2016)
- Dimitri Klimenko (PhD Student from Univ. Queensland, Australia, Nov - Dec 2015)
- Audrey Durand (PhD from Univ.Laval, Sep-Nov 2015)
- Holger Hoos (Pr. Univ. British Columbia, Oct 2014 - March 2015)

Other Collaborations

Dortmund University (Günter Rudolph), through the ANR project *NumBBO* (Anne Auger, Nikolaus Hansen).

University of Adelaide (Frank Neumann), within the ARC-DP (Australian Research Council Discovery Project) *Bio-inspired computing methods for dynamically changing environments*, 5 years, started 2016, 400 k$-AUS (Marc Schoenauer).

UC Berkeley (Alyosha Efros, Bernhard Boser), *Fingerprint verification with deep siamese neural networks using ultratonic sensor data*. Isabelle Guyon, co-advisor of a master student (Baiyu Chen) in 2017.

Indo-French Center of Applied Mathematics at IISc Bangalore (India) - ECE (Aditya Gopalan). *Contextual multi-armed bandits with hidden structure*, Odalric-Ambrym Maillard, April 2016–April 2017.
Recent advances in Multi-Armed Bandit (MAB) theory have yielded key insights into, and driven the design of applications in, sequential decision making in stochastic dynamical systems. Notable among these are recommender

systems, which have benefited greatly from the study of contextual MABs incorporating user-specific information (the context) into the decision problem from a rigorous theoretical standpoint. In the proposed initiative, the key features of (a) sequential interaction between a learner and the users, and (b) a relatively small number of interactions per user with the system, motivate the goal of efficiently exploiting the underlying collective structure of users. The state-of-the-art lacks a wellgrounded strategy with provably near-optimal guarantees for general, low-rank user structure. Combining expertise in the foundations of MAB theory together with recent advances in spectral methods and low-rank matrix completion, we target the first provably near-optimal sequential low-rank MAB.

PROMO - PROjected MOnte Carlo (PEPS INS2I), Odalric-ambrym Maillard, Remi Bardenet (CNRS, CRIStAL, UMR 9189), May-December 2015.
Application of Bayesian statistics to large amount of data is limited due to methodological locks. The goal of this project is to avance the applicability of thes methods to massive data. In order to achieve this goal, the project suggests to study the combination of concentration of measure and random projections together with Monte Carlo techniques, to see what theoretical guarantees can be obtained for novel variants of these technique in the case of large dimension and tall data. See also (**?**).

Group seminar

A & O weekly seminars are recorded (some are protected): https://tao.lri.fr/tiki-index.php?page=Seminars Some seminars are joint seminars with the Working Group Deep Learning of the Labex DigiCosme.[15]

Participation to national and international networks

- ACM-SIGEVO, Executive Board
- ECML-PKDD, Steering committee
- Univ. Paris-Saclay: Labex DigiCosme; Lidex *Center for Data Science*; Lidex *Institut de la Société Numérique*; Initiative de Recherche Stratégique (IRS) *Nutriperso*;
- Société Savante Francophone d'Apprentissage Machine;
- Journées Evolutionnaires Trimestrielles (JET).

Volunteer Professional Service

Management Positions in Scientific Organisations

- **Anne Auger** ACM-SIGEVO, member of Executive Board (2011-); THRaSH 2014, Theory of Randomized Search Heuristics, member of Steering Committee;
- **Isabelle Guyon** President and co-founder of ChaLearn, a non-for-profit organization dedicated to the organization of challenges;
- **Marc Schoenauer** ACM-SIGEVO, member of Executive Board (2000-), Secretary (2011-2014), **Chair** (2015-); PPSN, Steering Committee (1998-); LION (Learning and Intelligent OptimizatioN), member of the Steering Committee (2012-); Honorary Adjunct Professor, School of Computer Science, University of Adelaide, Australia (2009-2015); founding President of SPECIES (Society for the Promotion of Evolutionary Computation In Europe and Surroundings) (2015-);
- **Michèle Sebag EurAI Fellow** (2011); European Machine Learning and Knowledge Discovery from Databases Steering Committee (2010-2016, Chair since 2016);
- **Paola Tubaro** convenor of the Social Network Analysis Group of British Sociological Association (since 2013); co-founder, European Network on Digital Labor (since 2017); member of programme committee of Institut de Convergence DataIA (since 2017);
- **Marc Schoenauer** founding president, Association Evolution Artificielle, now member of the Advisory Committee;
- **Michèle Sebag** member of the CoNRS; Senior Advisory Board CHIST-ERA (2014-2017); member of the CSFRS (Conseil Supérieur de la Formation et Recherche Stratégique); member of the scientific council of Labex AMIES (Applications des Mathématiques et leurs Interfaces dans l'Entreprise et la Société)
- **Anne Auger** Conseil du Laboratoire de Recherche en Informatique (2012-2016);
- **Jamal Atif** Directeur d'études at Computer Science department of IUT d'Orsay ; membre de la CCSU 27 (membre du Bureau) since 2012; membre élu au conseil d'Institut, IUT d'Orsay ; membre du Bureau du département Informatique de l'IUT d'Orsay since 2011;
- **Philippe Caillou** Elected member, Conseil Scientifique, Conseil Académique de l'Université (2013-); directeur des études à l'IUT de Sceaux (2009-);
- **Cécile Germain** Université Paris-Sud: Board of Scientific Council (elected), Officer for Scientific Computing, Deputy head, Computer Science department, in charge of research; Université Paris-Saclay: Board of the Lidex *Center for Data Science* (2016-);
- **Marc Schoenauer** Délégué Scientifique (VP for Research), INRIA Saclay branch (2009-2016); Member of the Executive committee and chair of the Research Committee, DigiCosme Labex (2012-2015); co-chair (with Sylvain Arlot) of the Maths-STIC program of the *Labex of Mathematics Hadamard (LMH)*.

[15] https://digicosme.lri.fr/GT+Reseaux+profonds

- **Michèle Sebag** deputy director of LRI, CNRS UMR 8623 (2015-); member of Conseil du Laboratoire de Recherche en Informatique and CCSU 27 (2004-); member of Scientific Council of INS2I CNRS (2010-2014); member of Academic Council of Université Paris-Saclay; Board of University Paris-Saclay STIC department; Board of DigiCosme Labex; Board of the Lidexes *Institut de la Société Numérique* and *Center for Data Science* (2014-2016); head of Research Programme, Institut de Convergence DataIA (2017);

Organisation of Conferences and Scientific Events

- **Anne Auger** Organizer, invited mini-symposium on Function-Value-Free Optimization, SIAM Conference on Optimization 2014; Women@GECCO workshop GECCO 2014; co-organizer, BBOB workshops, IEEE Conference on Evolutionary Computation 2015 and GECCO 2015, 2016;
- **Guillaume Charpiat** Workshop Statistics/Learning at Paris-Saclay (2017 and 2018);
- **Cécile Germain** HEPML workshop at NIPS 2014; DataScience@LHCWorkshop 2015, CERN; DataScience@HEP 2016 and 2017; Hammers and Nails Weizmann Workshop 2017;
- **Isabelle Guyon** Program Chair, NIPS 2016; General Chair, NIPS 2017; NIPS 2016 workshops (*Challenges in Machine Learning* and *Spatiotemporal time series*); ICML *AutoML* workshops (2016 and 2017); *LAP challenge* workshops at ECCV and ICPR (2016 and 2017); BayLearn 2017 workshop;
- **Nikolaus Hansen** co-organizer, Dagstuhl seminar on Theory of Evolutionary Algorithms 2015, BBOB workshops, IEEE Conference on Evolutionary Computation 2015 and GECCO 2015, 2016;
- **Michèle Sebag** Senior Program Committee, ECAI 2014; Area Chair, IJCAI 2015, 2017, NIPS 2017, NIPS 2018; co-organizer, Dagstuhl seminar on "Constraints, Optimization and Data" (14411), 2014.
- **Paola Tubaro** Co-organizer, Second European Social Networks conference (EUSN 2016); Organizer, Recent Ethical Challenges in Social Network Analysis (RECSNA 2017); Co-organizer, 'Paris Seminar on the Analysis of Social Processes and Structures (SPS)' (2017-18); Member of Scientific Committee, Junior Data Science and Engineering Conference Paris-Saclay (JDSE 2018); Organizer, satellite meeting 'More than complex: large and rich network structures' at NetSci18 Conference (2018).

Honors

Awards

- **G. Grefenstette** : INRIASAC Winner, Taxonomy Induction task, SemEval 2015 (A192).
- **N. Belkhir**, J. Dréo, P. Savéant and **M. Schoenauer**: (AS-AC-CMA-ES) Winner, single objective track, **BBComp**, the Black Box Competition for continuous optimization at ACM-GECCO 2017. (see Appendix A in Nacim's PhD dissertation (94)).
- **F. Gonard, M. Schoenauer, and M. Sebag**: (ASAP V2 and V3) Winner and second place at the Open Algorithm Selection Challenge 2017, The official results; (A191).

Best Paper Awards

PPSN XIII, 2014 *Maximum Likelihood-based Online Adaptation of Hyper-parameters in CMA-ES*, **I. Loshchilov, M. Schoenauer, M. Sebag, N. Hansen** (60).

GP track, ACM-GECCO 2015 *Memetic Semantic Genetic Programming* by **R. Ffrancon, M. Schoenauer** (54).

Geometric Science of Information 2017 *Natural Langevin Dynamics for Neural Networks* by **G. Marceau-Caron, Y. Ollivier** (77).

runner-up, EMO track, ACM-GECCO 2017 *Progressively Adding Objectives: A Case Study in Anomaly Detection*, **L. Marti**, A. Fansi-Tchango, L. Navarro, **M. Schoenauer** (64).

- Test of time Award: ACM-SIGEVO Impact Award 2018 for Adaptive operator selection with dynamic multi-armed bandits published at GECCO 2008, Alvaro Fialho, Luis Da Costa, **Marc Schoenauer, Michèle Sebag**.

Keynote Addresses and invited talks

International

- Michele Sebag, Preferences, Invariances, Optimization, Dagstuhl, March 14
- Michele Sebag, Learning Constraint Values, Dagstuhl seminar, Oct. 2014
- Aurélien Decelle, workshop of Machine Learning at the Yukawa institute, 2015
- Cyril Furtlehner, International Workshop on Innovative Algorithms for Big Data (Kyoto 2015).
- Philippe Caillou, Workshop PICS at Hanoi, May 2015.
- Yann Ollivier, Deep Learning Workshop at ICML 2015, New York.
- Yann Ollivier, Deep Learning Scoping Workshop of the Alan Turing Institute (Edinburgh).
- Yann Ollivier, American Mathematical Society - Mathematical Association of America Joint Math Meetings (San Antonio, 2015).
- Michèle Sebag, DATA 2015, Strasbourg
- Michèle Sebag, AutoML Workshop at ICML 2015, New York.
- Michèle Sebag, Constructive Machine Learning Workshop at ICML 2015, New York.

- Marc Schoenauer, Rank-SVM for flexible optimization, ISEGI seminar, Lisbon, Jan. 2015.
- Marc Schoenauer, DataScience@LHC, CERN, Nov. 9-13, 2015
- Michele Sebag, 12 Oct. 2016, Deep Learning and Artificial Intelligence, Franco-Japanese Symposium, Tokyo
- Paola Tubaro. 8 Mar. 2016, University of Insubria (Italy) economics department seminar. Investigating peer effects and performance similarity in organizational networks: a longitudinal study.
- Paola Tubaro. 2 Nov. 2016, UQAM (Montréal), Seminar of the health communication research center (ComSante). Le phénomène 'pro ana' : Troubles alimentaires et réseaux sociaux.
- Paola Tubaro. 8 Nov. 2016, Université Laval (Québec), Seminar of the CELAT research center. Le phénomène 'pro ana' : Troubles alimentaires et réseaux sociaux
- Michele Sebag, 50th CREST Open Workshop, London, Jan. 2017
- Michele Sebag, Lorentz Center, University of Leiden, Netherlands, September 2017. Space Weather: A Multidisciplinary Approach.
- Michele Sebag, AutoML Workshop at ECMLPKDD 2017, Skopje, Macedonia.
- Michele Sebag, JST CREST Program on Big Data Applications, Tokyo, Sept. 2017.

France

- Gregory Grefenstette, CLEF 2015, Toulouse, Sept. 8, 2015
- Gregory Grefenstette, Journée Recherche - les Big Data, Ecole Contrale Marseille, Nov 18, 2015
- Odalric Maillard, Journées YSP at IHP, Paris, Jan. 31, 2015.
- Odalric Maillard, Workshop CIMI at Toulouse, November 2015.
- Michèle Sebag, Intelligence Artificielle et Interfaces Hommes-Machines, Journée AFIA-AIIH, Paris 2015
- Michèle Sebag and Marc Schoenauer, Big Data Business Convention (Paris-Saclay), Seeded Influencer Ranking, Dec. 2015.
- Marc Schoenauer, Numbers don't Count, Conférence en l'honneur de Laurence Halpern, January 2015.
- Marc Schoenauer and Michèle Sebag, More is different: When, and What For? Journées scientifiques Inria, Nancy, June 2015.
- Isabelle Guyon. 17 Oct. 2016, ENS SMILE seminars. Network Reconstruction: the Contribution of Challenges in Machine Learning.
- Michele Sebag, 21 Jan. 2016, Deep Learning, SdFC, IHP
- Michele Sebag, 24 Mar. 2016, Nutrition personnalisée et alimentation sur mesure, AgroParisTech.
- Michele Sebag, 12 Oct. 2016, Deep Learning and Artificial Intelligence, Franco-Japanese Symposium. Tokyo
- Paola Tubaro. 15 Mar. 2016, EHESS seminar. Sociabilité et soutien social dans les communautés en ligne autour des troubles de l'alimentation.
- Michele Sebag, Deep Learning, Académie des Technologies, Paris, juillet 2017

Evaluation of Research

Editorial Boards

- **Anne Auger** Editorial Board, *Evolutionary Computation*, MIT Press;
- **Gregory Grefenstette** Editorial Board, *Journal of Natural Language Engineering*, Cambridge University Press;
- **Isabelle Guyon** Action Editor, *Journal of Machine Learning Research (JMLR)*; series editor, Microtome book series *Challenges in Machine Learning (CiML)*;
- **Nikolaus Hansen** Editorial Board, *Evolutionary Computation*, MIT Press;
- **Marc Schoenauer** Advisory Board, *Evolutionary Computation*, MIT Press; *Kluwer Genetic Programming and Evolvable Machines*, Editorial Board (2000-2015), Advisory Board (2016-); Action Editor, *Journal of Machine Learning Research (JMLR)*
- **Michèle Sebag** Editorial Board, *Machine Learning (MLJ)*, Springer Verlag
- **Olivier Teytaud** Action Editor, *Journal of Machine Learning Research (JMLR)*
- **Paola Tubaro** Associate Editor, *Sociology*, Sage; Editorial Board, *Revue Française de Sociologie*, Presses de Sciences Po.

Program Committees

All members of the team reviewed articles for the most prestigious conferences in the fields of Machine Learning(NIPS, ICML, ECML/PKDD), Artificial Intelligence (IJCAI, ECAI) and Evolutionary Computation (GECCO, PPSN).

Chair

- **Anne Auger** Organizer, invited mini-symposium on Function-Value-Free Optimization, SIAM Conference on Optimization 2014; Women@GECCO workshop GECCO 2014; co-organizer, BBOB workshops, IEEE Conference on Evolutionary Computation 2015 and GECCO 2015, 2016;

- **Guillaume Charpiat** Workshop Statistics/Learning at Paris-Saclay (2017 and 2018);
- **Cécile Germain** HEPML workshop at NIPS 2014; DataScience@LHCWorkshop 2015, CERN; DataScience@HEP 2016 and 2017; Hammers and Nails Weizmann Workshop 2017;
- **Isabelle Guyon** Program Chair, NIPS 2016; General Chair, NIPS 2017; NIPS 2016 workshops (*Challenges in Machine Learning* and *Spatiotemporal time series*); ICML *AutoML* workshops (2016 and 2017); *LAP challenge* workshops at ECCV and ICPR (2016 and 2017); BayLearn 2017 workshop;
- **Nikolaus Hansen** co-organizer, Dagstuhl seminar on Theory of Evolutionary Algorithms 2015, BBOB workshops, IEEE Conference on Evolutionary Computation 2015 and GECCO 2015, 2016;
- **Michèle Sebag** Senior Program Committee, ECAI 2014; Senior PC Chair, IJCAI 2015, 2017;
- **Paola Tubaro** Second European Social Networks conference (EUSN 2016); Recent Ethical Challenges in Social Network Analysis (RECSNA 2017);

Evaluation Committees and Invited Expertise

- **Michele Sebag**, Member of evaluation jury, Dpt Computer Science, U. Denmark (2017). Hiring jury U. Dortmund (2017); U. Liège (2017, 2018). ENS-Lyon (2018). LORIA (2018).

Interactions with the social, economic and cultural environment

Interaction with the economic environment

- **Michele Sebag**, Jury of Venture Capital Serena, selection of start-ups. 2016.

Dissemination

- **Yann Ollivier**, co-organization of the European Union Contest for Young Scientists (science fair for high school students from 30+ countries organized by the European Commission), 2016.
- **Yann Ollivier**, coordination, with IHP, of numerous activitives for the centenary of Claude Shannon, including a public exhibition at the Musée des Arts et Metiers, a cycle of public conferences, a contest for teachers on the best IT class project, and a workshop on the current state of information theory, 2017.

Popularisation of Research Results

- **Philippe Caillou**, TV emission on Xerfi;
- **Cécile Germain, io.datascience** presentations at: CNRS-INRIA day *data4ist : exploration et analyse des sources de données pour la recherche et ses environnements* (May 2016) ; Futur en Seine 2016 (Juin 2016) ; DGESIP/MiPNES seminar *Normes et échanges de données : où en est-on ?* (Sept. 2016).
- **Isabelle Guyon**, press release at NIPS conference (5/12/2015); interview l'Usine Nouvelle (12/12/2017), Le Monde (4/2018).
- **Odalric-Ambrym Maillard** and **Aurélien Decelle**, participation to day "Petits débrouillards"; to "la fête de la science";
- **Michele Sebag**, participation to IHP debate on AI; to Technion Research Day; to AI & China, at Medef; press release l'Usine Nouvelle; 2 articles The Conversation; interview TV France 2. <
- **Paola Tubaro**, invited talk on "Online social networks and eating disorders", ACT eating disorders association, Nîmes, 5 Feb. 2016; invited talk on "Are we all digital laborers?", Autonomy salon of urban mobility, Paris, 8 Oct. 2016; public interview, "L'économie peut-elle être collaborative? Rencontre avec la sociologue et chercheure Paola Tubaro", Montréal, 2 Nov. 2016; panelist at the round table "Big data, que fait-on de nos données?", organized at Museum of civilization, Québec, 3 Nov. 2016; co-animator, workshop on big data in the "International science and society forum" for high school students, Québec, 4-6 Nov. 2016; panelist at the round table "L'économie peut-elle être vraiment collaborative ET sociale et solidaire?", Ministry of the Economy, Paris, 13 Dec. 2016; training on the digital society and its effects on labor and the economy, for union leaders (CGT, 27 Apr. 2017, CFDT, 23 Jun 2017); round table on Open data at "Science and You" conference, Montréal, 5 May 2017; round table "Cuisine and Performance" at Centre Pompidou, Paris 18 Nov. 2017; invited speaker INTEFP (national continuing education institution), 4 Jul 2018; invited speaker Internet Governance Forum (CNNum, 5 Jul 2018); invited speaker France Stratégie (Prime Minister's office, 6 Jul 2018). Op-eds in national newspapers: Libération 2 Feb 2017, Le Monde 24 Jan 2018. Media interviews and panels: Radio France Inter, Radio France Culture, ICI Radio Canada, Aligre.fm (2016); Book reviews and mentions in the media: Le Monde, Rue89/L'Obs, Mashable/France24, Slate.fr, Journal International de Médecine, The Conversation (2016); Pourquoi Docteur (online health magazine, Le Devoir (daily newspaper, Canada), Les Echos, Le Monde (2017).

Contracts and grants

Public contracts and grants (jan 2013 - jun 2018)						
Type	*Scientific director*	*Name*	*Managing Institution*	*Start*	*Duration*	*Amount*
FP7	Cécile Germain	EGI-Inspire	Université Paris XI	2010	48	
FP7	Olivier Teytaud	CitINES	INRIA	2011	36	2024 k€
H2020	Gregory Grefenstette	EHRI-II	INRIA	2015	48	80 k€
H2020	Isabelle Guyon	See.4C	Univ. Marseille	2016	24	700 k€
ANR	Nikolaus Hansen	SIMINOLE	INRIA	2010	36	250 k€
ANR	Jamal Atif	LOGIMA	Université Paris XI	2012	36	136 k€
ANR	Anne Auger	NUMBBO	INRIA	2012	60	290 k€
ANR	Philippe Caillou	ACTEUR	Université Paris XI	2014	48	236 k€
ANR	Guillaume Charpiat	EPITOME	INRIA	2017	36	225 k€
PIA	Michele Sebag	MAJORE	INRIA	2013	36	105 k€
PIA	Michele Sebag	AMIQAP	INRIA	2015	12	50 k€
PIA	Michele Sebag	Nutriperso	INRIA	2017	12	87 k€
IRT	Marc Schoenauer	ROM	INRIA	2014	36	50 k€
Digiteo	Michele Sebag	ReMoDEL	Université Paris XI	2014	18	50 k€
PGMO	Anne Auger	NUMBBER	INRIA	2016	24	60 k€
CNRS Infinite	Cyril Furtlehner	BrainTime	INRIA	2017	12	7 k€
CNRS Interdisc.	Paola Tubaro	RESTO	Université Paris XI	2017	12	14 k€
MSH	Paola Tubaro	DiPLAB	Université Paris XI	2017	12	24 k€

EGI-Inspire

Type: FP7
Amount: k€
Duration: 48 months
Scientific director for LRI: Cécile Germain

See **EGI.eu**

Integrated Sustainable Pan-European Infrastructure for Researchers in Europe: To support European science and innovation, a longer lasting operational model is now needed – both for coordinating the infrastructure itself and for delivering integrated services that cross national borders.The EGI-InSPIRE project will support the transition from a project-based system to a sustainable pan-European infrastructure.

CitInES

Type: FP7
Amount: 824 k€
Duration: 36 months
Scientific director for LRI: Olivier Teytaud

Partners: 9. Coordinator: Artelys

See **https://cordis.europa.eu/project/rcn/100763_en.html**

Design of a decision support tool for sustainable, reliable and cost-effective energy strategies in cities and industrial complexes

EHRI-II

Type: H2020
Amount: 80 k€
Duration: 48 months
Scientific director for LRI: Gregory Grefenstette

Partners: 24. Coordinator: KNAW-NIOD Institute for War, Holocaust and Genocide Studies (NL)

See **https://www.ehri-project.eu/**

European Holocaust Research Infrastructure, Digital Humanities

See.4C

Type: H2020
Amount: 700 k€
Duration: 24 months
Scientific director for LRI: Isabelle Guyon

Partners: 4. Coordinator: Fraunhofer München

See **https://cordis.europa.eu/project/rcn/199868_en.html**

SpatiotEmporal ForEcasting : Coopetition to meet Current Crossmodal Challenges

SIMINOLE

Type: ANR
Amount: 250 k€
Duration: 36 months
Scientific director for LRI: Nikolaus Hansen

Partners: 2. Coordinator: LAL UPSud

Large-scale simulation-based probabilistic inference, optimization, and discriminative learning with applications in experimental physics. A & O role was i) to include CMA-ES within the ROOT library, the Open Source optimization library widely used in experimental physics; and ii) to propose efficient constraint handling techniques within CMA-ES beyond box constraints

LOGIMA

Type: ANR
Amount: 136 k€
Duration: 36 months
Scientific director for LRI: Jamal Atif

Partners: 3. Coordinator: MAS ECP

Logics, structural representations, mathematical morphology and uncertainty for semantic interpretation of images and videos

NUMBBO

Type: ANR
Amount: 290 k€
Duration: 60 months
Scientific director for LRI: Anne Auger

Partners: Inria Lille, Ecole des Mines de Saint-Etienne, TU Dortmund

Analysis, Improvement and Evaluation of Numerical Blackbox Optimizers. The goal of this project was to improve the COCO platform: COCO (COmparing Continuous Optimizers) is an Open Source platform dedicated to the evaluation of continuous Black-Box optimizers, and their comparisons based on wide benchmark, with the goal of promoting reproducible experimental research in the domain of Black-Box continuous optimization. It proposes a series of 24 test functions, and standardized procedures to run one's own optimizer on these functions, gathering and displaying the results, and the comparison of the results with those of other optimizers.

ACTEUR

Type: ANR
Amount: 236 k€
Duration: 48 months
Scientific director for LRI: Philippe Caillou

Partners: Univ. Rouen, Univ. Paris-XI

Cognitive agent development for urban simulations

EPITOME

Type: ANR
Amount: 225 k€
Duration: 36 months
Scientific director for LRI: Guillaume Charpiat

Partners: INRIA Sophia, INRIA Saclay

Efficient rePresentatIon TO structure large-scale satellite iMagEs

MAJORE

Type: PIA
Amount: 105 k€
Duration: 36 months
Scientific director for LRI: Michele Sebag

Partners: Lidex ISN, INRIA-Saclay, EHESS

A Collaborative Filtering Approach to Matching Job Openings and Job Seekers, Thomas Schmitt's PhD

AMIQAP

Type: PIA
Amount: 50 k€
Duration: 12 months
Scientific director for LRI: Michele Sebag

Partners: Lidex ISN, INRIA-Saclay, Mines-Telecom SES, RITM (Univ. Paris Sud) and La Fabrique de l'Industrie

Multivariate analysis of Quality of Life at Work. Extended for 6 months in 2018 via a donation from La Fabrique de l'Industrie (30ke), O. Goudet's PhD

Nutriperso

Type: PIA
Amount: 87 k€
Duration: 12 months
Scientific director for LRI: Michele Sebag

Partners: INRA (coordinator), INSERM, Agro Paris-tech, Mines Telecom, CEA

Personalized recommendations toward healthier eating practices

ROM

Type: IRT
Amount: 50 k€
Duration: 36 months
Scientific director for LRI: Marc Schoenauer

Partners: IRT System'X, Renault, INRIA-Saclay

Model Reduction and Multiphysics Optimization, François Gonard' PhD. ROM is a project within IRT SystemX dedicated to Multi-disciplinary Optimum Design. It was coordinated by Renault, and its goals include in particular the automatic choice of an optimization algorithm for any given problem arising from multi-disciplinary Optimum Design - aka Algorithm Selection. Several industrial partners were supposed to provide use cases - but the data never arrived, and the PhD student ended working on public data on known benchmarks. .

ReMoDEL

Type: Digiteo
Amount: 50 k€
Duration: 18 months
Scientific director for LRI: Michele Sebag

Partners: ENSTA, LRI

Data fusion with neural nets

NUMBBER

Type: PGMO
Amount: 60 k€
Duration: 24 months
Scientific director for LRI: Anne Auger

Partners: 4. Coordinator INRIA

Numerical optimization platform (Fondation mathématiques Jacques Hadamard). This is yet another project around the COCO platform, more specifically targeted toward multi-objective optimization. .

BRAINTIME

Type: CNRS
Amount: 7 k€
Duration: 12 months
Scientific director for LRI: Cyril Furtlehner

Partners: Institut de Neurosciences de la Timone, INRIA-Saclay

Interdisciplinary challenge, functional connectome dynamics of the brain.

RESTO

Type: CNRS
Amount: 14 k€
Duration: 12 months
Scientific director for LRI: Paola Tubaro

Partners: Telecom ParisTech and Université Paris-Dauphine

REseaux et Simulations, usages Technologiques et Opinions multiples sur les plateformes numériques dans les marchés de la restauration.

DiPLab

Type: MSH Paris-Saclay
Amount: 24 k€
Duration: 12 months
Scientific director for LRI: Paola Tubaro

Partners: Telecom ParisTech

Digital Platform Labor

Private contracts and grants (jan 2013 - jun 2018)						
Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*		*Amount*
Bull SA (FUI)	Cecile Germain	TIMCO	INRIA	2012	48	432 k€
Thales	Marc Schoenauer	E-LUCID	INRIA	2014	36	194 k€
Thalès	Marc Schoenauer	Cifre	INRIA	2011	36	45 k€
Thalès	Marc Schoenauer	Cifre	INRIA	2014	36	30 k€
TNO	Anne Auger	ESA Tender	INRIA	2016	12	52 k€
ADEME	Olivier Teytaud	POST	INRIA	2012	60	1,220 M€
Bull SA (FUI)	Marc Schoenauer	ADAMME	INRIA	2015	48	258 k€
CNES	Guillaume Charpiat	EPITOME	INRIA	2017	36	225 k€
ADEME	Isabelle Guyon	NEXT	INRIA	2017	60	675 k€
Augure	Marc Schoenauer	Modyrum	INRIA	2013	24	150k€
Artelys	Olivier Teytaud	METIS	INRIA	2011	36	40k€
Orange	Michele Sebag	Cifre RA	Université Paris-XI	2013	36	30 k€
Orange	Michele Sebag	Cifre RA2	Université Paris-XI	2016	36	30 k€
RTE	Olivier Teytaud	Cifre BD	INRIA	2015	36	30 k€
Therapixel	Guillaume Charpiat	Master PM	INRIA	2017	6	3 k€
Myndblue	Aurélien Decelle	DMH	INRIA	2017	12	50 k€
Renault	Marc Schoenayer	POC	INRIA	2017	24	200 k€
Renault	Marc Schoenauer	Cifre MN	INRIA	2017	36	45 k€
FO	Paola Tubaro	OPLA	Université Paris-XI	2012	12	27 k€

TIMCO

Type: Privé
Amount: 432 k€
Duration: 48 months
Scientific director for LRI: Cécile Germain

Partners: Bull

The overall goal of the project is to design, test and validate the original architecture proposed by Atos for a mega-RAM machine. A & O role is to adapt Machine Learning algorithm to this new architecture, and find out when having a huge RAM can be beneficial compared to more classical architectures.

E-LUCID

Type: Privé
Amount: 194 k€
Duration: 36 months
Scientific director for LRI: Marc Schoenauer

Partners: Thalès

A & O was subcontracing Thalès-THERESIS in the ANSSI-funded E-LUCID project. The goal of E-LUCID was to design a probe to be installed on the client network in order to detect intrusion based on network trafic analysis. A & O contributed with Evolutionary-based algorithms that were implemented in THERESIS deliverable.

POST

Type: Privé
Amount: 1,220 k€
Duration: 60 months
Scientific director for LRI: Olivier Teytaud

Partners: Artelys

Platform for the optimization and simulation of trans-continental grids. Optimization of the investment policy for a 50 years period of trans-continental power grids - European, or Mediteranean grids as use cases.

ADAMME

Type: Privé
Amount: 258 k€
Duration: 48 months
Scientific director for LRI: Marc Schoenauer

Partners: Bull SA

Follow-up of the TIMCO project, with the new generation of the Mega-RAM computer. A & O role is to test two applications : multi-label image tagging, with Armadillo SME, and prediction of SNCF yield management with Voyages-SNCF.com technology (VSCT).

NEXT

Type: Privé
Amount: 675 k€
Duration: 60 months
Scientific director for LRI: Isabelle Guyon

Partners: Artelys

Simulation, calibration, and optimization of local or regional power grids. A & O role is about the automatic configuration of graph optimization algorithms, and the prediction of consumers' consumption from past logs of clients.

Cifre GMC

Type: Privé
Amount: 36 k€
Duration: 45 months
Scientific director for LRI: Marc Schoenauer

Partners: Thalès

Cifre Thalès Air System, Gaétan Marceau-Caron: Optimisation of Air Trafic with multi-objective evolutionary algorithms.

Cifre NB

Type: Privé
Amount: 36 k€
Duration: 30 months
Scientific director for LRI: Marc Schoenauer

Partners: Thalès

Cifre Thalès Research and Technology (TRT), Nacim Belkhir: Automatic algorithm configuration for continuous optimisation.

Modyrum

Type: Privé
Amount: 150 k€
Duration: 24 months
Scientific director for LRI: Marc Schoenauer

Partners: Augure

Postdoc Marco Bressan: Identifying leaders in social media, discovery of influencers from tweets, viewing social influenceas a (weakly) supervised ranking problem.

Metis

Type: Privé
Amount: 40 k€
Duration: 36 months
Scientific director for LRI: Olivier Teytaud

Partners: Artelys

Cifre Jérémie Decoq. Metis is an Inria I-Lab (Industrial lab), whith SME Artelys, about optimisation methods for energy management and games.

Cifre RA

Type: Privé
Amount: 30 k€
Duration: 36 months
Scientific director for LRI: Michele Sebag

Partners: Orange

Cifre Robin Allesiardo: Multi-armed Bandits on non Stationary Data Streams.

Cifre RA2

Type: Privé
Amount: 30 k€
Duration: 36 months
Scientific director for LRI: Michele Sebag

Partners: Orange

Cifre Reda Alami: Bandits à Mémoire pour la prise de décision en environnement dynamique.

Cifre BD

Type: Privé
Amount: 30 k€
Duration: 36 months
Scientific director for LRI: Olivier Teytaud

Partners: RTE

Cifre Benjamin Donnot. Maintenance of the French Power Grid: identification of parades (modifications of the topology of the grid in order to preserve its safety in all circumstances) in the log of all actions by the grid supervisors, and learning of a strategy to propose parades when necessary. .

Master MP

Partners: Therapixel

3D medical image non-rigid registration with neural networks

Type: Privé
Amount: 3 k€
Duration: 6 months
Scientific director for LRI: Guillaume Charpiat

Myndblue

Partners: DMH

Consulting activities with DMH (Digital for Mental Health)

Type: Privé
Amount: 50 k€
Duration: 12 months
Scientific director for LRI: Aurélien Decelle

POC

Partners: Renault

Classification of scenarii for autonomous vehicles, and identification of "holes" in the space of scenarii – where simulations would be necessary.

Type: Privé
Amount: 200 k€
Duration: 12 months
Scientific director for LRI: Marc Schoenauer

Cifre NB

Partners: Renault

Cifre Marc Nabhan. Toward the validation of fully autonomous vehicles: Optimization of scenarii that lead to failures of the autonomous vehicles controlers.

Type: Priv'e
Amount: 45 k€
Duration: 36 months
Scientific director for LRI: Marc Schoenauer

OPLA

Partners: Force Ouvrière

Organizing Platform Labor. Coll. TelecomParisTech.

Type: Privé
Amount: 27 k€
Duration: 12 months
Scientific director for LRI: Paola Tubaro

ESA Tender

Partners: TNO, INRIA

Design Tools and Alignment Concepts for Free-Form Optics.

Type: TNO
Amount: 52 k€
Duration: 12 months
Scientific director for LRI: Anne Auger

DiPLab

Partners: France Stratégie

Digital Platform Labor. Coll. TelecomParisTech.

Type: Privé
Amount: 27 k€
Duration: 12 months
Scientific director for LRI: Paola Tubaro

Training and Education

Master Internships

- Salim Abdelfettah (Inria, from Apr 2014 until Sep 2014)
- Constance Deperrois (Inria, from Mar 2014 until Jul 2014)
- Arthur Leroy (Inria, from Apr 2014 until Aug 2014)
- Alexandre Quemy (INSA Rouen, until Oct 2014)
- Chang-Min Wu (Inria, from Aug 2014 until Sep 2014)
- Arturo Castellanos (Inria, from Jul 2015 until Sep 2015)
- Victor Estrade (Univ. Paris XI, until Apr 2015)
- Robyn Ffrancon (Inria, until Jul 2015)
- Ching-Nung Lin (Inria, from May 2015 until Oct 2015)
- Wen Wei (SUPELEC, from Apr 2015 until Sep 2015)

- Corentin Tallec (Ecole Polytechnique, from Mar 2015 until Jul 2015)
- Nithin Holla (IIT Karnataka, from May until Jul 2016)
- Laurent Cétinsoy (Master 2 UPSud, April-Aug. 2017)
- Aris Tritas (Master 2 UPSud, April-Aug. 2017)
- Jaouad Mourtada (Univ. Pierre et Marie Curie, from May until sep 2016)
- Bouatira Mohamed (Inria, Young Research Engineer, from February 2015 until January 2017)
- Priyanka Mandikal Phanindra (IIT India, from January until May 2017)
- Théophile Sanchez (INSA Lyon, from February until July 2017)
- Clément Leroy (ENS-Lyon, Master 1, from Mar 2017 until Jun 2017)
- Christina Oster (Inria, Mar-May 2017)
- Leonard Blier (ENS-Paris, Apr-Oct 2017)
- Mhamed Hajaiej (Ecole Polytechnique, Apr-Jul 2017)
- Raphaël Gueégan (Master 1 UPSud, April-Aug. 2017)
- Rumana Lakdawala (Inria, Apr-Aug 2017)
- Louis Beéthune (ENS-Lyon, June-July 2017)
- Cedric Vachaudez (Inria, Jun-Aug 2017)
- Erwann Martin (Inria, Jun-Aug 2017)
- Julian Posada (CNRS, Jul-Dec 2017)
- Hugo Richard (ENS Lyon, from Sept. 2017)
- Martin Toth (Parcours recherche Centrale, Sep 2017-June 2018)
- Eléonore Bartenlian (Master 2 UPSud, April-Aug. 2018)
- Adrian Pavao (Master 2 UPSud, April-Aug. 2018)
- Andrei Constantinescu (ESSEC, April-Aug. 2018)
- Nilo Schwencke (Ecole Polytechnique, Apr-Aug 2018)
- Maxime Besenval (Inria, June-Sept. 2018)
- Elizabeth Wong (Inria, June-July 2018)
- Marvin Lerousseau (Inria, April-Aug. 2018)
- Thomas Gespracher (Inria, April-Aug. 2018)

Graduate Courses

All permanent faculty members teach the standard "service" of French universities. Some administrative services can result in lighter teaching load (e.g., Cécile Germain after 2015). Permanent research scientists teach on a voluntary basis.

- Anne Auger Stochastic Optimization, 20h, L1-3, Ecole Centrale Paris, 2014; Optimisation, 12h, M2 Recherche, UPSud, 2015-2016;
- Jamal Atif Computer Science, approx. 192h, L1, IUT Orsay, UPSud, 2014.
- Philippe Caillou Computer Science for Managers, approx. 192h, L1, IUT Sceaux, UPSud, 2014-2017; Multi-Agents Systems, 27h, M2 Recherche, UPSud., Multi-Agent Based Simulation, 3h, M2 Recherche, U. Paris-Dauphine 2014-2015;
- Guillaume Charpiat Machine Learning, 34h, M2 Recherche, Centrale-Supelec, 2015-2017.
- Aurélien Decelle 192h L2-3, UPSud, 2014-2017, including Computer Architecture (30-60h), Machine Learning and Artificial Life (27-55h), Databases, Object-Oriented Programming; plus Machine Learning (6h), Information Theory (39h), Probability and Statistics (26h), M1, UPSud, 2016-2017.
- Cécile Germain Computer Architecture (head of Licence), approx. 120h, L2-L3, Polytech, UPSud, 2014- 2017; Parallelisme, approx. 50h, M1, UPSud, 2014-2017.
- Isabelle Guyon Project: Resolution of mini-challenges (created by M2 students), L2, UPSud, 2016-2017; Project: Creation of mini-challenges, M2, UPSude, 2016-2017.
- Flora Jay Population Genetics, 10h, M2, UPSud, 2017..
- Odalric-Ambrym Maillard Machine Learning, 6h, M2 Recherche, UPSud, 2015-2016.
- Yann Ollivier Deep learning, 4h, M2 Recherche, Telecom/Polytech, 2014-2017.
- Michèle Sebag Artificial Life, 10h, L2, 2014, UPSud; Introduction to Machine Learning, approx. 24h, L3, ENS-Cachan, 2014; Machine Learning, 25h, M1, MPRI, 2014; Machine Learning, 24h, M2 Recherche, U. Paris-sud, 2014; Evolutionary Robotics, 15h, M2 Recherche, UPSud, 2014;
  2015-2017: Machine Learning, 12h; Deep Learning, 6h; Reinforcement Learning, 12h; M2 Recherche, UPSud.
- Paola Tubaro Sociology of social networks, 24h, M2, EHESS/ENS/ENSAE, 2016-2018; Research Methods, 12h, doctorate, University of Insubria, Italy, 2016-2018; Incubator project, Telecom ParisTech, M1, 2018; Digital platforms, online socialization and new economic models, 6h, M2, Arts et Métiers ParisTech (ENSAM), 2016.

Internships

Schools

- Tutorial on CMA-ES: Nikolaus Hansen and Anne Auger, GECCO 2013.
- Tutorial on Domain Adaptation: Michèle Sebag and Arthur Pesah, Deep Learn Summer School 2018 (5h30).

Other

Honors

Thesis

Habilitation à Diriger des Recherches	
Name	*Defense*
Anne AUGER	05.2016

Defended thesis				
Name	*Start*	*Defense*	*Funding*	*Advisor*
O. Ait Elhara	01.10.2015	07.2017	Alloc. Ministère	Anne Auger
R. Akrour		09.2014	SYMBRION, FP7	M. Sebag & M. Schoenauer
R. Allesiardo		10.2016	Cifre Orange	M. Sebag
L. Arnold		06.2013	Alloc. Ministère	Michèle Sebag & Y. Ollivier
S. Astete Morales		10.2016	Contrat POST	Olivier Teytaud
N. Belkhir		11.2017	Cifre Thales	Marc Schoenauer
J. Bensadon		2.2016	Alloc. Ministère	Yann Ollivier
V. Berthier		9.2017	Alloc. Ministère	Olivier Teytaud
M.-L. Cauwet		9.2016	Contrat POST	Olivier Teytaud
A. Chotard		9.2015	Contrat NUMBBO	Anne Auger
A. Couétoux		9.2013	Contrat	Olivier Teytaud
J. Decoq		11.2014	Contrat	Olivier Teytaud
D. Feng		3.2014	Chinese Academy of Science	Cécile Germain
N. Galichet		9.2015	Alloc. Ministère	Michele Sebag
F. Gonard		6.2018	IRT System'X	Marc Schoenauer
J.-B. Hoock		4.2013	Contrat	Olivier Teytaud
Y. Isaac		5.2015	Contrat CEA	Michele Sebag
J. Liu		12.2015	Contrat	Olivier Teytaud
I. Loschilov		1.2013	Contrat	Marc Schoenauer & Michele Sebag
G. Marceau-Caron		9.2014	Cifre Thalès	Marc Schoenauer
V. Martin		5.2013	Alloc. Ministère	Cyril Furtlehner
P.Y Massé		12.2017	Alloc. Ministère	Yann Ollivier
J.-M. Montanier		3.2013	Alloc. Ministère	Nicolas Bredèche
T. Schmitt		6.2018	PIA Majore	Philippe Caillou
W. Wang		7.2014	Alloc. Ministère	Michele Sebag
G. Zhang		9. 2015	Chinese Academy of Science	Michele Sebag

Position after the thesis	
Name	*Position*
Riad AKROUR	Post-doc TU Darmstadt
Robin ALLESIARDO	Ingénieur Orange
Ludovic ARNOLD	CEO
Alexandre CHOTARD	Postdoc KTH, Sweden
Adrien COUETOUX	Cardinal Blue Software
Jerémie DECOQ	Postdoc CEA
Nicolas GALICHET	Post doc IBM UK
Francois GONARD	Ingénieur SevenHugs
Yoann ISAAC	Ingénieur SRETT
Jialin LIU	Research Assistant Professor, U. Shenzhen, China
I. LOSCHILOV	Post-doc U. Freiburg
G. MARCEAU-CARON	MILA, Montréal
J.M. MONTANIER	Ingénieur Aldebaran
W. WANG	Engineer in Flight Automatic Control Research Institute (FACRI), China
G. Zhang	postdoc Northwestern Polytechnical University, China

Thesis in progress			
Name	*Start*	*Funding*	*Advisor*
Reda ALAMI	9.2016	Cifre Orange	Odalric-Ambrym Maillard & MIchele Sebag
Victor BERGER	9.2017	Contrat NEXT	Michele Sebag & Marc Schoenauer
Benjamin DONNOT	9.2015	Cifre RTE	Isabelle Guyon
Guillaume DOQUET	9.2015	MENRT	Michele Sebag
Victor ESTRADE	9.2015	Univ. Paris-Saclay IDI	Cécile Germain
Giancarlo FISSORE	10.2017	MENRT	Cyril Furtlehner & Aurélien Decelle
Diviyan KALAINATHAN	10.2016	Chaire	Isabelle Guyon
Zhengying LIU	10.2017	AMX	Isabelle Guyon
Adrian POL	10.2016	CERN	Cécile Germain
Herilalaina RAKOTOARISON	10.2017	Contrat NEXT	Marc Schoenauer & Michele Sebag
Théophile SANCHEZ	10.2017	MENRT	Flora Jay & Guillaume Charpiat
Lisheng SUN	9.2016	Chaire	Isabelle Guyon
Corentin TALLEC	9.2016	AMX	Yann Ollivier
Aris TRITAS	10.2017	MENRT	Philippe Caillou & Michele Sebag
Pierre Wolinski	10.2016	MENRT	Yann Ollivier & Guillaume Charpiat

Software Licensing and Distribution

ACM-ES - Surrogate models for CMA-ES

https://www.lri.fr/~ilya

Contact: Ilya LOSHCHILOV

* Hyper-parameter tuning for CMA-ES (mono-modal and multi-modal optimization problems) * Surrogate models for CMA-ES (preserving invariance w.r.t. monotonous transformation of the objection function and w.r.t. affine transformations of the search space) See Ilya Loshchilovs PhD for all detail: http://hal.inria.fr/tel-00823882/PDF/Thesis.pdf

GridObservatory - Grid Observatory

http://www.grid-observatory.org

Contact: Cécile GERMAIN

The Grid Observatory software suite collects and publishes traces of EGEE grid (Enabling Grid for E-sciencE) usage. With the release and extensions of its portal, the Grid Observatory has made a database of grid usage traces available to the wider computer science community. These data are stored on the grid, and made accessible through a web portal without the need of grid credentials. More than 100 users are currently registered.

CMA-ES - Covariance Matrix Evolution Strategy

http://www.lri.fr/~hansen/cmaes_inmatlab.html

Contact: Nikolaus HANSEN

evolutionary optimization with covariance matrix adaptation.

COCO - Comparing Continuous Optimizers

http://coco.gforge.inria.fr/doku.php

Contact: Nikolaus HANSEN

COCO (COmparing Continuous Optimizers) is a platform for systematic and sound comparisons of real-parameter global optimizers. COCO provides benchmark function testbeds (noiseless and noisy) and tools for processing and visualizing data generated by one or several optimizers. The code for processing experiments is provided in Matlab and C. The post-processing code is provided in Python. The code has been improved and used for the GECCO 2009 and 2010 workshops on Black Box Optimization Bench-

marking (BBOB) (see Section

MultiBoost - MultiBoost

http://www.multiboost.org/
Contact: Balázs KÉGL

The MultiBoost package is a multi-class / multi-label / multi-task classification boosting software implemented in C++. It implements essentially a multi-class version of AdaBoost (namely AdaBoost.MH) along with several multi-class weak-learning algorithms and cascades. It is free and easy to build into other applications due to its high modularity. If you use this software in any publication, please refer to the following article: D. Benbouzid, R. Busa-Fekete, N. Casagrande, F.-D. Collin, and B. Kégl MultiBoost: a multi-purpose boosting package Journal of Machine Learning Research, 13:549553, 2012.

MoGo - Computer-Go program

http://www.lri.fr/~teytaud/mogo.html
Contact: Olivier TEYTAUD

(55000 lines of code, C++): Currently the best Computer-Go program worldwide (including advanced options as multithreading). Only the binary code is released, with hundreds of downloads (http://www.lri.fr/ gelly/MoGo_Download.htm). Many computer-go programmers discuss their experiments with MoGo on the computer-go mailing-list.

Metis - Metis

Contact: Olivier TEYTAUD

Codalab - Codalab

https://codalab.lri.fr/
Contact: Isabelle GUYON

CodaLab Competitions is a powerful open source framework for running competitions that involve result or code submission. You can either participate in an existing competition or host a new competition. Most competitions hosted on Codalab are machine learning (data science) competitions, but Codalab is NOT limited to this application domain. It can accommodate any problem for which a solution can be provided in the form of a zip archive containing a number of files to be evaluated quantitatively by a scoring program (provided by the organizers). The scoring program must return a numeric score, which is displayed on a leaderboard where the performances of participants are compared.

CARTOLABE - CARTOLABE

http://cartolabe.lri.fr/
Contact: Philippe CAILLOU

The goal of Cartolabe is to build a visual map representing the scientific activity of an institution/university/domain from published articles and reports (authors and full text of the articles). Using the HAL Database and building upon the AnHALytics processing chain, Cartolabe provides the user with a query-able map of the thematics, authors and articles.

io.datascience - io.datascience

https://io.datascience-paris-saclay.fr
Contact: Cécile GERMAIN

io.datascience (Input Output Data Science) is the instance of the Linked Wiki platform developed specifically in Paris-Saclay University as part of its Center for Data Science. The goal of io.datascience is to facilitate the sharing and use of scientific data, thanks to the exploitation of semantic web advances, and in particular wiki technologies.

A & O team publications (20 %)

Journal articles

Major international journals

(1) Y. Akimoto, S. Astete-Morales, and O. Teytaud. Analysis of runtime of optimization algorithms for noisy functions over discrete codomains. *Theoretical Computer Science*, 605:42:50, 2015.

(2) S. Astete-Morales, M.-L. Cauwet, J. Liu, and O. Teytaud. Simple and Cumulative Regret for Continuous Noisy Optimization. *Theoretical Computer Science*, 617:12–27, 2015.

(3) A. Auger and N. Hansen. Linear Convergence of Comparison-based Step-size Adaptive Randomized Search via Stability of Markov Chains. *SIAM Journal on Optimization*, June 2016.

(4) G. Charpiat, G. Nardi, G. Peyré, and F.-X. Vialard. Piecewise rigid curve deformation via a Finsler steepest descent. *Interfaces and Free Boundaries*, Dec. 2015.

(5) A. Chotard, A. Auger, and N. Hansen. Markov Chain Analysis of Cumulative Step-size Adaptation on a Linear Constrained Problem. *Evolutionary Computation*, 23(4):611–640, 2015.

(6) S. Escalera, V. Athitsos, and I. Guyon. Challenges in multimodal gesture recognition . *Journal of Machine Learning Research*, 17:1 – 54, 2016.

(7) Y. Isaac, Q. Barthélemy, C. Gouy-Pailler, M. Sebag, and J. Atif. Multi-dimensional signal approximation with sparse structured priors using split Bregman iterations. *Signal Processing*, 130:389–402, 2017.

(8) E. Maggiori, G. Charpiat, Y. Tarabalka, and P. Alliez. Recurrent Neural Networks to Correct Satellite Image Classification Maps. *IEEE Transactions on Geoscience and Remote Sensing*, 55(9):4962–4971, Sept. 2017.

(9) E. Maggiori, Y. Tarabalka, G. Charpiat, and P. Alliez. High-Resolution Semantic Labeling with Convolutional Neural Networks. *IEEE Transactions on Geoscience and Remote Sensing*, Dec. 2017.

(10) M. Misir and M. Sebag. Alors: An algorithm recommender system. *Artificial Intelligence*, 244:291–314, Mar. 2017. Published on-line Dec. 2016.

(11) Y. Ollivier, L. Arnold, A. Auger, and N. Hansen. Information-Geometric Optimization Algorithms: A Unifying Picture via Invariance Principles. *Journal of Machine Learning Research*, 18(18):1–65, 2017.

(12) N. Sokolovska, O. Teytaud, S. Rizkalla, K. Clément, and J.-D. Zucker. Sparse Zero-Sum Games as Stable Functional Feature Selection. *PLoS ONE*, 10(9):e0134683, Sept. 2015. MicroObese consortium.

(13) W. Wang and M. Sebag. Hypervolume indicator and dominance reward based multi-objective Monte-Carlo Tree Search. *Machine Learning*, 92(2-3):403–429, May 2013.

(14) X. Zhang, C. Furtlehner, C. Germain-Renaud, and M. Sebag. Data Stream Clustering with Affinity Propagation. *IEEE Transactions on Knowledge and Data Engineering*, 26(7):1, 2014.

Other journals

(15) R. Allesiardo, R. Féraud, and O.-A. Maillard. The Non-stationary Stochastic Multi-armed Bandit Problem. *International Journal of Data Science and Analytics*, 3(4):267–283, 2017.

(16) J. Atif, C. Hudelot, and I. Bloch. Explanatory reasoning for image understanding using formal concept analysis and description logics. *IEEE Transactions on Systems, Man and Cybernetics, Part Systems and Humans: Systems and Humans*, pages 1–19, Oct. 2013.

(17) C. Boufenar, M. Batouche, and M. Schoenauer. An Artificial Immune System for Offline Isolated Handwritten Arabic Character Recognition. *Evolving Systems*, pages 1–17, 2016.

(18) I. Brigui-Chtioui and P. Caillou. Multidimensional Decision Model for Classifying Learners: the case of Massive Online Open Courses (MOOCs) . *Journal of Decision Systems*, Jan. 2017.

(19) M.-L. Cauwet, J. Liu, R. Baptiste, and O. Teytaud. Algorithm Portfolios for Noisy Optimization. *Annals of Mathematics and Artificial Intelligence*, pages 1–30, Nov. 2015.

(20) A. Decelle, F. Ricci-Tersenghi, and P. Zhang. Data quality for the inverse Ising problem. *Journal of Physics A: Mathematical and Theoretical*, 49(38), Aug. 2016.

(21) A. Decelle and P. Zhang. Inference of the sparse kinetic Ising model using the decimation method. *Physical Review E : Statistical, Nonlinear, and Soft Matter Physics*, 91(5), May 2015.

(22) D. Feng and C. Germain. Fault monitoring with sequential matrix factorization. *ACM Transactions on Autonomous and Adaptive Systems*, 10(3):20:1–20:25, 2015.

(23) C. Furtlehner and A. Decelle. Cycle-based Cluster Variational Method for Direct and Inverse Inference. *Journal of Statistical Physics*, 164(3):531–574, Aug. 2016.

(24) Y. Güçlütürk, U. Güçlü, X. Baró, H. J. Escalante, I. Guyon, S. Escalera, M. A. J. van Gerven, and R. van Lier. Multimodal First Impression Analysis with Deep Residual Networks. *IEEE Transactions on Affective Computing*, PP(99):1–14, Sept. 2017.

(25) I. Guyon, H. J. Escalante, V. Athitsos, P. Jangyodsuk, and J. Wan. Principal motion components for one-shot gesture recognition. *Pattern Analysis and Applications*, 20(1):167 – 182, Feb. 2017.

(26) V. Martin, J.-M. Lasgouttes, and C. Furtlehner. Latent binary MRF for online reconstruction of large scale systems. *Annals of Mathematics and Artificial Intelligence*, 77(1):123–154, 2016.

(27) Y. Ollivier. Riemannian metrics for neural networks I: Feedforward networks. *Information and Inference*, 4(2):108–153, 2015.

(28) Y. Ollivier. Riemannian metrics for neural networks II: Recurrent networks and learning symbolic data sequences. *Information and Inference*, 4(2):154–193, 2015.

(29) M. Sebag. A tour of Machine Learning: an AI perspective. *AI Communications*, 27(1):11–23, 2014.

(30) K. Shun, Y. Muneki, C. Furtlehner, and K. Tanaka. Traffic data reconstruction based on Markov random field modeling. *Inverse Problems*, 30(2):15, 2014.

(31) P. Tubaro, L. Ryan, and A. D'Angelo. The Visual Sociogram in Qualitative and Mixed-Methods Research. *Sociological Research Online*, 21(2):1, May 2016.

(32) V. Ventos and O. Teytaud. Le bridge, nouveau défi de l'intelligence artificielle ? *Revue des Sciences et Technologies de l'Information - Série RIA : Revue d'Intelligence Artificielle*, 31(3):249 – 279, June 2017.

Conference articles

Major international conferences and workshops

(33) O. Ait Elhara, A. Auger, and N. Hansen. Permuted Orthogonal Block-Diagonal Transformation Matrices for Large Scale Optimization Benchmarking. In T. Friedrich and F. Neumann, editors, *GECCO 2016*, Proceedings GECCO'16, pages 189–196, Denver, United States, July 2016. ACM-Press.

(34) Y. Akimoto, A. Auger, and N. Hansen. Quality Gain Analysis of the Weighted Recombination Evolution Strategy on General Convex Quadratic Functions. In *Proceedings of the 14th ACM/SIGEVO Conference on Foundations of Genetic Algorithms, FOGA*, pages 111–126, Copenhagen, Denmark, Jan. 2017.

(35) Y. Akimoto and N. Hansen. Online Model Selection for Restricted Covariance Matrix Adaptation. In J. Handl, E. Hart, P. Lewis, M. L.-I. nez, G. Ochoa, and B. Paechter, editors, *Parallel Problem Solving from Nature – PPSN XIV*, LNCS, pages 3–13, Edinburgh, United Kingdom, Sept. 2016. Springer Verlag.

(36) Y. Akimoto and N. Hansen. Projection-Based Restricted Covariance Matrix Adaptation for High Dimension. In T. Friedrich and F. Neumann, editors, *Genetic and Evolutionary Computation Conference 2016*, Proc. ACM-GECCO'16, pages 197–204, Denver, United States, July 2016.

(37) Y. Akimoto and Y. Ollivier. Objective Improvement in Information-Geometric Optimization. In *Foundations of Genetic Algorithms XII*, Adelaide, Australia, Jan. 2013.

(38) R. Akrour, M. Schoenauer, M. Sebag, and J.-C. Souplet. Programming by Feedback. In *International Conference on Machine Learning*, number 32 in JMLR Proceedings, pages 1503–1511, Pékin, China, June 2014. JMLR.org.

(39) R. Allesiardo, R. Féraud, and D. Bouneffouf. A Neural Networks Committee for the Contextual Bandit Problem. In *The 21st International Conference on Neural Information Processing*, pages 374 – 381, Kuching, Malaysia, Nov. 2014.

(40) S. Astete-Morales, M.-L. Cauwet, and O. Teytaud. Evolution Strategies with Additive Noise: A Convergence Rate Lower Bound. In *Foundations of Genetic Algorithms*, Foundations of Genetic Algorithms, pages 76–84, Aberythswyth, United Kingdom, 2015. ACM.

(41) S. Astete-Morales, M.-L. Cauwet, and O. Teytaud. Analysis of Different Types of Regret in Continuous Noisy Optimization. In T. Friedrich and F. Neumann, editors, *Genetic and Evolutionary Computation Conference 2016*, Proc. ACM-GECCO'16, pages 205–212, Denver, United States, July 2016.

(42) A. Atamna, A. Auger, and N. Hansen. Analysis of Linear Convergence of a (1 + 1)-ES with Augmented Lagrangian Constraint Handling. In T. Friedrich and F. Neumann, editors, *GECCO 2016 - Genetic and Evolutionary Computation Conference*, pages 213–220, Denver, United States, July 2016.

(43) A. Atamna, A. Auger, and N. Hansen. Augmented Lagrangian Constraint Handling for CMA-ES—Case of a Single Linear Constraint. In *Proceedings of the 14th International Conference on Parallel Problem Solving from Nature*, pages 181 – 191, Edinburgh, United Kingdom, Sept. 2016.

(44) D. Auger, A. Couetoux, and O. Teytaud. Continuous Upper Confidence Trees with Polynomial Exploration - Consistency. In H. Blockeel, K. Kersting, S. Nijssen, and F. Železný, editors, *ECML/PKKD 2013*, volume 8188 of *LNCS*, pages 194–209, Prague, Czech Republic, Sept. 2013. Springer Verlag.

(45) R. Bardenet, M. Brendel, B. Kégl, and M. Sebag. Collaborative hyperparameter tuning. In S. Dasgupta and D. McAllester, editors, *30th International Conference on Machine Learning (ICML 2013)*, volume 28, pages 199–207, Atlanta, United States, June 2013. Acm Press.

(46) N. Belkhir, J. DREO, P. Savéant, and M. Schoenauer. Per instance algorithm configuration of CMA-ES with limited budget. In *GECCO 2017 - Proceedings of the Genetic and Evolutionary Computation Conference* , pages 681–688, Berlin, Germany, July 2017.

(47) D. Brockhoff, T.-D. Tran, and N. Hansen. Benchmarking Numerical Multiobjective Optimizers Revisited. In A. Esparcia and S. Silva, editors, *Genetic and Evolutionary Computation Conference (GECCO 2015)*, pages 639–646, Madrid, Spain, July 2015.

(48) M.-L. Cauwet and O. Teytaud. Noisy Optimization: Fast Convergence Rates with Comparison-Based Algorithms. In T. Friedrich and F. Neumann, editors, *Genetic and Evolutionary Computation Conference*, Proc. ACM-GECCO'16, pages 1101–1106, Denver, United States, July 2016.

(49) M.-L. Cauwet, O. Teytaud, S.-Y. Chiu, K.-M. Lin, S.-J. Yen, D. L. Saint-Pierre, and F. Teytaud. Parallel Evolutionary Algorithms Performing Pairwise Comparisons. In J. He, T. Jansen, G. Ochoa, and C. Zarges, editors, *Foundations of Genetic Algorithms*, Foundations of Genetic Algorithms, pages 99–113, Aberythswyth, United Kingdom, 2015. ACM.

(50) A. Chotard and M. Holeňa. A Generalized Markov-Chain Modelling Approach to (1,λ)-ES Linear Optimization. In *Parallel Problem Solving from Nature – PPSN XIII*, volume 8672 of *Lecture Notes in Computer Science*, pages 902 – 911, Ljubljana, Slovenia, Sept. 2014. Springer.

(51) F.-M. De Rainville, M. Sebag, C. Gagné, M. Schoenauer, and D. Laurendeau. Sustainable Cooperative Coevolution with a Multi-Armed Bandit. In C. Blum and E. Alba, editors, *Proc. 15th Genetic and Evolutionary Computation COnference - ACM-GECCO*, pages 1517–1524, Amsterdam, Netherlands, July 2013. ACM SIGEVO, ACM Press.

(52) J. Decock and O. Teytaud. Noisy Optimization Complexity Under Locality Assumption. In *FOGA - Foundations of Genetic Algorithms XII - 2013*, Adelaide, Australia, Jan. 2013.

(53) A. Erraqabi, M. Valko, A. Carpentier, and O.-A. Maillard. Pliable rejection sampling. In *International Conference on Machine Learning*, New York City, United States, June 2016.

(54) R. Ffrancon and M. Schoenauer. Memetic Semantic Genetic Programming. In A. Esparcia and S. Silva, editors, *Genetic and Evolutionary Computation COnference (GECCO 2015)*, pages 1023–1030, Madrid, Spain, July 2015. ACM. Best Paper Award in the GP track - see http://www.sigevo.org/gecco-2015/papers.html.

(55) E. Galván-López, E. Mezura-Montes, O. Ait ElHara, and M. Schoenauer. On the Use of Semantics in Multi-objective Genetic Programming. In J. Handl, E. Hart, P. R. Lewis, M. López-Ibáñez, G. Ochoa, and B. Paechter, editors, *14th International Conference Parallel Problem Solving from Nature – PPSN XIV*, volume 9921 of *LNCS - Lecture Notes in Computer Science*, pages 353 – 363, Edinburgh, United Kingdom, Sept. 2016. Springer Verlag.

(56) B. Hanczar and M. Sebag. Combination of One-Class Support Vector Machines for Classification with Reject Option. In T. Calders, F. Esposito, E. Hüllermeier, and R. Meo, editors, *Machine Learning and Knowledge Discovery in Databases - Part I*, volume 8724 of *Machine Learning and Knowledge Discovery in Databases - Part I*, pages 547 – 562, Nancy, France, Sept. 2014.

(57) M. R. Khouadjia, M. Schoenauer, V. Vidal, J. Dréo, and P. Savéant. Pareto-Based Multiobjective AI Planning. In F. Rossi, editor, *IJCAI 2013*, Proceedings of the 23rd International Joint Conference on Artificial Intelligence, pages 2321–2327, Beijing, China, Aug. 2013. IJCAI/AAAI, IJCAI/AAAI.

(58) A. Llamosi, A. Mezine, F. D'alché-Buc, V. Letort, and M. Sebag. Experimental Design in Dynamical System Identification: A Bandit-Based Active Learning Approach. In *Machine Learning and Knowledge Discovery in Databases - Part II*, volume 8725, pages 306 – 321, Nancy, France, Sept. 2014. Springer Verlag.

(59) I. Loshchilov, M. Schoenauer, and M. Sebag. Intensive Surrogate Model Exploitation in Self-adaptive Surrogate-assisted CMA-ES (saACM-ES). In C. Blum and E. Alba, editors, *Genetic and Evolutionary Computation Conference (GECCO 2013)*, pages 439–446, Amsterdam, Netherlands, July 2013.

(60) I. Loshchilov, M. Schoenauer, M. Sebag, and N. Hansen. Maximum Likelihood-based Online Adaptation of Hyper-parameters in CMA-ES. In T. Bartz-Beielstein, J. Branke, B. Filipič, and J. Smith, editors, *13th International Conference on Parallel Problem Solving from Nature (PPSN 2014)*, volume 8672 of *Lecture Notes in Computer Science*, pages 70–79, Ljubljana, Slovenia, Sept. 2014. Springer Verlag.

(61) M. Loth, M. Sebag, Y. Hamadi, and M. Schoenauer. Bandit-based Search for Constraint Programming. In C. Schulte, editor, *International Conference on Principles and Practice of Constraint Programming*, volume 8124 of *LNCS*, pages 464–480, Uppsala, Sweden, Sept. 2013. Springer Verlag.

(62) T. LUCAS, C. Tallec, J. Verbeek, and Y. Ollivier. Mixed batches and symmetric discriminators for GAN training. In *International Conference on Machine Learning*, Stockholm, Sweden, July 2018.

(63) G. Marceau and M. Schoenauer. Racing Multi-Objective Selection Probabilities. In T. Bartz-Beielstein, J. Branke, B. Filipič, and J. Smith, editors, *13th International Conference on Parallel Problem Solving from Nature*, volume 8672 of *LNCS*, pages 631–640, Ljubljana, Slovenia, Sept. 2014. Springer Verlag.

(64) L. Martí, A. Fansi-Tchango, L. Navarro, and M. Schoenauer. Progressively Adding Objectives: A Case Study in Anomaly Detection. In *Genetic and Evolutionary Computation Conference (GECCO 2017)*, Berlin, Germany, July 2017.

(65) V. Martin, C. Furtlehner, Y. Han, and J.-M. Lasgouttes. GMRF Estimation under Topological and Spectral Constraints. In T. Calders, F. Esposito, E. Hüllermeier, and R. Meo, editors, *7th European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases*, volume 8725 of *Lecture Notes in Computer Science*, pages 370–385, Nancy, France, Sept. 2014. Springer Berlin Heidelberg.

(66) D. Rousseau, S. Amrouche, P. Calafiura, S. Farrell, C. Germain, V. Gligorov, T. Golling, H. Gray, I. Guyon, M. Hushchyn, V. Innocente, M. Kiehn, A. Salzburger, A. Ustyuzhanin, J.-R. V. Vlimant, and Y. Yilmaz. The TrackML challenge. In *NIPS 2018 - 32nd Annual Conference on Neural Information Processing Systems*, pages 1–23, Montreal, Canada, Dec. 2018.

(67) M. Sebag, R. Akrour, B. Mayeur, and M. Schoenauer. Anti Imitation-Based Policy Learning. In P. Frasconi, N. Landwehr, G. Manco, and J. Vreeken, editors, *Machine Learning and Knowledge Discovery in Databases - European Conference, ECML-PKDD 2016*, number 9852 in LNCS, pages 559 – 575, Riva del Garda, Afghanistan, Sept. 2016.

(68) F. Teytaud and O. Teytaud. QR mutations improve many evolution strategies -a lot on highly multimodal problems. In T. Friedrich and F. Neumann, editors, *ACM-GECCO'16*, Poster in GECCO'16 Companion, pages 35–36, Denver, United States, July 2016.

Other conferences and workshops

(69) N. Belkhir, J. Dréo, P. Savéant, and M. Schoenauer. Surrogate Assisted Feature Computation for Continuous Problems. In P. Festa, editor, *LION 10 Learning and Intelligent OptimizatioN Conference*, Proc. Learning and Intelligent OptimizatioN Conference, page To appear, Ischia, Italy, May 2016. Springer Verlag.

(70) T. Cazenave, J. Liu, and O. Teytaud. The Rectangular Seeds of Domineering, Atari-Go and Breakthrough. In *2015 IEEE Conference on Computational Intelligence and Games (CIG)*, pages 530 – 531, Tainan, Taiwan, Aug. 2015.

(71) J. Decock and O. Teytaud. Linear Convergence of Evolution Strategies with Derandomized Sampling Beyond Quasi-Convex Functions. In *EA - 11th Biennal International Conference on Artificial Evolution - 2013*, Lecture Notes in Computer Science, Bordeaux, France, Oct. 2013. Springer.

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Theses and habilitations

(A285) O. Ait Elhara. *Stochastic Black-Box Optimization and Benchmarking in Large Dimensions*. Theses, Université Paris-Saclay, July 2017.

(A286) R. Akrour. *Robust Preference Learning-based Reinforcement Learning*. Theses, Université Paris Sud - Paris XI, Sept. 2014.

(A287) R. Allesiardo. *Multi-armed Bandits on non Stationary Data Streams*. Theses, Université Paris-Saclay, Oct. 2016.

(A288) L. Arnold. *Learning Deep Representations : Toward a better new understanding of the deep learning paradigm*. Theses, Université Paris Sud - Paris XI, June 2013.

(A289) S. Astete Morales. *Contributions to Convergence Analysis of Noisy Optimization Algorithms*. Theses, Université Paris-Saclay, Oct. 2016.

(A290) A. Auger. *Thèse d'habilitation à diriger des recherches "Analysis of Comparison-based Stochastic Continuous Black-Box Optimization Algorithms"*. Theses, University Paris Sud, May 2016.

(A291) N. Belkhir. *Per Instance Algorithm Configuration for Continuous Black Box Optimization*. Theses, Université Paris-Saclay, Nov. 2017.

(A292) J. Bensadon. *Applications of Information Theory to Machine Learning*. Theses, Université Paris-Saclay, Feb. 2016.

(A293) V. Berthier. *Studies on Stochastic Optimisation and applications to the Real-World*. Theses, Université Paris-Saclay, Sept. 2017.

(A294) V. Berthier. *Studies on stochastic optimisation and applications to the real world*. Theses, Université Paris 11, Sept. 2017.

(A295) P. T. Cao. *Approximation of OLAP queries on data warehouses*. Theses, Université Paris Sud - Paris XI, June 2013.

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(A303) Y. Isaac. *Redundant representations for electroencephalography signals*. Theses, Université Paris Sud - Paris XI, May 2015.

(A304) J. Liu. *Portfolio Methods in Uncertain Contexts*. Theses, Université Paris-Saclay, Dec. 2015.

(A305) I. Loshchilov. *Surrogate-Assisted Evolutionary Algorithms*. Theses, Université Paris Sud - Paris XI ; Institut national de recherche en informatique et en automatique - INRIA, Jan. 2013.

(A306) A. T. Ly. *Accessing and using complex multimedia documents in a digital library*. Theses, Université Paris Sud - Paris XI, July 2013.

(A307) G. Marceau Caron. *Optimization and uncertainty handling in air traffic management*. Theses, Université Paris Sud - Paris XI, Sept. 2014.

(A308) G. Marceau Caron. *Optimization and Uncertainty Handling in Air Traffic Management*. Theses, Paris-Sud XI, Sept. 2014.

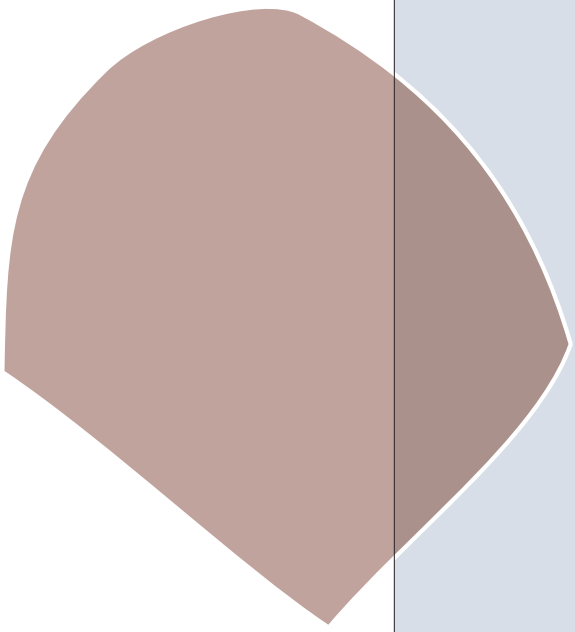
(A309) V. Martin. *Probabilistic Modelling and Inference using the Belief Propagation Algorithm*. Theses, Ecole Nationale Supérieure des Mines de Paris, May 2013.

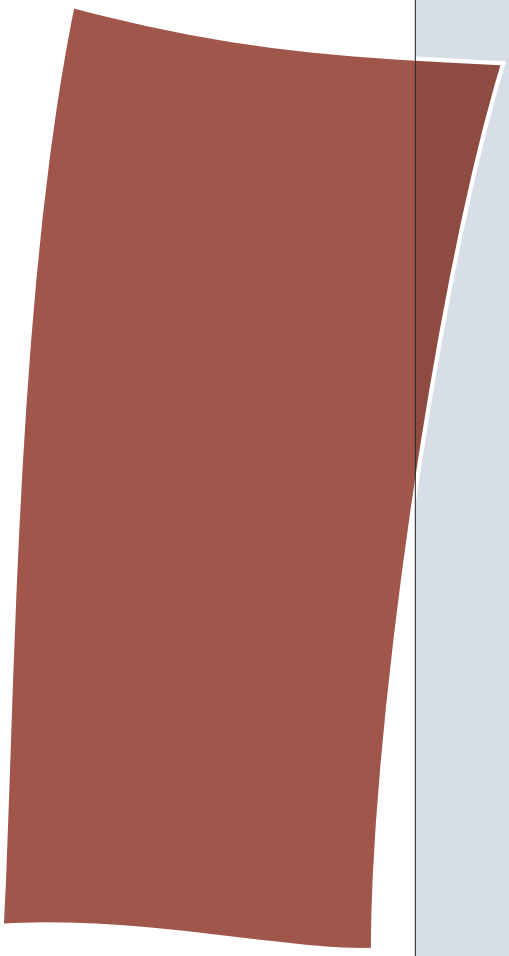
(A310) P.-Y. Masse. *Around the Use of Gradients in Machine Learning*. Theses, Université Paris-Saclay, Dec. 2017.

(A311) J.-M. Montanier. *Environment-driven Distributed Evolutionary Adaptation for Collective Robotic Systems*. Theses, Université Paris Sud - Paris XI, Mar. 2013.

(A312) W. Wang. *Multi-objective sequential decision making*. Theses, Université Paris Sud - Paris XI, July 2014.

(A313) G. Zhang. *Exploratory Robotic Controllers : An Evolution and Information Theory Driven Approach*. Theses, Université Paris Sud - Paris XI, Sept. 2015.





3/ Bioinfo

Bioinformatics

équipe
Bioinformatique

Responsable: Alain Denise, Sarah Cohen-Boulakia

L'objectif du groupe Bioinfo est de concevoir et de développer de nouvelles approches informatiques pour répondre à de véritables questions biologiques et bioinformatiques. Le principal atout de notre groupe est non seulement d'être capable de comprendre les problèmes posés par l'étude des systèmes biologiques depuis l'échelle moléculaire jusqu'à celle des cellules et des populations, mais aussi de concevoir des solutions impliquant des compétences issues de domaines très variés (algorithmique, combinatoire, bases de données, représentation des connaissances, données (statistiques) et extraction de machines, méthodes formelles et simulation). Notre programme scientifique est structuré en trois thèmes, fortement corrélés : Analyse de séquences et de structures biologiques, Biologie des systèmes et biologie de synthèse et Intégration et analyse de données biologiques.



Bioinformatics

Head: Alain Denise, Sarah Cohen-Boulakia

The objective of the Bioinfo group is to design and develop new computational approaches to address real biological and bioinformatic issues. The main asset of our group is not only to be able to understand the problems posed by the study of biological systems from the molecular scale to the scale of cells and populations, but also to design solutions involving skills from very various domains of computer science (algorithmic, combinatorics, databases, knowledge representation, data analysis (statistics) and machine learning, formal methods and simulation). Our scientific program is structured in three themes, strongly correlated: Analysis of sequences and biological structures, System and synthetic biology and Integration and analysis of biological data.

Synthetic Presentation

Head of the group: **Alain DENISE, Sarah COHEN-BOULAKIA**

Staff On January 1st, 2018, the group is composed of 5 assistant and full professors (3 full professors with one working at 70%, 3 assistant professors including one HdR), 2 junior CNRS researchers, 1 senior CNRS researcher (emeritus).

Staff left during the period Jérôme Azé was hired as a Professor at Montpellier University in September 2013.

Recruitment performed during the period 1 assistant professor hired in 2014, 1 junior CNRS in 2015. Moreover, one assistant professor has been hired as a full professor in the group.

Scientific production during the period

1. In collaboration with Sys2diag lab, we have worked on the **automatic design of biochemical nano-calculators for the diagnosis of human pathologies**. We designed and developed the software SILICELL MAKER (p. 147) and specific plugins that automatically synthetise enzymatic networks detecting targeted pathologies. Thanks to the Sys2diag microfluidics platform, the incorporation of these networks in an artificial liposome gave correct results on actual clinical samples. The associated publication has been selected for the cover of *Molecular Systems Biology* (9).
2. Our work on the analysis and the prediction of RNA molecule structures led to the development of an original methodology of **coarse grain prediction of three-dimensional structures by sampling**, based on game theory concepts (A12, 4). Our experiments have shown that our algorithm (implemented in the GARN software) behaves as well or better than the competing programs in the vast majority of cases. This work was done in collaboration with the GALaC team and the Versailles DAVID laboratory (Digiteo JAPARIN-3D project).
3. The addition of biological constraints in the calculation of metabolic pathways (EFMs) is an essential step to reduce their number and thus increase their relevance. We have shown in collaboration with S. Schuster (Jena University, Germany) that **thermodynamic constraints** based on the constant equilibrium (i) required fewer amounts of biological data than other thermodynamic constraints, (ii) reduced by 50% the number of FSMs, and that (iii) their removal was biologically relevant (19).
4. In the context of a CNRS Mastodon project and a collaboration with the University of Montréal, we studied the problem of consensus ranking and its application to biological data. We have (5) (*VLDB* paper) (i) performed a comparative study of rank aggregation algorithms to derive recommendation to users on which algorithms to use depending on data features we have identified, (ii) provided new results on the complexity of the problem and (iii) designed ConQur-Bio, a concrete tool able to efficiently classify the biological data obtained in response to a query on major biological databases.
5. In collaboration with LSV, we explored the combination of abstract interpretation with concurrency semantics of dynamical systems to tackle the formal analysis of Boolean networks and related formalisms. We designed a static model reduction technique (A71, 17) which can then be applied on on-the-fly during the unfolding of network dynamics, enhancing the analysis of trajectories of large-scale biological networks. This work has been presented at *CONCUR'17* (28). Moreover, we have been able to define an abstract interpretation of parametric Boolean networks, published recently in *Theoretical Computer Science* (14), paving the way towards the formal analysis of dynamics of sets of models.
6. In collaboration with the INRA BIOS (Tours), we proposed a method for automatic construction of signaling networks (22) (in *Scientific Reports*). The performance of our method was evaluated on the reconstruction of a single signaling network combining the underlying data of two reduced networks, FSH and EGF. This unique network has made it possible to formulate a new biological hypothesis (on the activation of MEK by p38MAPK) that we have been able to validate experimentally.

Publications (Figures)

- Articles in journals: international (A*,A): 46, other: 13
- Papers in conferences: international (A, A*): 20, other: 35
- Book edition: 9
- Book chapters: 3

5 major publications

- D. Ellison, A. Mugler, M. D. Brennan, S. H. Lee, R. J. Huebner, E. R. Shamir, L. A.Woo, J. Kim, P Amar, I. Nemenman, A. J. Ewald, and A. Levchenko. Cell-cell communication enhances the capacity of cell ensembles to sense shallow gradients during morphogenesis. Proceedings of the National Academy of Sciences of the United States of America , 113(6):E679-E688, Jan. 2016 (10)
- J. Starlinger, B. Brancotte, S. Cohen-Boulakia, and U. Leser. Similarity Search for Scientific Workflows. Proceedings of the VLDB Endowment (PVLDB), 7(12):1143-1154, Sept. 2014 (24)

- M. Martin, F. Jay, S. Castellano, and M. Slatkin. Determination of genetic relatedness from lowcoverage human genome sequences using pedigree simulations. Molecular Ecology, 26(16):4145-4157, Aug. 2017 (15)
- J. Kolčák, D. Šafránek, S. Haar and Loïc Paulevé. Parameter Space Abstraction and Unfolding Semantics of Discrete Regulatory Networks. Theoretical Computer Science, 2018 (14)
- A. Rougny, P. Gloaguen, N. Langonné, E. Reiter, P. Crépieux, A. Poupon and Ch. Froidevaux. A logic-based method to build signaling networks and propose experimental plans. Scientific Reports 8, 7830 (2018) (22)

5 softwares

- CaRNAval (**http://carnaval.lri.fr/**): This online resource enables structural biologists and bioinformaticians to explore three-dimensional RNA structures to discover and analyze the recurrent interaction networks (RINs), small substructures of the molecule that are essential for shaping the architecture of the molecule and to endow it with functions such as affinity to proteins or ligands. This resource is the result of algorithmic developments of automatic extraction and classification of these RINs, based on a representation of the structures by graphs (21).
- Pint (A72), available under CeCiLL licence at **https://loicpauleve.name/pint/** implements the abstract interpretation of automata networks. It allows addressing reachability properties in very large-scale automata (including Boolean) networks - it has been applied for the formal analysis of dynamics of networks ranging from 100 to 10,000 nodes, which was unprecedented. It is notably used in ongoing work with partners at Institut Curie and Univ Luxembourg to predict mutation for controlling reachability properties.
- ConquR-Bio (**http://conqur-bio.lri.fr/**) provides a list of disease-related genes, carefully sorted by rank aggregation approaches. The tool has about fifty distinct users since 2014 mainly from the APHP (Paul Brousse and George Pompidou) and the Institut Curie as well as North American universities and the researchers from the ELIXIR European network.
- Silicell Maker (**https://silicellmaker.lri.fr**) is a graphic editor for SBGN metabolic networks including various plugins, such as HSIM for simulation, NETGATE for automatic extraction of logic gates from metabolic networks and NETBUILD for automatic assembly of logical gates to obtain a given Boolean function (9).
- In collaboration with IBENS and Institut Curie, we designed the "CoLoMoTo Interactive Notebook" (16), available at **https://colomoto.github.io/colomoto-docker**, which provides a joint Docker distribution of software tools for systems biology (including Pint) with a unified interface through the Jupyter Web application. We expect that this very recent contribution will foster the concern for reproducible science in the computational systems biology community, and suggest new standard for the durable distribution of tools and the sharing and reproduction of computational analyses of biological networks.

5 actions demonstrating the activities of the group in the academic world

- Bioinfo group members are program committee members of various conferences ranked A* and A, in Bioinformatics and Computer science, including ECCB, ICDE, SIGMOD, and SSDBM.
- We actively participate in the life of international and national infrastructure networks such as ELIXIR and IFB (Institut Francais de Bioinformatique, funded by PIA).
- We have numerous long term international collaborations, witnessed by common funded projects (two international ANRs, two PHCs, one MITACS funding) and numerous joint publications.
- Group members have been invited to give keynote talks in International workshops (workshop on Data Provenance and Computational Linguistics, Workshop on Logical modelling of Biological regulatory network, symposium on Structure and dynamics of RNA interactions) and invited talks in industry (Bayer Crop Science, ABLife company, Cairn Bioscience)
- Group members have a strong involvement in National (GDRs) and local structures (Institute IMSV, CDS Center, funded by Idex).

Interactions of the group with the socio-economical or cultural world

- Strong involvement in the SIF (*Société Informatique de France*), member of the CA and steering committee, vice-presidence and vice-presidence in charge of education.
- Involvement in working National groups on Ethics in Science (member of the CERNA, *Commission de Reflexion sur l'éthique de la Recherche en sciences et Technologies du Numérique d'Allistene*)
- Involvement in national working groups on scientific integrity (leading actions in GDR MaDICS and IFB on computational reproducibility in bioinformatics).

Main contributions of the group to teaching activities in relationship with research

- Design and lead of several tracks: lead of the Master of Bioinformatics at the University of Paris-Saclay, head of the steering committee that created the Master in 2015; head of the steering committee that created the Master of Computer science of the Université Paris-Saclay; head of the "Magistère" of computer science at the University Paris-Sud (L3 to M2).
- Duties in the Department of computer science in Paris-Sud : vice-presidence in charge of teaching (2012-2014) then presidence of the department (2015-2017); vice-presidence in charge of the undergraduated studies (2018-)

- Numerous courses and invited talks in Spring and Summer schools (*école d'été CNRS Cumulo-Numbio, école d'été CNRS Bases de Données Avancées, école de la société francophone de Biologie théorique, école thématique de biologie des système et de synthèse avancées, école de printemps Labex Digicosme*).
- Co-authorship of the SPOC, available on the FunMooc platform in English, on Ethics and scientific integrity for the PhDs of the STIC doctoral school of Paris-Saclay entitled « Research Integrity & Ethics in Information and Communications Sciences and Technologies ».
- Participation in the pedagogic initiative Meet-U, associated with a publication in PLOS Computational Biology (A1). Meet-U aims at making collaborating students of two Bioinformatics Masters, at Paris-Sacaly and Sorbonne Université (UPMC). Meet-U allows students to work by group of 4 to 5 supervised by (associate-)professors to design and implement a project answering a complex biological question using computer science technics.

Research Group Members and Evolution

The tables below give all the members of the Bioinfo group during the period. The names of the present members (in June 2018) are in bold.

Permanent Members (9 in June 2018)				
Name	*First name*	*Position*	*Institution*	*Remarks*
AMAR	**Patrick**	MCF HDR	Univ. Paris-Sud	
AZ É	Jérôme	MCF HDR	Univ. Paris-Sud	until Sept. 2013
COHEN-BOULAKIA	**Sarah**	PR	Univ. Paris-Sud	
DENISE	**Alain**	PR	Univ. Paris-Sud	
FROIDEVAUX	**Christine**	PR	Univ. Paris-Sud	
JAY	**Flora**	CR	CNRS	since Sept. 2015
LABEDAN	**Bernard**	DR émérite	CNRS	
PAULEVÉ	**Loïc**	CR	CNRS	since Sept. 2013
PERES	**Sabine**	MCF	Univ. Paris-Sud	
PIERROT	**Adeline**	MCF	Univ. Paris-Sud	since Sept. 2014

PhD. students (5 in June 2018)				
Name	*First name*	*Funding*	*Institution*	*Remarks*
ANDRIEU	**Pierre**	Alloc. Ministère	Univ. Paris-Sud	2017-
BOUDARD	Mélanie	RTRA Digiteo	Univ. Versailles	2012-2016
BOUFFARD	Marc	Alloc. Ministère	Univ. Paris-Sud	2013-2016
BRANCOTTE	Bryan	Alloc. Ministère	Univ. Paris-Sud	2012-2015
CHEN	Jiuqiang	China Scholarship Council (CSC)	Univ. Paris-Sud	2011-2013
GUILHOT-GAUDEFFROY	Adrien	Alloc. Ministère	Univ. Paris-Sud	2011-2014
DA VEIGA MOREIRA	**Jorgelindo**	Cifre	Polytechnique & Soredab	2015-
MORTERO	Martin	Alloc. Ministère	Univ. Paris-Sud	2013-2016
MOULIN	**Cécile**	Alloc. Ministère	Univ. Paris-Sud	2016-
RAFES	**Karima**	self-founded	Univ. Paris-Sud	2014-
ROUGNY	Adrien	Alloc. Normalien	Univ. Paris-Sud	2013-2016
WANG	Wei	China Scholarship Council (CSC)	Univ. Paris-Sud	2014-2017
YANG	Bo	Univ. Paris-Sud (cotutelle)	Univ. Paris-Sud	2011-2014
ZAHARIA	**Alexandra**	Alloc. Ministère	Univ. Paris-Sud	2015-
ZENG	Cong	China Scholarship Council (CSC)	Univ. Paris-Sud	2011-2015

Other members (2 in June 2018)				
Name	*First name*	*Position*	*Institution*	*Remarks*
CURY	**Jean**	Postdoc	Univ. Paris-Sud	2018-
D'ALCHÉ-BUC	Florence	PR	University of Evry	on leave in our group and A&O group until Dec. 2013
HENRY	Vincent	Engineer	Univ. Paris-Sud	2015-2016
PEREIRA	Cécile	ATER	Univ. Paris-Sud	2014-2015
ROVETTA	**Christelle**	Postdoc	Inria Saclay	2017-

Group evolution

Between January 2013 and April 2018, one permanent member left the group (Jérôme Azé, for a PR position in Montpellier in September 2013) and three new permanent members joined the group: Loïc Paulevé as a junior CNRS researcher in September 2013; Adeline Pierrot as an Assistant Professor in September 2014; and Flora Jay as a junior CNRS researcher in September 2015. Additionally Sarah Cohen-Boulakia, former assistant professor in the group, was hired as a Professor in 2017. Moreover, the head of the group has changed: until July 2015 Ch. Froidevaux and A. Denise were respectively head and co-head of the group, in July 2015, A. Denise and S. Cohen-Boulakia became head and co-head.

During this period, ten doctoral students have defended their PhD theses and two assistant professors got their HDR. The group has welcomed 14 master students, one engineer, three postdocs, two international visiting professors and two international visiting students. In 2015, the LRI-LIX-INRIA joint group AMIB has been refocused on the themes and perimeter of the bioinfo group at LIX. The two bioinfo groups of LIX and LRI have continued their close collaboration: they share a common seminar, they co-supervise PhD and postdoctoral students, they have several common publications and grants (including one ANR grant). Additionally, the LIX group members are associate members of the Bioinfo group at LRI.

Additionally, during the period, three permanent members of the group had a 18 months-leave: Sarah Cohen-Boulakia (délégation Inria, 2014-2016) at IBC Montpellier in the Inria VitualPlants and Zenith groups; Patrick Amar (CRCT then délégation CNRS, 2015-2017) at UMR SYS2DIAG - ALCEDIAG, Montpellier ; Sabine Pérès (délégation INRA, 2016-2018) at INRA Jouy-en-Josas. On the other hand, Florence d'Alché-Buc, Professor at the University of Evry (UEVE, IBISC) has been on leave (délégation Inria) both in our group and in the A&O group between 2011 and 2013.

3/ BioInfo

Research Description

The goal of the Bioinfo group is to design and develop new computer science approaches to answer real biological and bioinformatic questions. The main asset of our group is to not only understand the problems posed by the study of biological systems from the molecular scale to the scale of cells and populations, but also to design solutions involving skills from very various domains computer sciences (algorithmics, combinatorics, databases, knowledge representation, (statistical) data and machine mining, formal methods, and simulation).

We aim to make valuable contributions in three disciplines: computer science, bioinformatics and biology. This leads us to publish in computer science and applied mathematics journals and conferences (Theoretical Computer Science, PVLDB, SSDBM, CONCUR, AUTOMATA, Discrete Applied Mathematics, Annals of Applied Statistics, . . .) as well as in Bioinformatics and computational biology journals and conferences (Bioinformatics, BMC Bioinformatics, Algorithms for molecular Biology, IEEE/ACM transactions on Computational Biology and Bioinformatics, Molecular Systems Biology, PLoS Computational Biology, BMC Systems Biology, BMC Genomics, RECOMB, CMSB, ACM-BCB, . . .), and in Biology journals (PNAS, Nature Methods, Scientific Reports, Nature Structural and Molecular Biology, Nucleic Acids Resarch, Molecular Ecology, PLoS ONE, BMC Biochemistry, . . .).

Our scientific programme is structured into three themes according to the following major biological and bioinformatics fields: (i) Biological sequence and structure analysis, (ii) Systems biology and synthetic biology, and (iii) Integration and analysis of biological data.

Activities conducted within these three axes are highly correlated as witnessed by the presence of the same group members in several themes. More precisely, theme (iii) tackles the problem of rank aggregation in an innovative way by exploiting skills in combinatorial algorithmics usually developed to analyse biological sequences of theme (i); themes (ii) and (iii) have developed a framework to promote the edition of accessible and reproducible workflows for the analysis of qualitative models in systems biology (16, A28) (in close collaboration with IBENS and Institut Curie); a PhD thesis is currently co-directed in the group on the reconstruction of metabolic networks and involves algorithmics on the graph structure of metabolic networks, at the intersection of themes (i) and (ii).

Biological Sequences and Structures

Permanent participants: Alain Denise, Christine Froidevaux, Flora Jay.
PhD theses: Mélanie Boudard (A134, A12, 4) Adrien Guilhot-Gaudeffroy (A139, A84, 12) Bo Yang (A143, A43) Wei Wang (A142, A89, A66) Cong Zeng (A144) In progress : Théophile Sanchez (A112)

This axis is devoted to the development of computational (mainly algorithmic and statistic) methods for the **analysis and prediction of biological information in sequences and structures**. We notably work on population genetics, which involves designing new statistical approaches for deciphering the past history of human populations, based on the analysis large sets of genomic sequences. The second main topic of this axis is the development of algorithms for analysis, prediction and design of RNA structures and their interactions with proteins.

Statistics and Machine Learning for Population Genetics

Our main expertise in the population genetics field is the inference of the past history of one or several populations using various statistical tools, **from basic descriptive statistics to Bayesian Computation**. It includes reconstructing the demography and relationships of human or non human species both from modern and ancient DNA sequences.

We contributed to *tess*, a method for fast **inference of population genetic structure**. This method analyses SNP data and estimates the admixture coefficients (that is, the probability that an individual belongs to different groups given the genetic data) via matrix factorisation. The observed high dimensional genetic data are reduced automatically via the rank-k approximation of the matrix factorisation and thereby highlight the latent structure of the data: the matrix factorisation scores correspond to the admixture coefficients while the loadings give the genetic characteristics of each cluster. This method is faster than the hierarchical Bayesian models that we had previously developed and hence well suited for large NGS data. We participated in the **tess3 R package**, developed primarily by BCM (TIMC-IMAG), that implements this algorithm, facilitates the visualization of population genetic structure and the projection on maps (6). When zooming on a closer group of individuals, a new interest arise in **understanding the population structure**: inferring the specific family relationships between samples rather than their membership to one or several broad genetic clusters. In a collaboration with UC Berkeley, we developed a method to **infer the relatedness of individuals** from ancient DNA data, based on a measure of similarity between sequences and on simulations of genetic data over different pedigrees (family trees). In particular we investigated the robustness to the quality of the sequence data that is often poor for ancient samples due to DNA degradation (low coverage, error-prone, contamination) (15).

Although *tess* is very fast and has the advantage of reducing the data automatically, it reconstructs only a part of a population demography, e.g., the population structure. To infer more complex demographic histories, we contributed to the development of an Approximate Bayesian Computation (ABC) method that **estimates changes in the past effective population size of a single population** (3, A93). ABC frameworks applied to population genetics imply that the usually high dimension dataset is summarized into handcrafted summary statistics, and the likelihood of the model is approximated using a large amount of simulated data. We further extended this method to process sequence data rather than SNP-array genotype data by computing many summary statistics previously not combined in analyses, such as haplotype similarity, sequence sharing length, linkage between different genetic variants, and so on (A99, A92) (collab. MNHN, INRA Toulouse). Notably, many of these features take into account the position of sites along the sequence, hence the 1D structure of the sampled individual DNA sequences, rather than assuming that sites are unlinked and ignoring spatial information, as commonly done in SNP-array or site-frequency-spectrum -based approaches.

Algorithmics of Molecular Structures

Regarding structural bioinformatics, we mainly focus on RNA structures, aiming to develop **combinatorial and graph-based approaches** for solving key problems in structural bioinformatics. We notably developed new approaches for the comparison (A89) and the design of RNA structures (A66, 31), as well as for predicting RNA-protein interactions (A84, 12). Meanwhile we mainly focused on analysis and prediction of RNA three-dimensional (3D) structures.

In collaboration with DAVID (Versailles) and LIX (Ecole Polytechnique), we developed an original method of **prediction of the three-dimensional structure of large RNA molecules** at a coarse grain level, given their secondary structure only. Our approach is based on concepts of **game theory**. We represent the secondary structure by a *skeleton graph* where each element (e.g. helix, internal loop, hairpin loop) is a player who seeks to maximize his gain. Our first publication in the field (A27) was a kind of proof-of-concept. Then we developed in (A12) **regret minimization algorithms** which can sample a set of candidate 3D structures. Our experiments showed that our method behaves as well or better than its competitors in most cases. The subsequent article (4) presented several improvements, the main one being a criterion which allows to select two good candidates from the entire sample. This provides an essential advantage to our method compared to its competitors which return a large sample of structures. The resulting program is fully available at **http://garn.lri.fr**. This work was granted by the Digiteo JAPARIN-3D project.

In order to progress onto predicting the RNA structure at a fine grain level, we need to better understand the intricate and precise interactions which govern the 3D folding. This is why we also focused on the analysis of so-called *recurrent interaction networks* (RINs) in RNA 3D structures: these are small substructures composed of complex interactions between nucleotides, which are strongly involved in the

three-dimensional folding. We developed in (21) a **graph-based approach for automatically detecting and classifying these RINs**, and a web server (**carnaval.lri.fr**) allowing to browse, analyze, classify the patterns in the known structures and in new structures provided by users. This work was done in collaboration with McGill University and IBMC at Strasbourg University. It was granted by the 3D-Probing projet of *Fondation pour la Recherche Médicale*.

Systems Biology and Synthetic Biology

Permanent participants: Patrick Amar, Alain Denise, Christine Froidevaux, Bernard Labedan, Loïc Paulevé, Sabine Pérès.
PhD theses: Marc Bouffard (A135, A82), Martin Morterol (A261, A105, A200), Adrien Rougny (A141, A111, A122, A113, A76, A119, A40, 22) In progress: Juraj Kolčák (A100, 14), Hugues Mandon (A105, A68), Cécile Moulin (19). Alexandra Zaharia (A114)

The team has a strong activity in developing new computer science methods with applications oriented towards the modelling, design, and analysis of biological networks. Our main contributions include logic programming and abstract interpretation for capturing qualitative dynamics of signalling and gene networks, constraint based analysis of fluxes in metabolic networks, and network design and stochastic simulation frameworks for synthetic biology.

Formal methods for signalling and gene networks

Biological interaction networks account for indirect influences between the activity of proteins, RNA, and genes. Signalling networks detail cascades of biochemical reactions triggered by the cell receptors leading to the activation or inhibition of transcription factors mediating downstream gene expression, and, gene networks model the intertwined regulation of gene activities. These networks are central objects for studying main cellular processes such as cell cycle and cell fate decision (differentiation), as involved in many applications such as cancer and cell reprogramming for regenerative medicine.

In the group, we focus on the ***qualitative* modelling of signalling and gene networks using logic programming**, Boolean networks (BNs), Petri nets (PNs), and related formalisms. This approach allows capturing essential dynamical features of networks, such as attractors and differentiation processes, whereas requiring few parameters compared to quantitative models. Our approach builds on ***formal methods*** to offer scalable analyses and robust predictions.

Semantics of biological maps and BNs The knowledge of biomolecular interactions is usually represented as graphical maps which gather information on the entities, the kind of interaction, and other various annotations. Despite offering structured information on the network, these maps do not form fully-defined computational models, and additional interpretation have to be designed. Based on the *SBGN* (Systems Biology Graphical Notation) map formalism, we defined a translation of SBGN-AF maps (used to model biological activity flows) into *normal logic programs* which allow then the automatic reasoning on network structure and dynamics (A111, A122). We also defined an interpretation of SBGN-PD maps (used to model biological processes) into ***automata networks*** to further analyse dynamical properties, including the assessment of reachability properties and attractors (A119, A40). In this later work, we have been able to prove that an actual biological map of the cell cycle was missing key interactions in order to reproduce adequately the expected sequence of cell cycle phases. These results are part of A. Rougny PhD thesis.

Additionnaly and in collaboration with LSV, we have also transferred *concurrent semantics* of PNs to BNs, enabling new behaviours compared to their usual (a)synchronous semantics (A63).

Static analysis of dynamics of BNs The number of configurations and transitions of BNs being exponential with the number of nodes in the network, the analysis of trajectories of BNs is a common bottleneck. Actually, the verification of most of dynamical properties is PSPACE-complete.

Our speciality is the **design of an abstract interpretation for BNs and automata networks** in general. Our abstract interpretation lead to efficient decision of necessary or sufficient conditions for reachability properties, which scale to genome-scale networks (A21, A20, A120, A57, A121). We notably designed a *model reduction* which preserves minimal traces to a given configuration of interest, enhancing substantially the model-checking of biological networks (A71, 17). In collaboration with LS2N Nantes, we combined Answer-Set Programming with our abstract interpretation to implement **an efficient static identification of transitions** being responsible of cellular differentiation processes (A94, 11). These static analyses are implemented in the software Pint (A117, A72).

In collaboration with LSV, we employed Petri net unfolding techniques to tackle dynamics of BNs by taking into account their concurrency features for computing attractors (A62), and their combination with

our model reduction (28). We initiated the **formalization of *temporal reprogramming* of BNs** (A105, A68) in order to predict mutations inducing a drastic change in cellular behaviour (PhD work of H. Mandon, ANR-FNR AlgoReCell project). Importantly, we designed an abstract interpretation of *parametric* BNs, defining families of BNs sharing an architecture, which combines abstract domains of parameters with unfolding semantics (A100, 14) (PhD work of J. Kolčák, ANR-FNR AlgoReCell project). This work paves the way towards the formal reasoning on dynamics of *sets* of models.

Logic programming for map building and BN inference The team has also a strong expertise in logic programming and demonstrated its adequacy to tackle systems biology challenges. In collaboration with INRA Tour and NII Tokyo, we designed a deductive method to build signaling networks from experimental data (22) and we devised **an abductive reasoning to complete maps of signaling networks** so they become compliant with perturbation experiments data (A122, A113, A76) (PhD work of A. Rougny). In collaboration with IRISA Rennes, Potsdam University, and LS2N Nantes, we developed a framework for the systematic identification of BNs which can reproduce given time series with perturbations (A70, A56). Our framework combines Answer-Set Programming and abstract interpretation methods described above.

Biological process modelling In collaboration with microbiologists from I2BC, we have proposed the first explicative model for the sigmoidicity of the shape of the survival curve of the bacteria (*S. lividans*) possessing an antibiotic resistance gene, expressed at different levels, in presence of a constant concentration of antibiotics (23). This is particularly important since this method of inclusion of an antibiotics resistance gene to report the activity of its promoter is widely used in the streptomyces community.

Constraint-based analysis of fluxes in metabolic networks

Metabolic pathway analysis is a key method to study metabolism, and thus critical for improving our understanding of the functioning of living systems. A key concept is elementary flux mode (EFM) analysis (EFMA), which allows one to analyze without bias metabolic networks in terms of minimal pathways (A87, A85). The challenge is associated with two main problems: (i) the number of EFMs explodes with the size of the metabolic network (ii) even if a full EFMA in large networks was possible, then gazillions of EFMs would need to be stored, processed and further analyzed to gain biological knowledge, which would by far exceed current computational capabilities. We proposed different methods of computation which: (i) add biological constraints to reduce their number (ii) use new method to compute directly the EFMs of interest to gain in memory size. Another key concept is the dynamical simulation (A81) of the fluxes and of the metabolite concentrations but it is limited to the kinetics information availability.

Integration of biological constraints in the EFMs computation In collaboration with the University of minas Gerai Brazil, we included the structural information associated with enzymes to **calculate more relevant pathways** when they are confronted to genetic regulations (18). In collaboration with the University of Jena, we proposed a new method to integrate thermodynamic constraints in the computation of EFMs *EFMs* (19). Our method only checks a formulae for each EFM and needs few biological data (equilibrium constant and external metabolite concentrations) whereas the traditional method call a linear program and need biological data which are more difficult to obtain (the internal metabolite concentrations) (A209, 26). We integrated kinetics and resources allocation information in the analysis of *EFMs* in collaboration with MaIAGE INRA Jouy-en-Josas and we showed that it reduced considerably the feasibility space and allow the prediction of the optimal concentrations.

New approach for computing the EFMs based on logic programming In collaboration with the LaBRI Bordeaux, we were the first to propose a method to **compute EFMs based on SAT** (satifiability) solving (A105). The main advantage is the gain in memory space because it computes EFMs of interest without generating all of them. Even if computing all of them is less efficient than the traditional method, this proof of concept opens new perspectives in their computation. To improve the computation performances, we extended our method in a SMT (for *Satisfiability Modulo Theories*) (A200). This method is well-adapted to integrate the transcriptomic regulation constraints as Boolean formulas.

Dynamic analysis of metabolic networks In collaboration with Polytechnique Montréal Canada, we constructed two dynamical models able to (i) describe the butanol production in the *Chlostridium acetobutylicum* with riboflavin as a by-product (A46) and (ii) identify biomarkers of Wharton's Jelly mesenchymal stromal cells (A52). We analyzed the implication of the metabolism in the cancer cell (A80, A50, A54) and we constructed a **dynamic model** which proposes a metabolic therapy to reroute the cancer metabolism in a healthy metabolism (A109).

Design and simulation of circuits for synthetic biology

Simulation In the continuation of the previous works on simulation systems, and in collaboration with the PRiSM lab at the university of Versailles, a new parallelised implementation of the entity-centered approach (HSIM-like system) has been developed (A60). This approach is the most accurate but is limited to small systems (thousands of molecules) due to its great needs of computing resources. The parallel implementation uses the BOBPP **high-level parallelisation framework** on multi-core processors. These works lead to a new parallel version of the HSIM system; The speed-up was near the maximum possible thanks to the variant of the sub-volume method where no synchronization is needed; So the only limiting factor that remains is the global memory access time (unpublished results).

In a collaboration with Yale Systems Biology Institute, we studied whether cell-cell communication can enhance the ability of cell ensembles to sense and respond to weak gradients of chemotactic cues. Using a combination of experiments and mathematical modeling we found that multicellular sensing enables detection of and response to shallow epidermal growth factor gradients that are undetectable by single cells. The ability of HSIM to take into account 3D space and the efficiency of its implementation allows us to build models and make numerous simulations to study the influence of the communication noise on the ability to sense weak gradients (10).

Synthetic biology In a collaboration with the Sys2diag lab. (UMR 9005) at Montpellier, we worked on the automatic design an artificial embedded biological nano-computer that detects markers of selected human pathologies (for example, metabolic complications of diabetes: diabetic ketoacidosis, hyperglycemic hyperosmolar state, hypoglycemia and lactic acidosis).

We have developed the *in silico* framework *Silicell Maker* (software p. 147), supporting design automation of synthetic biochemical logic circuits (**https://silicellmaker.lri.fr**). Silicell Maker is a metabolic network oriented SBGN graphical editor that includes general purpose plugins, such as HSIM for network simulation, and specific plugins for logic gates extraction (NetGate) and logic gates assembly (NetBuild). These last two plugins were part of the PhD work of Marc Bouffard (A82, A135).

Early versions of Silicell Maker have been used at Sys2diag, to design the synthetic networks embedded in artificial liposomes that has been actually build using the Sys2diag microfluidic plateform. We used HSIM (Amar *et al.* 2008, software p. 148) to perform the simulations and BIOCHAM (Fages & Soliman 2008) for robustness analysis, prior to the *in vitro* tests. This is the first accurate *in vitro* micro devices integrating medically relevant diagnostic algorithms, working in the biochemically noisy environment found in real clinical samples. These works lead to common publications (A17, 9).

Integration and Analysis of Biological Data

Permanent participants: Sarah Cohen-Boulakia, Alain Denise, Christine Froidevaux, Adeline Pierrot.
PhD theses: Bryan Brancotte (A136, A61, A115, 5, 24) Jiuqiang Chen (A137, 29, 8); In progress: Pierre Andrieu.

This axis is complementary to the two previous ones as it focuses on *the way* Bioinformatics analyses are performed (A138). Such analyzes are increasingly complex, they involve big and heterogeneous datasets which need to be combined. Challenges to be tackled are then particularly numerous and include reproducing, reusing and optimizing scientific experiments but also querying and ranking large biological datasets.

Scientific workflow systems (including notebooks and other approaches used to represent bioinformatics analyzes) are massively used by the Bioinformatics community and are the privileged object of study of the first sub-axis. As taking into account the level of quality and trust (expert preferences) in biological data sets is a particularly important point in Bioinformatics, **ranking** approaches are then the core of the second sub-axis.

Reproducibility and Reuse with Scientific Workflows

Scientific workflow management systems have been developed to support scientists in developing, running, and monitoring chains of data analysis programs. A variety of systems have reached a level of maturity that allows them to be used by scientists to conduct their bioinformatics experiments.

The first series of our contributions to this field aims at **increasing reuse of scientific workflows**, following two directions.

First, in collaboration with Humboldt University (Berlin), we have studied *workflow similarity* as a means

to find workflows in existing repositories (such as myExperiment). We have compared various approaches performing **scientific workflow comparison** (based on text/annotation, graph structure...), investigated how these approaches can best be combined into aggregated measures, and made available a gold standard of over 2000 similarity ratings contributed by 15 workflow experts on a corpus of 1,500 workflows and re-implementations of all methods evaluated (24). We have then presented a novel and intuitive **workflow similarity measure based on "layer decomposition"** (which accounts for the directed dataflow underlying scientific workflows) (A77) and showed how it is able to deliver high quality results with much lower runtime than other structure-based approaches (25).

Second, we have proposed an approach to reduce the complexity of scientific workflows by removing redundancy in workflows using the concept of ***workflow anti-patterns*** that we introduced (8). This approach has been designed in collaboration with members of the Taverna project (University of Manchester) and driven by user needs expressed during interviews of end-users, and evaluated on the workflows of the BioVel European project (leaded by the Univ. of Manchester). The resulting system, *DistillFlow* (29), is able to reduce the complexity of any taverna workflows and can be used by any Taverna user (A137).

Another series of contributions is related to the use of scientific workflows to ***improve the reproducibility of scientific experiments***. In close collaboration with members of Inria and INRA at Montpellier, we have demonstrated the ability of the workflow system OpenAlea (designed at Montpellier) to perform reproducible experiments (30). We have then designed and implemented InfraPhenoGrid (20), a full infrastructure able to handle and analyze large plant phenotyping datasets produced by the PhenoArch platform of INRA Montpellier. Finally, in (7), we have defined **levels of reproducibility** that can be reached when using scientific workflows and we have characterized the criteria that need to be catered for by reproducibility-friendly scientific workflow systems. This work has been done in collaboration with members of the action on reproducibility that LRI co-leads in the GDR MaDICS.

Consensus Ranking of biological datasets

The aim of biological data ranking is to help users face with huge amounts of data and choose between alternative pieces of information. This is particularly important in the context of querying biological data, where very simple queries can return thousands of answers. Ranking biological data is a difficult task since data may be associated with various degrees of confidence and various ranking criteria can be considered (the most well-known data ranked first, or the freshest, etc). The general and original approach we propose to follow is to rank biological data by considering two steps: (i) several ranking methods are applied to biological data (results are ordered using alternative ranking criteria and/or exploiting various ranking methods), (ii) **rank aggregation** approaches are used to reflect the input rankings' common points while not putting too much importance on elements classified as "good" by only one or a few rankings (that is, minimizing their disagreements). The problem is known to be difficult (NP-complete) and while rank aggregation techniques (also called *consensus ranking approaches*) are very promising in this context, they are intrinsically complex and a plethora of approximations and heuristics have thus been designed, making the choice of the approach to follow for the user very difficult to make.

This work has been performed in the context of a long-term collaboration with members of the University of Montréal and in the context of several National projects, CNRS PEPS and Mastodons projects. Our aim is to carefully study the problem of rank aggregation for biological data **both practically and fundamentally**. So far, our results are three-folds. First, we have performed a **comparative study of rank aggregation algorithms** (5). A total of twelve algorithms have been reimplemented, benched on 19 000 generated and real datasets. As a result, we have identified the data features (e.g., the similarity between input rankings) allowing to **understand the behavior of algorithms** to then guide users. Second, we have provided new results on the **complexity of the problem** and on more fundamental aspects of the mediane problem (27, 1, A47, A136, A107). Third, in close collaboration with members of the APHP, we have designed ConQuR-Bio, a tool able to **efficiently rank biological data** obtained as answer to a query on major biological data repositories (http://conqur-bio.lri.fr/) (A61, A115).

The Bioinfo group members have at two kinds of regular meetings: (i) our seminar series, every two to three weeks, and (ii) the permanent members meetings, once a month. The *seminar series* (joint with the LIX AMIBio group) has been very active: there were about 80 talks during the period. Among them 47 were given by invited researchers: 13 foreign researchers and 34 French researchers from other groups. The remaining talks were given during internal seminars by members or associate members of the group. They notably help the group members to know each other's works and to start or strengthen collaborations.

As for *the permanent monthly meeting*, it allows the (permanent) members to share information about the research they currently conduct and express the need they may have in terms of budget, e.g. to travel to conferences or to hire master student interns. Current open calls for projects (at international, national and local levels) and responses to such calls by group members are discussed. Main expenses are decided together by the permanent members.

Special attention is paid to welcoming our new members: trainees and Ph.D. students as well as new permanent members. They are systematically allocated a desk in a room (2 or 3 students per room), and a laptop or desktop computer. They attend the group seminar and are invited to give talks in our seminar series. We encourage and help Ph.D. students (by scientific and financial support) to give talks in workshops and conferences in France or abroad. Regarding the new permanent members, additionally we give them as much help as possible for preparing grant applications (from local to national and international projects) and we strongly encourage them to supervise students.

Self Assessment

Strengths: The main strength of the Bioinfo group is to be able to design and develop new computer science approaches to answer actual questions in Biology and in Bioinformatics. The main asset of our group is to both understand the problems posed by the study of biological systems in the broad sense of the term, from the molecular scale to the scale of cells and populations, and to design solutions involving skills from various domains in computer science: from algorithmics and combinatorics to databases, knowledge representation, (statistical) data and machine mining, formal methods, and simulation. Our originality lies in combining such different skills to solve a given problem, *e.g.* considering both combinatorics and databases to rank biological datasets or combining knowledge representation, formal methods and simulation to study systems biology networks.

Another strength of our group is to conduct long-term collaborations non only with computer scientists but also with various biological groups (joint Bioinformatics group at I2BC; Sys2diag, a joint-institute between the biotech company Alcediag and CNRS, Montpellier; Curie Institute and Pasteur Institute, Paris; IBMC, Strasbourg; INRA Montpellier, Tours and Jouy-en-Josas...). These groups include experimental biologists, which leads to collaborations where our hypotheses and models can be experimentally validated.

The visibility and the attractiveness of the group is high. At the international level, we have acquired a good visibility in our three scientific axes (Systems Biology, RNA algorithmics and Data integration) as evidenced by co-supervising PhD theses, supporting travels, and common publications. At the national level, we have been involved, often as leaders, in several projects (ANR, CNRS PEPS and Mastodons) and we are active in several GDRs.

During this period, our group has hired a full professor (data integration), an assistant professor (combinatorics), and twp junior CNRS researcher (system biology and statistical machine learning). Our seminar series is still very active with numerous invited talks, fostering discussion and exchange between biologists, bioinformaticians and computer scientists.

Last but not least, from the local side, the Bioinfo group is strongly involved in the Master of Bioinformatics and Biostatistics to attract students with a strong pluridisciplinary background for internships and PhD theses (in the last five years, members of our group supervised 18 PhD students and doctors of our group have mainly continued their activity in the field in recognized institutes, universities or companies in France or abroad).

Weaknesses: Members of the Bioinfo group have been strongly involved in the animation of the Bioinformatics community both from the research side (implication in GDRs, working groups, IFB, ELIXIR...) but also from the teaching side (head of the Paris-Saclay Master of Bioinformatics). They have been also strongly involved in the animation and management of the Computer Science community, at the national level (SIF) as well as the local level (Department of Computer Science, Paris-Saclay STIC Department, Paris-Saclay Master of Computer Science...). We consider all these aspects of our work as mandatory duties while they are, in essence, highly time-consuming.

Working in a pluri-disciplinary setting may also be time-consuming and in particular it implies to both depend on experimental results to be performed to validate results, and includes, even more than in other domains, developing software to provide proof-of-concepts of our approaches or make our solutions available for the scientific community. Without any engineer dedicated to the group, we have to deal with the development and valorization of our own software. We have been affected by the reconfiguration of the *LRI software development service* (following the departure of the engineer in charge of the service). We used such a service for the licensing (in particular, "APP" deposit) of several of our software programs.

Opportunities: The recent hiring of Flora Jay (CR CNRS on machine learning and population statistics) is an excellent opportunity, providing new highly complementary skills in the data-oriented activities of the group. Additionally, we will benefit from our strong involvement in the CDS (Center for Data Science) and labex DigiCosme ("DataSense" action line) and more generally in projects of the Université Paris-Saclay.

Threats: Loic Paulevé (CR CNRS) is leaving the group to move to the LaBRI. The risk could be to get research activities on System Biology less active. However, Loïc Paulevé will become an associated member of the group since active collaborations will go on with him, notably across a thesis co-supervision which will begin in October 2018. Additionally, we plan to hire assistant professors (and hope to get CR CNRS) for the group on the next period.

3/ Bioinfo

Strategy and five-year Project

Group's identity and positioning

The identity of the Bioinfo group is funded on two main pillars.

- We are willing to tackle true biological problems. For this, we develop data-driven approaches leading us to introduce new concepts and methods in computer science and mathematics.
- We combine our areas of expertise in computer science (algorithmics, combinatorics, databases, knowledge representation, data analysis using statistics and machine learning, formal methods and simulation) to tackle biological problems.

Given the characteristics of biological data – highly distributed (more than 1,500 databases identified), highly heterogeneous (many data formats, various quality level), reflecting growing and constantly refined expertise over time – combining different and complementary skills in computer science is of paramount importance and a strong asset of our group.

We cannot consider our project without considering the local, national and international context of our work.

At the local level, we collaborate and will continue collaborating with the groups in Paris-Saclay and nearby. Within the LRI, we have natural collaborations with several computer science groups: A&O (*machine learning*, in the context of CDS, one PhD co-supervised), GAIaC (*algorithmics and combinatorics*, one PhD co-supervised), LaHDAK (*data integration*, joint LRI project, involvement in the Mastodons project), VALS (*process certification*, joint LRI project). Nearby, we also closely collaborate with groups from DAVID (Versailles), LIX (Polytechnique), LSV (ENS Paris-Saclay). Whatever will be the future structure of research in computer science in the near future in Paris-Saclay, we will continue cultivating these fruitful relations, as well as our close collaborations with Biology institutes (I2BC, INRA). In this local context, our group has been particularly active in promoting the Bioinformatics discipline and in animating the Bioinformatics community. For example, we have been strongly involved in several projects funded by the IDEX

Paris-Saclay, namely the multidisciplinary IMSV initiative (Institut de Modélisation des Systèmes Vivants), the CDS (Center for Data sciences), and the CompBio (Computational Biolgy) initiative. Our group is active in the "DataSense" action line of the labex DigiCosme, where we co-lead the TheoBioR and the PASADENA working groups, giving us the opportunity to extend our collaborations in computer science, and be at the heart of an active and strong network on bioinformatics in the region. Last but not least, members of our group are major actors of the Master in Bioinformatics of Paris-Saclay, involving the Universities of Versailles and Evry, and Ecole Polytechnique.

From the National perspective, we are actively involved in several GDRs, notably "Bioinformatique Moléculaire" (BIM) and "MaDICS" (Masses de Données, Informations et Connaissances en Sciences) where we co-lead working groups. We are collaborating with a large number of Inria (especially from the "Digital Health, Biology and Earth" research field) and INRA/CIRAD groups, notably in Montpellier, Bordeaux, Rennes and Tours, and with several research groups in Universities, in computer science, bioinformatics and biology. Our group is also part of the IFB (Institut Francais de Bioinformatics) funded by PIA and leads the action on Interoperability.

At the international level, the BioInfo group has strong and long-term collaborations with several renowned groups (from USA, Canada, China, Germany, UK, Luxembourg...). Our group is involved in several research networks and actively involved in the ELIXIR European Infrastructure of research network. Up to now all these collaborations have led to joint publications, funding for exchange of researchers (mid-term visits, PHC grants), and international ANRs (with Austria and Luxembourg).

Project Resarch themes

We now briefly present our main scientific projects in the three thematics of the group.

Biological Sequences and Structures

Statistics and Machine Learning for Population Genetics We will pursue our research on the development of demographic inference methods, focusing on deep learning approaches and paleogenetics applications. Our goal is to develop a family of methods that automatically solves population genetics tasks. For that we will leverage the strength of ABC to tackle highly complex tasks (corresponding to model with unknown likelihood), and the strength of deep learning to automatically extract relevant information from data. We are currently developing a deep neural network architecture that takes as input the aligned sequence data of multiple individuals, and is trained on simulations to predict demographic descriptors (collaboration with the A&O group (A112)). Many works will follow to extend this proof of concept: (i) encoding the invariance properties of population genetics data into the architecture (ii) adapting the methods of network visualization that easily highlight the recognized patterns in image but not in population genetic patterns, (iii) making use of probabilistic networks that provide the uncertainty estimates that are inherent to most of the current population genetics tools. To our knowledge this is the first work on the use of end-to-end deep learning for population genetics demographic inference and these steps will be of paramount importance to motivate the use of this methodology by the community. A major application of this work will be the development of a method to reconstruct demographic and selective history of bacterial populations (collaboration with Pasteur Institute and MNHN). More generally we are part of consortiums that are preparing applications for funds on various topics of paleogenetics, such as: better understanding the Bronze/Iron Age transition in central Asia; modelling cultural and genetic evolution in the Neolithic, and will thus direct our methodological development efforts towards these tasks by modelling explicitly ancient DNA.

Algorithmics of Molecular Structures Our main long-term objective is to better understand how RNA folds, and to develop data-driven algorithmic approaches able to predict the structure of large RNA molecules. Our recent works on RNA structure alignment, on coarse-grained sampling on 3D structures, and on fine-tuned analysis of recurrent interaction motifs (RINs), give us a solid basis to go further towards the prediction of RNA 3D structures, given the sequence only. One of the main bottlenecks of the current approaches is the problem of predicting the so-called non-canonical interactions. These interactions, and the way they assemble together to form recurrent networks, are essential to shape the 3D architecture of the molecule and to provide the key elements to carry molecular functions such as protein or ligand binding. Predicting RNA structures including non-canonical interactions will be our main concern in the next years. For this purpose and together with McGill University, IBMC at Strasbourg and DAVID at Versailles University, we notably aim at developing new algorithmic approaches which will take advantage of our recent works on RINs.

Systems Biology and Synthetic Biology

Formal methods for signalling and gene networks A prime challenge in systems biology is the delineation of computational models which are compatible with experimental data, and are able to accurately predict mutations to control the biological system. We will continue exploring the use of logic programming (including Answer-Set Programming) and knowledge representation to offer scalable methods for inferring qualitative networks from experimental data, and apply logical reasoning on sets of candidate models. Notably, we are just starting to work on the inference of Boolean networks from cell differentiation data and genome-wide CRISPR screening of mutants, with applications to predict synergistic genetic interaction for the colon cancer. This research direction involves close collaborations notably with LaBRI, Institut Curie and LSV. This project has just received the support of ITMO Cancer of Aviesan (Plan Cancer) for the funding of a PhD student.

As concerns signalling networks, we have been working at developing a method capable of building signalling networks from all available data: results of experiments from the scientific literature and omics data available within public databases. We will continue in this direction, enriching the set of interpretative logic rules that allow mimicking the reasoning that biologists apply when interpreting experimental results and developing the use of deductive reasoning within the framework of Answer Set Programming. Also we plan to investigate an argumentation theory approach for the search for explanations to deduced facts. This work will be done with the LaHDAK team at LRI and will be performed in the context of the ANR project ABLIS (2018-) with the BIOS group at INRA Tours and The Natural Language Processing group of the LIFAT (Univ. Tours).

Constraint-based analysis of fluxes in metabolic networks As for metabolic modelling, we aim to develop a novel and comprehensive, high-performance EFM analysis software suite using the logic based methods. It will integrate omics data sets and relevant biological constraints as well as user-defined queries into the EFMA in order to identify only the biologically relevant EFMs. For this purpose, we will develop new methods to describe the metabolic networks based on logic-based modeling, notably in collaboration with LaBRI. In particular we will notably extent our approach which takes into account thermodynamic and kinetics constraints in addition to Boolean regulatory constraints. We will apply it to study the metabolism of *Bacillus subtilis*, notably in collaboration with MaIAGE (INRA Jouy-en-Josas) which has a strong expertise on this bacteria and will provide computational tools and methods for the consolidation of the genetic regulatory network of bacteria, the formalization/integration of protein cost (resource allocation) in the efficient computation of EFMs, and the omic data analysis for algorithm validation. We thus will carry out the first EFMA of a genome-scale metabolic model. The combined development of established and innovative methods and their validation on *Bacillus subtilis* metabolic models guarantee that we will deliver the first EFM analysis of a genome-scale metabolic model. This should represent a major breakthrough in terms of computational achievements and biological insight into metabolism.

Synthetic Biology Concerning synthetic Biology, we plan to concentrate our efforts at developping further the design of an artificial embedded biological nano-computer that detects markers of selected human pathologies, in collaboration with the Sys2diag lab (Montpellier, joint research CNRS unit with the ALCEDIAG company). We have achieved the first part of our project, the SILICELL MAKER software that can automatically translate a medical diagnosis algorithm (represented as a boolean formula where the inputs are the biomarkers of a pathology) to one or more enzymatic networks, that, when implemented in an artificial liposome can sense the biomarkers and give a colorimetric output in actual clinical samples. Prior to actually build the liposome embedding the enzymatic network, many simulations must be made using HSIM with the actual dimensions of the liposome and the real concentrations of enzymes and metabolites in order to obtain the "best" concentrations that will give the best sensitivity and robustness to the actual device. For this purpose, we explore ways to speed-up the HSIM simulator by at least two (and possibly three) orders of magnitude in order to: first, use it as the fitness function of an automatic tool that could efficiently search in a huge parameter space the best possible concentrations of molecular species that give the maximal robustness to the diagnosis device, and second, use the unique features of HSIM (spacial localisation, and real size and geometry of protein assemblies) to make simulations of models that cannot be achieved without these features. We consider to use highly parallel computations to speedup the simulator. A complete redesign of the HSIM system using GPGPU (high performance computing co-processors used in graphic cards) using new parallel algorithms is under development.

Integration and Analysis of Biological Data

The current program has two main axes, management of scientific workflows (with a specific focus on reproducibility) and rank aggregation for biological data.

Scientific workflows The major problem we want to work on during the next period is the design of a framework to ensure the reproducibility of the results obtained in a research paper. Scientific workflow and Provenance will play a major role. This line of research will be fed by the series of *ReproHackathons* we have started to launch with IFB and the CompBio Paris-Saclay STIC/Life-Science working group. This work will more generally be placed in the action of the group in research integrity and ethics. Another line of research on scientific workflow consists in considering the dynamics of workflows (while they have been studied statically so far). We plan to design new hybrid approaches for the discovery of workflows, combining *graph mining* and *process mining* and design optimization technics (refactoring) of workflows mixing graphs and model aspects. Still on the use of specification and/or verification methods in the context of scientific workflows, ongoing work includes Coq certification of biological data processing. Such work will be done notably in collaboration with the VALS group and the LSV.

Rank aggregation As for the rank aggregation topic, our aim is to continue mixing combinatics and database technics to tackle the problem. Our first objective is to design a generic framework, able to uniformly consider all the distances (and metrics) that can be designed to compare rankings. Being able to formulate the mathematical properties underlying various ranking systems would allow to reach a better understanding of such system. This work will be performed with members of LORIA (in the context of the Mastodons QCM-BioChem), experts of social choice theory where rank aggregation is highly studied. Our second objective is to consider the robustness of a consensus ranking provided: for each ranking obtained we want to provide the user with the confidence s/he may have on the order provided (it may be the case that some elements are should be at a given position while others are more "volatile" and could be possibly placed at several positions). This work has just started and is performed in collaboration with members of the Laboratoire de Mathématiques (Paris-Sud) in the context of a project funded by CDS (Center for Data Sciences). Our third objective is the main target of this work: explore the results obtained by rank aggregation techniques in biological datasets. Carefully tuning the distances and kind of algorithms used is highly challenging and will be provided by the two previous points. Very first results obtained on datasets carefully inspected by haematologists from APHP Paul Brousse (on acute myeloid Leukamia) are very promising.

Annex 4

Collaborations

Participation in National and International collaborative research projects

During the period, the Bioinfo group has participated to two international ANRs (one as leader) and has co-leaded three PHC programs and participated to another PHC and to one collaborative program with NII. The group has also been involved as partner of another (national) ANR, has leaded an IFB project (funded by PIA 3), a three-year CNRS Mastodons project and two CNRS PEPS. On the regional side, we lead two DIM projects, one RTRA project and have been part of two large projects funded by the Paris-Saclay IDEX. The amount of funding are provided in the section "Contracts and grants" (only for the projects we lead).

International projects LRI is co-leader of all projects below except the ANR *RNALands* and the two last projects (one PHC and the collaboration with NII).

- *AlgoReCell: Computational Models and Algorithms for the Prediction of Cell Reprogramming Determinants with High Efficiency and High Fidelity* (2017-2010), **ANR and FNR (Luxembourg)**, Coordinator: L. Paulevé. Partners: LRI, LSV, Institut Curie, Université du Luxembourg.
- *RNALands: Fast and Efficient Sampling of Structures in RNA Folding Landscapes* (2014-2019), **ANR and FWF (Austria)**, Coordinator: Y. Ponty (LIX), Partners: Inria AMIB, Inria BONSAI, LRI, University of Vienna.
- *Abstract interpretation for parametric biological networks* (2018), **PHC** Barrande project, Campus France, Coordinator: Loïc Paulevé. Partners: LRI, LSV, Masaryk University (Czechia).
- *Combination of time-course gro-seq assay, algorithmic and software development for measuring geneome-wide transcription rates*, **PHC** project Xu Guangqi 2017 (Campus France), Coordinator : A. Denise, Partners : Wuhan University, Ecole Polytechnique.
- *Sharing and Optimizing Scientific Workflows* (2013), **PHC** Project Procope, Campus France, Coordinator: S. Cohen-Boulakia. Partners: LRI, Humboldt University zu Berlin (Germany). Joint publications: (24, A77, 25).

- *Constrained random permutations: algorithms and analysis* (2015), **PHC** Project Germaine de Staël, Campus France, Coordinators: Lucas Gerin and Mathilde Bouvel. Partners: LRI, LIX, Zurich University (Switzerland). Joint publications: (2).
- ***NII*** *Collaborative Research Project* "Hypothesis finding by Reasoning and its Applications to Scientific Discovery" (2013-2014) and "Food and Health by Information Technology" (2014-2015). Coordinator: Y. Yamamoto, Participants: Ch. Froidevaux, A. Rougny at LRI. Partners: NII Tokyo and Univ. of Yamanashi (Japan), LRI, LIP6, INRA Tours (BIOS). Joint publications: (A113, A122, A111, A76).

National projects

- *QCM-BioChem*, **CNRS Mastodons** grant 2016-2018, leader: S. Cohen-Boulakia, Partners: eleven labs from INSII (including LORIA, IGM, LIRIS) and from INSB (including IFB). Joint publications: (A107).
- *FoRCe*, **CNRS PEPS** grant 2017, leader: L. Paulevé,
- *RankaBio*, **CNRS PEPS** grant 2015, leader: S. Cohen-Boulakia, Partners: IGM (Institut Gaspard Monge). Joint publications: (5)
- *IFB-NGphylogeny.fr*, **IFB Grant** grant 2016-2018, leader: S. Cohen-Boulakia, Partners: Institut Pasteur, LIRMM.
- *3D-Probing*, **FRM** grant 2015-2017, participant: A. Denise. Leader: Y. Ponty, LIX. Partners: LIX, Laboratoire de Cristallographie et RMN Biologiques (Univ. Paris-Descartes), Univ. Strasbourg, McGill University. Joint Publication: (21).
- *NGD-NSD*, **ANR** grant 2012-2015, participant: A. Denise. Leader: O. Namy, IGM. Partners: IGM, Paris-Sud, Institut Pasteur.

Regional and Local projects LRI members lead the three first projects below and they are active members for the two Idex Paris-Saclay projects.

- *BactPopGenML*, **DIM** Ile-de-France grant 2018-2020, Coordinator: F. Jay. Partners: Institut Pasteur, ISYEB (MNHN/CNRS/UPMC/EPHE).
- *FormaReBio*, **DIM** Ile-de-France grant 2018 Coordinator: L. Paulevé. Partners: LSV. Joint publications: (A63).
- *JAPARiN-3D*, **RTRA-Digiteo** grant 2012-2016 Coordinator: A. Denise. Partners: PRISM (UVSQ). Joint publications: (4, A12)
- *(Paris-Saclay) CDS*, Center for Data science, interdisciplinary project IDEX. Coordinator: B. Kegl (CNRS). Resp. of Life science axis, co-leader of the i/o data platform and responsible for the track on integrating Master students in research: S. Cohen-Boulakia. Partners: More than 350 permanent researchers in 50 laboratories participate in the CDS supporting many data science projects and events.
- *(Paris-Saclay) IMSV*, Institut de Modélisation des Sciences du Vivant, interdisciplinar project, IDEX. Coordinator: V. Fromion (INRA). Leader of track 3 "Integration for bacterial cells": Ch. Froidevaux. Partners: INRA MaIAge. Joint publications: (13, A98).

Collaborations with other laboratories leading to joint publications

We consider below only collaborations not already considered in the projects above.

International collaborations

- Biological sequences and structures: J. Waldispühl (U. McGill, Montreal) (31); Y. Zhang, Y. Zhou, X.D. Fu (U. Wuhan) (31, A43); M. Slatkin and Mike Martin (UC Berkeley, USA) (15);
- Systems biology and synthetic biology: A. Levchenko (University of Yale) (10); H. Koeppl (ETH Zürich) (A25, A78); S. Schuster (U. Jena, Germany) (19, A209); M. Jolicœur (Polytechnique, Canada) (A46); L. Felicori (U. Belo Horizonte , Brasil) (18);
- Integration and analysis of biological data: S. Hamel (U. Montreal) (5, A107); S. Davidson, S. Khanna (University of Pennsylvania) (24, A77, 25); C. Goble (U. Manchester), P. Missier (U. Newcastle) (8, 29); M. Bouvel (U. Zurich) (2).

National collaborations

- Biological sequences and structures: E. Westhof, IBMC, Strasbourg (21); S. Vialette, LIGM, Marne-la-Vallée (31); O. Francois (TIMC-IMAG) (6);
- Systems biology and synthetic biology: F. Molina, Sys2diag, Montpellier (A82, A17, 18); L. Calzone (Institut Curie) (A40); C. Guziolowski, M. Magnin, O. Roux (LS2N, Nantes) (11, A20, A21, A57, A120); A. Siegel, (IRISA, Rennes) (A70, A56); J-P. Mazat (IBGC, Bordeaux) (A85, A80, A81);
- Integration and analysis of biological data: P. Valduriez, Ch. Pradal (Inria Montpellier), P. Neveu (INRA Montpellier) (30, 20, A49); Ch. Blanchet (IFB, Gif-sur-Yvette), O. Collin (IRISA, Rennes), K. Belhajjame (Univ. Paris-Dauphine), F. Lemoine (Institut Pasteur, Paris) (7); G. Blin, LaBRI, Bordeaux (5); F. Bassino, C. Pivoteau (2);

Paris-Saclay and NewUni collaborations

- Biological sequences and structures: D. Barth, F. Quessette, S. Vial, DAVID, Versailles(A27, A12, 4); Y. Ponty, J. Bernauer, LIX, Ecole Polytechnique (A66, 31, A89, A101, A12, 4, A84); O. Lespinet, Ch. Drevet, I2BC, Université Paris-Sud (A86, A35, A118);

- Systems biology and synthetic biology: D. Barth, F. Quessette, S. Vial, B. LeCun, DAVID, Versailles (A60); S. Haar, T. Chatain (LSV, Cachan) (14, 28, A62, A68, A100, A105); V. Fromion (INRA, Jouy-en-Josas) (A98);
- Integration and analysis of biological data: L. Gerin, D. Rossin (Ecole Polytechnique) (27, 2, A47).

Visiting professors and students (more than one week)

- Robin Milosz, Université de Montréal, PhD. student, 6 months, 2017-2018.
- Vladimir Reinharz, McGill University, PhD. student, 6 months, 2013.
- David Safranek, Masaryk University, Czechia, Assistant prof., 2 weeks, 2017.
- Ulf Leser (Professor) and Johannes Starlinger (PhD student), Humboldt University zu Berlin, 2 weeks, 2013.

Other Collaborations

- Sabine Peres: Invited Professor at Polytechnique Montréal Canada, 3 months 2017.
- Flora Jay: Invited visitor at Estonian Biocentre Tartu Estonia, 1 week 2017

Participation to international, national and local networks

Members of the Bioinfo group are involved in the following networks and working group.

- International and National levels
  - The ELIXIR European research infrastructure network (**https://www.elixir-europe.org/**)
  - International Permutatioin Pattern community (regular talks at the annual workshop, A. Pierrot).
  - The IFB (Institut Francais de Bioinformatique, supported by PIA 3)
  - Four CNRS GdRs: the *GdR Bioinformatique Moléculaire (BiM)* (A Denise is a member of the Scientific Committee); the *GdR Mathématique Informatique (IM)*; the *GdR Masses de Données, Informations et Connaissances en Sciences (MaDICS)* (we co-lead the *ReproVirtuFlow* working group); the *GdR Approche Interdisciplinaire de l'Evolution Moléculaire (AEIM)*. We are also strongly involved in the *GT BIOSS* (biologie systémique symbolique) both supported by GDR BIM and IM.
  - The *Société Informatique de France* (SIF)
- Local level
  - "TheoBioR" working group of Labex Digicosme, Paris-Saclay, involving 7 labs (I2BC, IBISC, INRA Jouy-en-Josas, Inria Saclay, LRI, LSV, MAS) in the Paris-Saclay area: Loïc Paulevé, coordinator, 2016-2018; A. Denise, Ch. Froidevaux, P. Amar, S Pérès: members.
  - "PASADENA" (Prediction and Analysis of Structured and Heterogeneous Data) working group of Labex Digicosme, Paris-Saclay (2015-2018), involving LTCI, L2S, LRI, Neurospin, IBISC, Lamme, MICS, LSTA/LIP6, ICM, Univ. Dallas, Institut Pasteur. Flora Jay is one of the coordinators since 2017.

Volunteer Professional Service

Management Positions in Scientific Organisations

National or external organisations

- GdR MaDICS: S. Cohen-Boulakia, member of the Scientific Committee since 2015.
- GdR BiM (Bioinformatique Moléculaire): A. Denise, member of the Scientific Committee since 2010.
- *CERNA* (Commission de réflexion sur l'Ethique de la Recherche en sciences et technologies du Numérique d'Allistene): Ch. Froidevaux, member since 2016.
- *SIF* (Société Informatique de France): Ch. Froidevaux, member of the CA since 2013, vice-president from 2015 to 2018, vice-president in charge of education since February 2018.
- *ELIXIR* European network: S. Cohen-Boulakia, part of the ELIXIR French representatives for IFB, representant of the French node in the Interoperability Platform of ELIXIR.
- *IFB* (Institut Francais de Bioinformatique): S. Cohen-Boulakia, co-leader of the action on Interoperability.

Paris-Saclay University

- *Center for Data Science* (CDS) of Paris-Saclay: S. Cohen-Boulakia, member of the steering committee.
- *Institute on Modelling for Living Systems* (IMSV) of Paris-Saclay: Ch. Froidevaux, member of the steering committee.
- *STIC Research Department* (Science and Technology of Information and Communication) of Paris-Saclay: A. Denise, member of the board since 2015.
- *STIC Doctoral School* of Paris-Saclay: A. Denise, director since June 2018.
- *DATAIA Convergences Institute*: A. Denise, member of the board since its launching in 2017.
- *Labex Digicosme*: A. Denise, member of the education committee since 2012.
- *Academic Senate* of Paris-Saclay: A. Denise, member (2013-2015).

Paris-Sud University

- CCSU 27th section: S. Cohen-Boulakia, member (2013-2017), and Vice-President B (2015-2017); A. Denise, member since 2015; L. Paulevé, member since 2015; A. Pierrot, member since 2017.
- *Computer Science Department* of the Faculty of Sciences: A. Denise, president (2015-2017)
- *Conseil de la Faculté des Sciences*: A. Denise, member (2015-2017).

Organisation of Conferences and Scientific Events

- SeqBio 2015, *Annual meeting between GDR BIM (Bioinformatique moléculaire) and GDR IM (Informatique Mathématique)*; Alain Denise, chair of the organization committee, co-chair of the program committee.
- JDSE 2017, *2nd Junior Conference in Data Science and Engineering*, S. Cohen-Boulakia and F. Jay, Co-chairs of the local organization.
- Theory and Principles of Provenance (TaPP), S. Cohen-Boulakia, member of the steering committee
- Data Integration in the Life Sciences (DILS), S. Cohen-Boulakia, member of the steering committee
- advances in Systems and Synthetic Biology (aSSB), P. Amar, chair of the organization committee (2013, 2014), member of the steering committee (2013, 2014, 2015, 2016, 2017, 2018).
- *5th JFLI-NII-LRI Workshop on Formal Approaches for Modeling and Analyzing Biological Networks*, (NII Collaborative Research), LRI, 2013, Ch. Froidevaux and A. Rougny, co-chairs of the local organization.
- *Congress SIF- 2018*, Paris, Palais de la Découverte, Ch. Froidevaux, co-chair of the local committee.
- ESEB 2017, *Congress of the European Society for Evolutionary Biology*, Groningen, Netherlands, 2017: F Jay, organizer of the Spatial Evolution Symposium
- ALEA 2017, *annual meeting of the ALEA group of the GdR IM*, A. Pierrot, co-organizer
- First joint GT BIOSS-preGDR IA workshop "Modèles logiques pour la représentation formelle des systèmes vivants" 2017, Gif-sur-Yvette, L. Paulevé, co-organizer

Honors

Awards

- Christine Froidevaux, *Palmes académiques* (2016)

Keynote Addresses and invited talks

International

- S. Cohen-Boulakia: invited talks, Workshop on Data Provenance and Annotation in Computational Linguistics, Prague, January 2018; France-Mexico Meeting on Data Analysis, UNAM Mexico, November 2016
- A. Denise: invited talk, Symposium on Structure and dynamics of RNA interactions, Université de Montréal, 2014
- F. Jay: invited talk, European Mathematical Genetics Meeting, Tartu, Estonia, 2017
- L. Paulevé: invited talsk, Workshop on Logical modelling of biological regulatory networks, Basel, Switzerland, 2017; Doctoral Workshop on Mathematical and Engineering Methods in Computer Science, Masaryk University, Czechia, 2017
- S. Peres: invited talk, Workshop "Computational systems biology for cancer", Paris, January 2018

France

- P. Amar: invited talk, Société Francophone de Biologie Théorique, 2014
- S. Cohen-Boulakia: invited talks, Annual Scientific meeting de l'Institut de Biologie Computationnelle, Montpellier, January 2017 ; Workshop DaQuata (Data Quality: from Theory to Applications), Lyon, December 2016 ; kick-off of the new research structure at Institut Pasteur C3BI (Center of Bioinformatics, Biostatistics and Integrative Biology), February 2015
- A. Denise: invited talks, Journée Recherche de la Société Informatique de France, 2014; Workshop on Random Generation in Concurrent Systems and Applications, Université Paris-Diderot, 2017
- Ch. Froidevaux: invited talks, Spring school on Algorithmics and Programmation, Luminy, 2017; "L'usage des Big data en santé : révolution épistémologique et transformations des pratiques ?", Louvain, 2018
- F. Jay: invited talk, Journée Inférences Évolutives, GDR AEIM and GDR GE, Paris, 2018
- L. Paulevé: invited talks, DigiCosme Open University, Cachan, 2016; Workshop Réseaux d'interactions fondements et applications à la biologie, Marseille, 2017; Journées thématiques "Méthodes de réduction de modèles", Marseille, 2015; Journées du GDR BIM, Paris, 2017; Journées du GT BIOSS, Lyon 2016 and Lille 2016
- S. Peres: invited talks, Journées mitchondrie SB2 (biologie synthétique et biologie des système), Bordeaux, 2015; Metabolic Networks meeting, Nantes 2014
- A. Pierrot: invited talk, Séminaire Philippe Flajolet, IHP, Paris, 2014

Additionally, the group members gave much invited talks in several seminars in France (Bordeaux, Evry, Grenoble, Montpellier, Nice, Orléans, Orsay, Paris, Rennes...) and abroad : Germany (Jena, Humboldt zu Berlin), Canada (Hamilton, Montréal), China (Wuhan), etc.

Evaluation of Research

Editorial Boards

- Journal on data Semantics (JoDS): S. Cohen-Boulakia (since 2012)
- *Frontiers in Molecular Biosciences*, Frontiers: A. Denise (since 2014)
- 1024, Bulletin de la SIF (Société Informatique de France): Ch. Froidevaux (since 2013)

Program Committees

Chair

- SeqBio, *Annual meeting between GDR BIM (Bioinformatique moléculaire) and GDR IM (Informatique Mathématique)*: A. Denise, co-chair in 2015
- SIF-2018, *Annual congress SIF*, Paris, Palais de la Découverte: Ch. Froidevaux, chair of the program committee
- SASB, *International Workshop on Static Analysis and Systems Biology*: L. Paulevé, co-chair in 2014 and 2015
- JDSE 2017, *2nd Junior Conference in Data Science and Engineering*, S. Cohen-Boulakia and F. Jay, co-chairs of the program committee
- Symposium at ESEB2017, *Spatial Evolution Symposium at Congress of the European Society for Evolutionary Biology*: F. Jay

Member (international events)

- ECCB, *European Conference on Computational Biology*: A. Denise (2014, 2016), S. Peres (2014, 2016)
- ISMB, *Intelligent systems for molecular biology*: S. Peres (2017, 2018)
- SIGMOD, *ACM Special Interest Group on Management of Data* (conference ranked A*): S. Cohen-Boulakia (2015, 2016, 2017)
- ICDE, *IEEE International Conference on Data Engineering*: S. Cohen-Boulakia (2015)
- TAPP, *USENIX Workshop on the Theory and Practice of Provenance*: S. Cohen-Boulakia (2014, 2015, 2016)
- CMSB, *International Conference on Computational Methods in Systems Biology*: L. Paulevé (2015, 2017, 2018)
- SASB, *International Workshop on Static Analysis and Systems Biology*: L. Paulevé (2013, 2016, 2017)
- ICITA'16, *International Colloquium on Information Technology : Theory and Applications*, Meknès: A. Denise (2016)
- CMSR'14, *Computational Methods for Structural RNAs*, Strasbourg: A. Denise (2014)
- CARI'14, *African Conference on Research in Computer Science and Applied Mathematics*, Sain-Louis (Sénégal): A. Denise, 2014.

Member (national events)

- SeqBio, *Annual meeting between GDR BIM (Bioinformatique moléculaire) and GDR IM (Informatique Mathématique)*; A. Denise (2015, 2016, 2017), L. Paulevé (2015), A. Pierrot (2015)
- JOBIM *Open days in Biology, Computer Science and Mathematics*, the national conference in Bioinformatics: S. Cohen-Boulakia (2017), L. Paulevé (2017).
- aSSB *advances in Systems and Synthetic Biology*: P. Amar (2013, 2014, 2015, 2016, 2017, 2018).

Evaluation Committees and Invited Expertise

- HCERES evaluation committees of UPR MIAT (INRA Toulouse) in 2014; LITIS (Université de Rouen) in 2015: A. Denise
- HCERES evaluation committee of Cedric (CNAM Paris) in 2017: S. Cohen-Boulakia

Other evaluation activities

Scientific committees

- Member of the COMEPS of the Pasteur Institute (evaluation committee of Pasteur Institute's senior researchers) since 2016: A. Denise
- Expert for the Direction Générale de la Recherche et l'Innovation of the French Ministry of Research and Higher Education since 2008: A. Denise
- Member of the scientific committee of the Labex NUMEV (Montpellier) since 2013 : A. Denise
- Member of the scientific committee of INRIA Saclay (2014-2015): Ch. Froidevaux

Hiring committees

- Member of a hiring committee for Professor positions in Universities: A. Denise (Bordeaux 2014, Paris-Sud 2015, 2017, 2018 - chair in 2018), Ch. Froidevaux (Paris-Sud 2013, Evry 2015, Nantes 2015, Lille 2016 - 2 positions, Paris-Sud 2018 - co-chair), S. Cohen-Boulakia (Nice, 2018)
- Member of a hiring committee for *Maître de Conférences* positions in Universities: P. Amar (Nice 2014), S. Cohen-

Boulakia (Lyon 2017, Lille 2018, Paris-Sud 2015 and 2018), A. Denise (Bordeaux 2013, Paris-Sud 2015), Ch. Froidevaux (Paris-Sud 2014 - co-chair, Univ. Denis-Diderot 2016), F. Jay (Paris-Sud 2018), L. Paulevé (Paris-Sud 2015, Evry 2017), S. Peres (INSA Lyon 2014, Paris-Sud 2014 and 2015, Bordeaux 2015, Paris-Sud 2018 - co-chair)

- Member of a hiring committee for Bioinformatics researchers at Institut Pasteur: A. Denise (2015), S. Cohen-Boulakia (2017)
- Member of a hiring committee for researcher position: CRCN-INRIA 2018, hiring committee member for research engineer position: IR-INRA 2015, hiring committee member for teacher position: PRAG (Univ. Paris-Sud 2017): S. Peres

Thesis and HdR committees

Altogether, during the period the members of the groups were committee members of 27 theses and 9 HdRs, including 14 PhD theses and 5 HdRs as reviewers, and 7 PhD theses and 3 HdRs as chair of the committee.

Interactions with the social, economic and cultural environment

Interaction with the economic environment

- Invited talk at Bayer Crop Science, Ghent, 2016 (S. Cohen-Boulakia)
- Invited talk at ABLife company, Wuhan, 2016 (A. Denise)
- Invited talk at Cairn Biosciences, San Francisco, 2017 (F. Jay)

Interaction with the social environment

- Ch. Froidevaux: participation in a panel session, "Numérique, Big Data, Intelligence artificielle : de nouvelles questions éthiques ?", Etats généraux de la bioéthique, CCNE, Paris, 2017
- Ch. Froidevaux: participation in a panel session, Etats généraux de la bioéthique, Sciences Po Paris, "GAFAM, BATX : que valent nos données personnelles ?", Paris, 2018
- Ch. Froidevaux: invited talk on the teaching of bioinformatics, Colloque Femme et Sciences, Paris, 2013
- Ch. Froidevaux: invited talk at the workshop "L'enseignement des mathématiques, de l'informatique et de la physique dans la transition lycée-université : continuité ou rupture ?", CFEM, Paris, 2018

Dissemination

- Participation in the special issue of the Tangente journal about Mathematics and computer science, 2014, Ch. Froidevaux
- Ch. Froidevaux: co-author (with B. Defude) of a chapter "Algorithmes et traitement des données", in Les Big Data à découvert, M. Bouzeghoub et R. Mosseri eds., CNRS Editions, 2017
- S. Cohen-Boulakia: co-author (with P. Valduriez) of a chapter "Les chaînes de traitement de données et le partage d'expériences scientifiques", in Les Big Data à découvert, M. Bouzeghoub et R. Mosseri eds., CNRS Editions, 2017

Popularisation of Research Results

- Introduction to LRI research activities, 2015, middle-school students of a college at Orsay ("classe de 3ème"), Ch. Froidevaux with "Les Petits Débrouillards"
- "Fête de la science" at LRI: animation of an activity on bioinformatics, 2017, middle-school students ("classes de 3ème"), Ch. Froidevaux
- Ch. Froidevaux: in charge of the animation of activities on computer science in primaries schools at Bures-sur-Yvette ("Temps d'Activités Périscolaires"), with the support of labex DigiCosme

Contracts and grants

In the following tables, the amounts are in k€, and they correspond only to the part of the grants and contracts *devoted to the Bioinfo group*.

The group is involved in two international ANR projects (with Univ. of Vienna and Univ. of Luxemburg respectively) and is leader of one of them. We also participate to four bilateral PHC projects and three as co-leaders. At the national level, we were or are leader of CNRS pluridisciplinary projects (three-year Mastodons and two PEPS) involving several partners (our mastodons project has been merged with other Mastodons project each year while we kept the lead, we present it below as a unique 36 months project for the sake of clarity). We also benefit from regional and local projects (DIM, RTRA, Idex Paris-Saclay, some of them providing PhD thesis funding. Additionally, we benefit from a Cifre funding for supervising a PhD thesis in collaboration with the Soredab biotechnology company.

Public contracts and grants

International ANR grants						
Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*		*Amount*
ANR-FNR	L. Paulevé	AlgoReCell	Univ. Paris-Sud	01.2017	36	16
ANR-FWF	A. Denise	RNALands	INRIA	01.2015	48	50

International bilateral grants (PHC)						
Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*		*Amount*
PHC	L. Paulevé	iPaN	Campus France	01.2018	12	2.5
PHC Xu Guangqi	A. Denise	GRO-algo	Campus France	01.2017	12	4.6
PHC	S. Cohen-Boulakia	workflows	Campus France	01.2013	12	3.5

National grants						
Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*		*Amount*
Mastodons CNRS	S. Cohen-Boulakia	QCM-BioChem	CNRS DR04	04.2016	36	70
PEPS CNRS	L. Paulevé	FoRCe	CNRS DR4	06.2017	7	8
PEPS CNRS	S. Cohen-Boulakia	RankaBio	CNRS DR04	05.2015	12	10
IFB (ANR PIA 3)	S. Cohen-Boulakia	NGPhylogeny.fr	IFB	2016	24	20
FRM	A. Denise	3D-Probing	CNRS	04.2015	36	3

Regional and local grants						
Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*		*Amount*
Région Ile-de-France (DIM)	F.Jay	BactPopGenML	Univ. Paris-Sud	01.2018	24	103.6
Région Ile-de-France (DIM)	L. Paulevé	FormaReBio	Univ. Paris-Sud	01.2018	12	4.5
RTRA Digiteo	A. Denise	JAPARiN-3D	Digiteo	10.2012	48	102
Idex Paris-Saclay (IMSV)	Ch. Froidevaux	IMSV	Univ. Paris-Sud	02.2014	24	75
Idex Paris-Saclay (CDS)	F.Jay	DeepGenetics	Univ. Paris-Sud	02.2017	6	3.5
Idex Paris-Saclay (CDS)	S. Cohen-Boulakia	BioConsensus	Univ. Paris-Sud	02.2017	6	3.5
LRI grant	S. Peres	Bioinfo-LaDHAK grant	CNRS DR04	02.2015	24	5
LRI grant	F.Jay	Young researcher LRI	CNRS DR04	01.2017	24	10
LRI grant	S. Cohen-Boulakia	Bioinfo-Vals grant	CNRS DR04	01.2018	24	10

In the following, we detail some of the main contracts and grants from the above table.

AlgoReCell

Type: ANR-FNR 2016
Amount: 718.4 k€
Duration: 36 months
Scientific director for LRI: L. Paulevé

Partners: LSV, Institut Curie, Université du Luxembourg

See **https://algorecell.lri.fr**

Project leader: L. Paulevé (LRI). AlgoReCell (Computational Models and Algorithms for the Prediction of Cell Reprogramming Determinants with High Efficiency and High Fidelity) is a joint collaborative project on cell reprogramming. Cell reprogramming consists in acting on specific genes, so-called Reprogramming Determinants, in order to trigger a cell de- or trans-differentiation. The prediction in-silico of such determinants is a major challenge, notably for regenerative medicine. The goal of AlgoReCell is to design a

computational framework for the prediction of reprogramming strategies.

RNALands

Type: ANR-FWF 2014
Amount: 230 k€
Duration: 48 months
Scientific director for LRI: A. Denise

Partners: LIX, INRIA, University of Vienna

See **https://project.inria.fr/rnalands/**

Project leader: Yann Ponty (LIX). RNALands (Fast and Efficient Sampling of Structures in RNA Folding Landscapes) is a joint collaborative project on RNA kinetics. RNALands strives to provide efficient tools for the analysis of RNA kinetic landscape, which offers a much more faithful picture of the folding process than traditional approaches based on energy-minimization or thermodynamic equilibrium.

QCM-BioChem

Type: Mastodons CNRS
Amount: 70 k€
Duration: 36 months
Scientific director for LRI: S. Cohen-Boulakia

Partners: LRI, LIGM, IFB, LORIA, CERMN2, GREYC4, ICOA5, IRISA, IF, LIFO, LIRIS

See **https://www.lri.fr/~cohen/QCM-BioChem.html**

Project leader: S. Cohen-Boulakia (LRI). QCM-BioChem is the third year of a Mastodons project, named QualiBioConsensus in 2016 and HyQualiBio in 2017, which has been gathering four (in 2016) then six (in 2017) and now eleven different partners mainly from the INSII and INSB institutes of CNRS. QCM-BioChem aims to address the challenges posed by the wide variety of biological and chemical data, and the methods of analysis and search of these data. The originality of the approaches developed in QCM-BioChem lies on the systematic consideration of quality criteria, at data, analysis methods and knowledge levels.

NGPhylogeny.fr

Type: Institut Francais de Bioinformatique (in the context of ANR PIA 3)
Amount: 20 k€
Duration: 24 months
Scientific director for LRI: S. Cohen-Boulakia

Partners: Institut Pasteur, LIRMM

See **https://ngphylogeny.fr/**

Project leader: S. Cohen-Boulakia (LRI). With 50,000 data analysis per month and more than 1,500 citations, Phylogeny.fr is one of the most well-known tools for phylogenetic analyses. However, since its development, users' needs have evolved and new tools and workflows have been published, thus promoting new practices. The NGPhylogeny.fr project aims at providing an entirely redesigned web application dedicated to phylogenetic analyses. NGPhylogeny.fr is entirely based on the Galaxy workflow system to be more flexible and scalable than Phylogeny.fr.

BactPopGenML

Type: Régional (DIM)
Amount: 103.6 k€
Duration: 24 months
Scientific director for LRI: F. Jay

Partners: LRI, Institut Pasteur, YSEB (MNHN-CNRS-UPMC-EPHE)

DIM-1HEALTH Région Île-de-France; Project leader: F Jay (LRI). BactPopGenML is a collaborative project lead by BioInfo, together with population geneticists and microbiologists, that aims at developing machine learning methods targeted at bacterial population genetics data. These new predictive models will help reconstructing the complex demographic and adaptive histories of pathogens, and contribute to epidemiological surveillance by better understanding the impacts of public health policies on pathogen diversity, with a particular focus on Streptococcus agalactiae and Escherichia coli. Disentangling demographic and selective processes is a very challenging task because they leave similar signatures in the genome. Rather than specifically searching for these signatures with a limited number of descriptive statistics, we propose to design neural networks that handle raw genomic data and learn automatically how to embed them.

JAPARiN-3D

Type: Digiteo
Amount: 102 k€
Duration: 48 months
Scientific director for LRI: A. Denise

Partners: LRI, PRISM (UVSQ)

Project leader: A. Denise. Predicting the 3D structure of RNA molecules is a key feature towards predicting their functions. Methods which work at atomic or nucleotide level are not suitable for large molecules. In these cases, coarse-grained prediction methods aim to predict a shape which could be refined later by using more precise methods on smaller parts of the molecule. The aim of the project was to make substantific progress in automatic prediction of the three-dimensional (3D) shape of RNA molecules at a coarse-grained scale.

Private contracts and grants

Private contracts and grants (jan 2013 - jun 2018)						
Type	*Scientific director*	*Name*	*Managing Institution*	*Start*	*Duration*	*Amount*
CIFRE	Sabine Peres	Soredab	FX-conseil	10.2015	36	75

Soredab

Type: Privé
Amount: 75 k€
Duration: 36 months
Scientific director for LRI: Sabine Peres

Partners: Soredab

Soredab needs to increase the production of a specific molecule target to have a better preservation of their dairy product. We used methods based on constrainted optimisation to predict specific scenarii that are experimentally validated. The precise matter of this contract is subject to confidentiality.

Training and Education

Management positions

We are strongly involved in management positions related to teaching, both at the level of University Paris-Saclay and the level of University Paris-Sud.

- Paris-Saclay: Head of the *Master of Bioinformatic* (5 tracks, 4 institutions involved) and of the *track M2 AMI2B* of the Master: Ch. Froidevaux (since 2015). Head of the working group which created the *Master of Computer Science* (16 tracks, 11 institutions involved): A. Denise (2013-2015).
- Paris-Sud: Vice-president of the *Computer Science Department* at the Faculty of Science in charge of undergraduate education: S. Cohen-Boulakia (since 2018). Vice-president of the *Computer Science Department* at the Faculty of Science in charge of education: A. Denise (2012-2014). Co-head of the *Master of Bioinformatics and Biostatistics*: Ch. Froidevaux (2012-2015).

Graduate Courses

Members of the Bioinfo group are very active in graduate courses, especially in the Master in Bioinformatics; but also in other Master courses in the engineering curricula. We notably teach in 10 regular courses in M2 Bioinformatics of Computer Science. Below we only consider the courses in M2 and 5th year of engineer school.

- Master in Bioinformatics of the University Paris-Saclay (2nd year). *Simulation of Biological Systems*; *Software Engineering*: P. Amar. *Database Optimization*: S. Cohen-Boulakia. *Data Integration and Big Data*: S. Cohen-Boulakia, Ch. Froidevaux. *Theoretical Computer Science*; *Graphs and Biological Networks*: A. Denise. *Professionalization (introduction to research methods*: Ch. Froidevaux. *Case study Meet-U* (introduction to research in labs) (A1): Ch. Froidevaux. *Population Genetics and metagenomics*: F. Jay. *Dynamical analysis of biological systems*: L. Paulevé.
- Master "Data and Knowledge" in Computer Science of the University Paris-Saclay (2nd year). *Very Large Bioinformatics Data*: S. Cohen-Boulakia. *Information Integration*: S. Cohen-Boulakia.
- École Centrale de Nantes, engineer curriculum. *Dynamical analysis of biological systems*: L. Paulevé

SPOC

Ch. Froidevaux is co-author (with T. Baudel from IBM) of a SPOC (Small Private Online Course) on research ethics and scientific integrity designed for the STIC Paris-Saclay doctoral school (with N. Bidoit). The course is taught on the platform FUN-MOOC (2018).

Internships

During the period we welcomed 14 master students for internships (4 to 6 months), in majority from the Master of Bioinformatics of Paris-Saclay (9 students), but also from masters in other locations, as Masaryk (Czechia), Nice, Montpellier, Lyon, Rennes. Among these 14 students, 5 continued as PhD students in the group.

Thematic Schools

The group members were strongly involved in lecture talks and scientific committees of the following thematic schools.

- Member of scientific committees: *School for young researchers in Bioinformatics ((JC)BIM) of the GDR BIM*, June 2018; *3rd Thematic School on Formal Modelling of Biological Regulation Networks*, Porquerolles, June 2016 (A. Denise).
- Lecture talks: *GdR Informatique Mathématique Young Researcher School*, Nancy, 2018 (L. Paulevé); *AgreenSkills Annual Meeting* (international postdoctoral fellowship programme), Edinburgh, June 2018 (S. Cohen-Boulakia); *Thematic school on advances on Systems and synthetic biology*, Evry 2018, Lyon 2017, Evry 2016, Strasbourg 2015, Evry 2014, La Colle-sur-Loup 2013 (S. Peres); Summer school *Cumulo Numbio*, Aussois, June 2015 (S. Cohen-Boulakia and Ch. Froidevaux); *Spring school DigiCosme* DataSense, ENSTA ParisTech, Palaiseau, May 2015 (S. Cohen-Boulakia); *Spring school of Theoretical Computer Science* (EPIT), Oleron, May 2014 (A. Denise); *Société Francophone de Biologie Théorique* Spring school, Saint Flour, June 2014 (P. Amar).

Evaluation Committees and Invited Expertise

- HCERES evaluation committee of the Licence and Master curricula in the Science and Technology domain at Aix-Marseilles University in 2016-2017: Alain Denise

Theses and HdRs

Habilitation à Diriger des Recherches	
Name	*Defense*
Patrick Amar	12.2013
Sarah Cohen Boulakia	06.2015

Defended thesis				
Name	*Start*	*Defense*	*Funding*	*Advisor*
Mélanie BOUDARD	09.2012	04.2016	Digiteo	A. Denise (with D.Barth and J. Cohen, PRISM/DAVID)
Marc BOUFFARD	10.2013	09.2016	Alloc. Ministère	P. Amar
Bryan BRANCOTTE	10.2012	09.2015	Alloc. Ministère	A. Denise, S. Cohen Boulakia
Jiuqiang CHEN	09.2011	10.2013	China Scholarship Council (CSC)	Ch. Froidevaux, S. Cohen Boulakia
Adrien GUILHOT-GAUDEFFROY	10.2011	09.2014	Alloc. Ministère	Ch. Froidevaux, J. Azé (with J. Bernauer, LIX)
Martin MORTEROL	10.2013	12.2016	Alloc. Ministère	S. Peres (with L. Simon (LaBRI) & P. Dague (LaDAHK))
Adrien ROUGNY	09.2013	10.2016	Alloc. normalien	Ch. Froidevaux
Bo YANG	03.2011	09.2014	Université (cotutelle)	A. Denise (with Xiong-Dong Fu, Wuhan), *co-tutelle*
Wei WANG	01.2014	12.2017	China Scholarship Council (CSC)	A. Denise (with Y. Ponty, LIX)
Cong ZENG	07.2011	07.2015	China Scholarship Council (CSC)	A. Denise

Position after the thesis	
Name	*Position*
Mélanie BOUDARD	Consultant, Octo Technology
Marc BOUFFARD	R&D manager, INGIMA, Paris
Bryan BRANCOTTE	R&D engineer, Pasteur Institute, Paris
Jiuqiang CHEN	Junior teacher, Lanzhou University (China)
Adrien GUILHOT-GAUDEFFROY	
Martin MORTEROL	Software developper, Nokia, Antony
Adrien ROUGNY	Post-doc, AIST, Computational Biology Research Center, Tokyo
Bo YANG	Post-doc, Shanghai (China)
Wei WANG	Engineer in Bioinformatics, Shanghai (China)
Cong ZENG	Junior teacher, Chongqing University (China)

Theses in progress			
Name	*Start*	*Funding*	*Advisor*
Pierre ANDRIEU	10.2017	Alloc. Ministère	S. Cohen-Boulakia, A. Denise)
Jorgelindo DA VEGA MOREIRA	10.2015	Bourse Cifre	S. Peres (with L. Schwartz APHP)
Juraj KOLČÁK	03.2017	ANR AlgoReCell	L. Paulevé (with S. Haar, LSV)
Hughes MANDON	10.2016	Labex Digicosme	L. Paulevé (with S. Haar, LSV)
Cécile MOULIN	10.2016	Alloc. Ministère	S. Peres (with L. Tournier, INRA MaIAGE)
Karima RAFES	10.2014	self-funded	S. Cohen-Boulakia (with S. Abiteboul, ENS)
Théophile SANCHEZ	10.2017	Alloc. Ministère	F. Jay (co-advisor) (with G. Charpiat and M. Schoenauer, LRI TAU)
Alexandra ZAHARIA	10.2015	Alloc. Ministère	Ch. Froidevaux, A. Denise

Software Licensing and Distribution

We consider as very important to implement the algorithms and methodologies which result from our research projects, and to make them available for the need of the scientific communities in Bioinformatics and Biology. This is why we developed a number of software, pipelines, databases, all available online. We regularly maintain a total of 19 programs, on-line tools and on-line databases. During the 2013-2018 period, we have made available 8 new programs, on-line tools and on-line databases: CaRNAval, Garn, Licorna, Orphea, Pint, SiliCell Maker, ConQur-Bio and SPFlow. Additionally, we co-developped CoLoMoTo, which is not a stand alone software thus not appearing in the list of software below but it is an interactive Notebook available at **https://colomoto.github.io/colomoto-docker** providing a joint Docker distribution of software tools for systems biology (including Pint) with a unified interface through the Jupyter Web application.

Additionally, several programs which were developed before are still very appreciated by the community, as for example Varna (developed in 2006, whose associated paper (Bioinformatics 2009) has been cited more than 560 times up to June 2018) and HSIM (early version in 2004, constantly improved since and used for both research and teaching in many universities (associated article: BMC Systems Biology 2008).

Finally, the teaching service management system, *voeux*, developed 20 years ago, is still maintained and currently used by the computer sciences department at Paris-Saclay and by several other departments in France.

Main software developed between 2013 and June 2018

Biological Sequences and Structures

CaRNAval - Database of RNA Recurrent Interaction Networks
http://carnaval.lri.fr/
Contact: Alain DENISE

CaRNAval is a comprehensive and interactively explorable database of RNA Recurrent Interaction Networks in RNA molecules (RINs). We developed a graph-based methodology to extract all RINs in crystallized RNA tertiary structures and to cluster them according to their similarity. We applied our methodology to a large set of experimentally resolved RNA structures. Our method gives a global view on interaction networks and their modularity, by organizing them in families according to their inclusion relations. CaRNAval is a publicly accessible database that allows to visually explore and study all the interaction networks and their intricate relationships. Publication: (21)

GARN - Game Algorithms for RNa 3D sampling

http://garn.lri.fr/
Contact: Alain DENISE, Johanne COHEN

GARN is a software to compute a sampling of RNA 3D structure from a secondary structure. GARN can thus be a suitable starting point for large RNA molecular modelling and experimental structure resolution. Publications: (4, A12, A134)

LiCoRNA - aLignment of Complex RNAs

https://licorna.lri.fr/
Contact: Alain DENISE

LiCoRNA is a software for structure sequence alignment for two RNAs in the presence of arbitrary pseudoknots. The program is based on the tree decomposition of query sequence and a general parameterized algorithm to compute the optimal alignment. Publications: (A89, A142)

Orphea - Pseudo-knot RNA sequence finder

http://orphea.lri.fr/
Contact: Patrick AMAR

Orphea is a sofware tool that takes a cDNA sequence file(s), search for a folding of the associated RNA that forms pseudo-knots that are good candidates for -1 frame-shift in the translation process leading to two different proteins. Orphea implements a new dynamic programming algorithm that identify -1PRF signals in genomic databases (i) by identifying the heptameric sequences where the ribosome shifting will occur and (ii) by searching for a potential stem-loop or pseudoknot that could stimulate -1PRF at the heptameric site. Publication: (A144)

Systems Biology and Synthetic Biology

Pint - Static analyzer for dynamics of Automata Networks

http://loicpauleve.name/pint
Contact: Loïc PAULEVE

Pint implements static analyses for computing dynamical properties on very large-scale Automata Networks, ranging from hundreds to several thousands of concurrently interacting components. Provided analyses include notably the listing of fixed points, successive reachability properties, cut sets for reachability, and model reduction preserving transient dynamics. The translation to related formalisms, in particular Boolean and multi-valued networks, is also provided. Automata Networks are defined by a set of finite-state machines whose local transitions can be conditionned by the state of other automata in the network. Applications are in particlar in systems biology with the modelling and analysis of signalling pathways and gene regulatory networks, gathering multiple interacting components with a few local states. Pint comes with several command line tools to perform formal analyses, reductions, simulations, and translation to other formalisms and a Python Jupyter notebook web interface. Publication: (A72)

Silicell Maker - Silicell Maker: computer aided synthetic bionetwork design system

https://silicellmaker.lri.fr
Contact: Patrick AMAR

Silicell Maker is a modelling editor / simulator for biochemical network design, with a highly intuitive graphical user interface. It uses the SBGN graphical notation, and support many standard file formats (SBML, Metatool, etc.) Models can be exported to be used by various other modelling tools (HSIM, BIOCHAM, Metatool) In the PhD memoir of Marc Bouffard (in French) one can find a complete descrip-

tion of the NetGate (logic gate finder) and NetBuild (boolean formula to metabolic network) plugins. Publication: (9)

Integration and Analysis of Biological Data

ConQuR-Bio - ConQuR-Bio
http://conqur-bio.lri.fr/
Contact: Sarah COHEN-BOULAKIA

ConQuR-Bio assists scientists when they query public biological databases. Various reformulations of the user query are generated using medical terminologies (MeSH, OMIM, ...). Such alternative reformulations are then used to rank the query results using a new consensus ranking strategy. The originality of our approach thus lies in using consensus ranking techniques within the context of query reformulation. The ConQuR-Bio system is able to query the Entrez-Gene NCBI database. The benefit of using ConQuR-Bio compared to what is currently provided to users has been demonstrated on a set of biomedical queries.

SPFlow - Rewriting a non SP workflow into an SP workflow while preserving provenance
https://spflow.lri.fr/
Contact: Sarah COHEN-BOULAKIA

Scientific workflow systems are numerous and equipped of provenance modules able to collect data produced and consumed during workflow runs to enhance reproducibility. An increasing number of approaches have been developed to help managing provenance information. Some of them are able to process data in a polynomial time but they require workflows to have series-parallel (SP) structures. Rewriting any workflow into an SP workflow is thus particularly important. SPFlow answers this need and takes in a workflow (from the Taverna system) and provide a runnable and provenance equivalent (Taverna) workflow.

Main software developed before 2013 (and still maintained)

Biological Sequences and Structures

VARNA - Visualisation Applet for RNA
http://varna.lri.fr
Contact: Alain DENISE

VARNA is Java lightweight Applet dedicated to drawing the secondary structure of RNA. It is also a Swing component that can be very easily included in an existing Java code working with RNA secondary structure to provide a fast and interactive visualization.

Systems Biology and Synthetic Biology

HSIM - Hyperstructure Simulator
http://www.lri.fr/~pa/Hsim/index.html
Contact: Patrick AMAR

HSIM is a stochastic automaton used for modelling and simulating biochemical processes in a virtual bacterium.

Integration and Analysis of Biological Data

GeneValorization - Gene List significance at-a-glance
http://www.bioguide-project.net/gv/
Contact: Sarah COHEN-BOULAKIA

High-throughput technologies provide fundamental informations concerning thousands of genes. Most of the current biological research laboratories daily use one or more of these technologies and identify lists of genes. Understanding the results obtained includes accessing to the latest publications concerning individual or multiple genes. Faced to the exponential growth of publications avaliable, this task is be-

coming particularly difficult to achieve. Here, we introduce a web-based Java application tool named GeneValorization which aims at making the most of the text-mining effort done downstream to all high throughput technology assays. GeneValorization gives a very clear and handful overview of the bibliography corresponding to one particular gene list.

Other software (still maintained)

Cartaj - Classification Of RNA threeway Junctions

http://cartaj.lri.fr/
Contact: Alain DENISE

Cartaj automatically predicts the topological family of any RNA three-way junction, given only the information from the secondary structure: the sequence and the canonical WatsonCrick pairings. Publication: (21)

Voeux - Teaching service management system

http://www.lri.fr/~pa/Voeux/index.html
Contact: Patrick AMAR

Causalex - Causality Graph Explorer

Contact: Loïc PAULEVE

The Graphs of Local Causality (GLC) are a compact representation of possible state changes within automata networks. They have been introduced for studying the activation of important components in very large biological networks. Causalex is a graphical interface for visualizing, navigating and manipulating GLCs. A javascript interface allows to edit scripts for modifying the GLC and visualize the execution of algorithms (node colouration while computing, step-by-step execution). A javascript library includes implementations of algorithms recently developed for GLCs, such as semi-decision of reachability properties, identification of cut-sets for reachability, etc.

GenRGenS - Generation of Random Genomic Sequences and Structures

http://www.lri.fr/~genrgens/
Contact: Alain DENISE

GenRGenS is a software dedicated to random generation of genomics sequences and structures that supports several classes of models, including Markov chains, HMM, context-free grammars, automata, PROSITE patterns and more. Authors : Yann Ponty, Michel Termier, Alain Denise. GenRGenS is being developped as a collaboration between Bioinformatics group of LRI Orsay and the Molecular Bioinformatics group of IGM Orsay by Alain Denise, Yann Ponty and Michel Termier. Reference: Y. Ponty, M. Termier and A. Denise GenRGenS: Software for generating random genomic sequences and structures Bioinformatics, June 2006 22(12):1534-1535.

WXD - Text editor

http://www.lri.fr/~pa/pub/wxd-src.tar.gz
Contact: Patrick AMAR

Text editor for multiple programming languages.

SPChecker - SPChecker

http://www.lri.fr/~chenj/SPChecker/
Contact: Sarah COHEN-BOULAKIA

Scientific workflow systems are numerous and equipped of provenance modules able to collect data produced and consumed during workflow runs to enhance reproducibility. An increasing number of approaches have been developed to help managing provenance information. Some of them are able to process data in a polynomial time but they require workflows to have series-parallel (SP) structures. SPChecker is able to detect whether or not any Taverna workflow has a series-parallel structure.

Rna3Dmotif - Software for extracting RNA tertiary motifs

http://rna3dmotif.lri.fr

Contact: Alain DENISE

Rna3Dmotif is a free bundle of three easy-to-install programs aimed to be used in combination to automatically extract recurrent RNA local tertiary motifs. The approach used is based on a graph representation of the RNA tertiary structure using LW no-menclature. It was applied to three widely studied ribosomal RNA structures and the motifs thus found were deposited in a dedicated repository.

BioInfo team publications (20 %)

Journal articles

Major international journals

(1) F. Bassino, M. Bouvel, V. Féray, L. Gerin, and A. Pierrot. The Brownian limit of separable permutations. *Annals of Probability*, 46(4):2134 – 2189, July 2018.

(2) F. Bassino, M. Bouvel, A. Pierrot, C. Pivoteau, and D. Rossin. An algorithm computing combinatorial specifications of permutation classes. *Discrete Applied Mathematics*, 224:16–44, 2017.

(3) S. Boitard, W. Rodríguez, F. Jay, S. Mona, and F. Austerlitz. Inferring Population Size History from Large Samples of Genome-Wide Molecular Data - An Approximate Bayesian Computation Approach. *PLoS Genetics*, 12(3):e1005877, 2016.

(4) M. Boudard, D. Barth, J. Bernauer, A. Denise, and J. Cohen. GARN2: coarse-grained prediction of 3D structure of large RNA molecules by regret minimization. *Bioinformatics*, 16:2479–2486, 2017.

(5) B. Brancotte, B. Yang, G. Blin, S. Cohen-Boulakia, A. Denise, and S. Hamel. Rank aggregation with ties: Experiments and Analysis. *Proceedings of the VLDB Endowment (PVLDB)*, page 2051, Aug. 2015.

(6) K. Caye, F. Jay, O. Michel, and O. François. Fast Inference of Individual Admixture Coefficients Using Geographic Data. *Annals Of Applied Statistics*, 2018.

(7) S. Cohen-Boulakia, K. Belhajjame, O. Collin, J. Chopard, C. Froidevaux, A. Gaignard, K. Hinsen, P. Larmande, Y. Le Bras, F. Lemoine, F. Mareuil, H. Ménager, C. Pradal, and C. Blanchet. Scientific workflows for computational reproducibility in the life sciences: Status, challenges and opportunities. *Future Generation Computer Systems*, 2017.

(8) S. Cohen-Boulakia, J. Chen, P. Missier, C. Goble, A. Williams, and C. Froidevaux. Distilling structure in Taverna scientific workflows: a refactoring approach. *BMC Bioinformatics*, 15(Suppl 1):S12, 2014.

(9) A. Courbet, P. Amar, F. Fages, E. Renard, and F. Molina. Computer-aided biochemical programming of synthetic microreactors as diagnostic devices. *Molecular Systems Biology*, 14(4), Apr. 2018.

(10) D. Ellison, A. Mugler, M. D. Brennan, S. H. Lee, R. J. Huebner, E. R. Shamir, L. A. Woo, J. Kim, P. Amar, I. Nemenman, A. J. Ewald, and A. Levchenko. Cell-cell communication enhances the capacity of cell ensembles to sense shallow gradients during morphogenesis. *Proceedings of the National Academy of Sciences of the United States of America* , 113(6):E679–E688, Jan. 2016.

(11) L. F. Fitime, O. Roux, C. Guziolowski, and L. Pauleve. Identification of bifurcation transitions in biological regulatory networks using Answer-Set Programming. *Algorithms for Molecular Biology*, 12(1):19, July 2017.

(12) A. Guilhot-Gaudeffroy, C. Froidevaux, J. Azé, and J. Bernauer. Protein-RNA Complexes and Efficient Automatic Docking: Expanding RosettaDock Possibilities. *PLoS ONE*, 9(9):e108928, 2014.

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(A84) A. Guilhot-Gaudeffroy, J. Azé, J. Bernauer, and C. Froidevaux. Apprentissage de fonctions de tri pour la prédiction d'interactions protéine-ARN. In *Extraction et Gestion des Connaissances*, Rennes, France, Jan. 2014.

(A85) B. P Beauvoit, S. Colombié, J.-P. Mazat, C. Nazaret, and S. Pérès. Systematic study of a metabolic network. In *advances in Systems and Synthetic Biology*, Evry, France, Mar. 2014. edp science.

(A86) C. Pereira, J. Azé, A. Denise, C. Drevet, C. Froidevaux, P. Silar, and O. Lespinet. Comparative analysis of phylogenetic profiles for the enzymatic characterization of fungal group. In *JOBIM 2013 - Journées Ouvertes en Biologie, Informatique et Mathématiques*, page à paraître, Toulouse, France, July 2013.

(A87) S. Pérès. Analysis of metabolic networks using elementary flux modes. In edp science, editor, *Advances in systems and synthetic biology*, pages 165–170, La Colle-sur-Loup, France, Mar. 2013.

(A88) K. Rafes, S. Cohen-Boulakia, and S. Abiteboul. Une autocomplétion générique de SPARQL dans un contexte multi-services. In *BDA 2017 - 33ème conférence sur la "Gestion de Données - Principes, Technologies et Applications"*, Nancy, France, Nov. 2017.

(A89) W. Wang, M. Barba, P. Rinaudo, A. Denise, and Y. Ponty. Homology modeling of complex structural RNAs. In *JOBIM - Journées Ouvertes en Biologie, Informatique et Mathématiques - 2016*, Lyon, France, June 2016.

Other conferences and workshops

(A90) P. Amar. Systèmes oscillants chaotiques en biologie. In *Ecole de Printemps 2014 de la Société Francophone de Biologie Théorique*, St Flour, France, May 2014. Société Francophone de Biologie Théorique.

(A91) P. Amar. Metabolic network Boolean bio-computer embedded in an artificial vesicle: timing with an enzymatic oscillator. In *Séminaire de la Société Francophone de Biologie Théorique*, Saint Flour, France, June 2018.

(A92) F. Austerlitz, C. Aimé, and F. Jay. Inference of past historical events using ABC and MCMC methods on population genomics data sets. Applications to human populations. In *ESEB 2017 - Congress of the European Society for Evolutionary Biology*, Groningen, Netherlands, Aug. 2017.

(A93) S. Boitard, W. Rodriguez, F. Jay, S. Mona, and F. Austerlitz. Inferring Population Size History from Large Samples of Genome-Wide Molecular Data - An Approximate Bayesian Computation Approach. In *conférence Jaques Monod "Coalescence des approches théoriques et expérimentales en génomique évolutive et biologie des systèmes"*, page np, roscoff, France, 2016.

(A94) L. Fippo Fitime, O. Roux, C. Guziolowski, and L. Pauleve. Identification of Bifurcations in Biological Regulatory Networks using Answer-Set Programming. In *Constraint-Based Methods for Bioinformatics Workshop*, Toulouse, France, Sept. 2016.

(A95) A. Fouchet, J.-M. Delosme, and F. D'alché-Buc. Gene Regulatory Network Inference using ensembles of Local Multiple Kernel Models. In *Seventh international workshop on Machine Learning in Systems Biology, satellite meeting of ISMB'2013*, Berlin, Germany, July 2013.

(A96) M. Heinonen, O. Guipaud, F. Milliat, B. Micheau, V. Buard, and F. D'alché-Buc. Time-dependent gaussian process regression and significance analysis for sparse time-series. In *Seventh international workshop on Machine Learning in Systems Biology, satellite meeting of ISMB'2013*, Berlin, Germany, July 2013.

(A97) V. Henry, F. Saïs, E. Marchadier, J. Dibie, A. Goelzer, and V. Fromion. BiPOm: Biological interlocked Process Ontology for metabolism. How to infer molecule knowledge from biological process? In *International Conference on Biomedical Ontology, ICBO 2017*, page np, Newcastle upon Tyne, United Kingdom, Sept. 2017.

(A98) V. J. Henry, A. Ferre, C. Froidevaux, A. A. Goelzer, V. V. Fromion, S. Cohen-Boulakia, S. S. Derozier, M. Dinh, G. Fievet, S. Fischer, J.-F. J.-F. Gibrat, V. L. Loux, and S. Pérès. Représentation systémique multi-échelle des processus biologiques de la bactérie. In *IC2016: Ingénierie des Connaissances*, Montpellier, France, June 2016.

(A99) F. Jay, S. S. Boitard, and F. Austerlitz. Reconstructing past history from whole-genomes: an ABC approach handling recombining data. In *European Mathematical Genetics Meeting*, Tartu, Estonia, Apr. 2017.

(A100) J. Kolčák, D. Šafránek, S. Haar, and L. Pauleve. Unfolding of Parametric Boolean Networks. In *7th International Workshop on Static Analysis and Systems Biology (SASB 2016)*, volume 335 of *Electronic Notes in Theoretical Computer Science*, pages 67–90, Edimbourg, United Kingdom, Sept. 2016. Elsevier.

(A101) V. Le Gallic, A. Denise, and Y. Ponty. Résultats algorithmiques pour le design d'ARN avec contraintes de séquence. In *SeqBio 2015*, pages 26–31, Orsay, France, Nov. 2015.

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(A103) N. Lim, Y. Senbabaoglu, G. Michailidis, and F. D'alché-Buc. Boosting an operator-valued kernel model and application to network inference. In *Workshop on Machine Learning for System Identification*, Atlanta, United States, June 2013.

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(A105) H. Mandon, S. Haar, and L. Pauleve. Relationship between the Reprogramming Determinants of Boolean Networks and their Interaction Graph. In E. Cinquemani and A. Donzé, editors, *Fifth International Workshop on Hybrid Systems Biology (HSB 2016)*, volume 9957 of *Lecture Notes in Computer Science*, pages 113–127, Grenoble, France, Oct. 2016. Springer International Publishing.

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(A107) R. Milosz, A. Pierrot, and S. Hamel. Median of 3 Permutations, 3-Cycles and 3-Hitting Set Problem. In *IWOCA (International Workshop on Combinatorial Algorithms)* , Singapour, Singapore, 2018.

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(A110) S. Pérès, P. Dague, M. Jolicœur, and S. Schuster. Computing EFMs consistent with equilibrium constants. In *Metabolic Pathway Analysis MPA 2017*, Bozeman, United States, July 2017.

(A111) A. Rougny, C. Froidevaux, Y. Yamamoto, and K. Inoue. Translating the SBGN-AF language into logic to analyze signalling networks. In K. Inoue and C. Sakama, editors, *LNMR - 1st International Workshop on Learning and Non Monotonic Reasoning*, volume arXiv:1311.4639, pages 44–55, La Coruña, Spain, Sept. 2013. CORR.

(A112) T. Sanchez, G. Charpiat, and F. Jay. SPI-DNA: End-to-end Deep Learning Approach for Demographic History Inference. In *Paris-Saclay Junior Conference on Data Science and Engineering*, Orsay, France, Sept. 2017.

(A113) Y. Yamamoto, A. Rougny, H. Nabeshima, K. Inoue, H. Moriya, C. Froidevaux, and K. Iwanuma. Completing SBGN-AF Networks by Logic-Based Hypothesis Finding. In *Formal Methods In Macro-Biology*, volume 8738 of *Formal Methods in Macro-Biology*, pages 165–179, Nouméa, New Caledonia, Sept. 2014. Springer.

(A114) A. Zaharia, B. Labedan, C. Froidevaux, and A. Denise. Heterogeneous Graph Mining for Biological Pattern Discovery in Metabolic Pathways. In *SeqBio 2016*, Nantes, France, Nov. 2016.

Posters and other short communications

(A115) B. Brancotte, B. Rance, A. Denise, and S. Cohen-Boulakia. Interrogation de bases de données biologiques publiques par reformulation de requêtes et classement des résultats avec ConQuR-Bio. JOBIM (Journées Ouvertes Biologie Informatique Mathématiques), July 2015.

(A116) C. Fournier, S. Artzet, J. Chopard, M. Mielewczik, N. Brichet, L. Cabrera, X. Sirault, S. Cohen-Boulakia, and C. Pradal. Phenomenal: a software framework for model-assisted analysis of high throughput plant phenotyping data. IAMPS 2015 (International Workshop on Image Analysis Methods for the Plant Sciences), Sept. 2015.

(A117) L. Pauleve. Pint, a static analyzer for dynamics of Automata Networks. 14th International Conference on Computational Methods in Systems Biology (CMSB 2016), Sept. 2016.

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Books and book chapters

(A120) L. Pauleve, C. Chancellor, M. Folschette, M. Magnin, and O. Roux. Analyzing Large Network Dynamics with Process Hitting. In L. F. nas del Cerro and K. Inoue, editors, *Logical Modeling of Biological Systems*, pages 125 – 166. Wiley, July 2014.

(A121) L. Pauleve and A. Richard. Analyse statique des réseaux booléens. In E. Jeandel and L. Vigneron, editors, *Informatique Mathématique, Une photographie en 2018*, pages 157–194. CNRS Éditions, Mar. 2018.

(A122) A. Rougny, C. Froidevaux, Y. Yamamoto, and K. Inoue. Analyzing SBGN-AF Networks Using Normal Logic Programs. In *Logical Modeling of Biological Systems*. Wiley, July 2014.

Edited books

(A123) P. Amar, F. Képès, and V. Norris, editors. *avances in Systems and Synthetic Biology*, avances in Systems and Synthetic Biology, France, Mar. 2013. EDP Sciences.

(A124) P. Amar, F. Képès, and V. Norris, editors. *avances in Systems and Synthetic Biology*, avances in Systems and Synthetic Biology, France, Mar. 2014. EDP Sciences.

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(A126) P. Amar, F. Képès, and V. Norris, editors. *advances in Systems and Synthetic Biology*, Evry, France, Mar. 2016. EDP Sciences.

(A127) P. Amar, F. Képès, and V. Norris, editors. *advances in Systems and Synthetic Biology*, Lyon, France, Mar. 2017. EDP Sciences.

(A128) P. Amar, F. Képès, V. Norris, and A. Csikasz-Nagy, editors. *advances in Systems and Synthetic Biology*, Evry, France, Mar. 2018. EDP Sciences.

(A129) A. Denise, O. Lespinet, and M. Régnier, editors. *Proceedings of the SeqBio 2015 workshop: String algorithms for bioinformatics*, Orsay, France, Nov. 2015.

(A130) L. Pauleve and H. Koeppl, editors. *5th International Workshop on Static Analysis and Systems Biology (SASB 2014)*, volume 316 of *Electronic Notes in Theoretical Computer Science*, Munich, Germany, Sept. 2015. Elsevier.

(A131) L. Pauleve and N. Theret, editors. *6th International Workshop on Static Analysis and Systems Biology (SASB 2015)*, volume 326 of *Electronic Notes in Theoretical Computer Science*, Saint-Malo, France, Oct. 2016. Elsevier.

Other publications

(A132) L. Pauleve and P. Dague. Journées BIOSS-IA 2017, July 2017. Bulletin 97 de l'AFIA - Association française pour l'Intelligence Artificielle.

Theses and habilitations

(A133) P. Amar. *Contributions to the study of the dynamics of biological systems and to computing systems in synthetic biology*. Habilitation à diriger des recherches, Université Paris Sud - Paris XI, Dec. 2013.

(A134) M. Boudard. *Prediction of three-dimensional structure of RNA molecules by regret minimization*. Theses, Université Paris-Saclay, Apr. 2016.

(A135) M. Bouffard. *Design, modeling and simulation in silico of an artificial biological nanosystem for medical diagnosis*. Theses, Université Paris-Saclay, Sept. 2016.

(A136) B. Brancotte. *Rank aggregation with ties : algorithms, user guidance et applications to biologicals data*. Theses, Université Paris Sud - Paris XI, Sept. 2015.

(A137) J. Chen. *Designing scientific workflow following a structure and provenance-aware strategy*. Theses, Université Paris Sud - Paris XI, Oct. 2013.

(A138) S. Cohen-Boulakia. *Data Integration in the Life Sciences: Scientific Workflows, Provenance, and Ranking*. Habilitation à diriger des recherches, Université Paris-Sud, June 2015.

(A139) A. Guilhot-Gaudeffroy. *Modelling and scoring of protein-RNA complexes*. Theses, Université Paris Sud - Paris XI, Sept. 2014.

(A140) M. Morterol. *Advanced reasoning methods in propositional logics: application to metabolic networks*. Theses, Université Paris-Saclay, Dec. 2016.

(A141) A. Rougny. *Qualitative methods for the construction and the analysis of SBGN molecular networks*. Theses, Université Paris-Saclay, Oct. 2016.

(A142) W. Wang. *Practical structure-sequence alignment of pseudoknotted RNAs*. Theses, Université Paris-Saclay, Dec. 2017.

(A143) B. Yang. *Bioinformatics analysis and consensus ranking for biological high throughput data*. Theses, Université Paris Sud - Paris XI, Sept. 2014.

(A144) C. Zeng. *Classification of RNA Pseudoknots and Comparison of Structure Prediction Methods*. Theses, Université Paris Sud - Paris XI, July 2015.

4/ GALaC

Graphs, Algorithms and Combinatorics

équipe Graphes, ALgorithmes et Combinatoire

Responsable: Johanne Cohen, Yannis Manoussakis

En janvier 2013, l'équipe GALaC (Graphs, ALgorithms and Combinatorics) a été créée. Elle est le résultat du regroupement entre des membres de l'équipe Algo et des membres de l'équipe Graphes, Parallèlisme et Réseaux. Cette équipe s'article sur trois axes de recherches : Algorithmes pour les systèmes en réseaux, Combinatoire, Théorie des graphes.

Dans l'axe *Théorie des graphes*, les travaux portent sur des problèmes fondamentaux comme les couplages, la coloration, la connexité, la domination, *etc*. Nous travaillons aussi sur des propri ét és structurelles de graphes en lien avec les problèmes hamiltoniens et sur la conception d'algorithmes. Certains problèmes étudiés ont des applications directes en lien avec la bioinformatique, réseaux de capteurs, réseaux sociaux (correspondant à des graphes colori és).

L'axe *Algorithmes pour les systèmes en réseaux* a pour objectif de concevoir, modéliser, étudier le contrôle et les performances des algorithmiques conçus spécifiquement pour les systèmes répartis et leurs applications.

L'axe *Combinatoire* porte sur l'étude divers aspects algébriques et énum ératifs (Algèbres de Hopf, théorie des représentations, partitions et q-s érie, combinatoire des mots) en lien avec les systèmes dynamiques, les systèmes de numération, et la complexité.



Graphs, ALgorithms and Combinatorics

Head: Johanne Cohen, Yannis Manoussakis

In January 2013, the GALaC (Graphs, ALgorithms and Combinatorics) team was created. It is the result of the regrouping between some members of the former Algo team and some members of the Graphs, Parallelism and Networks teams. GALaC is articulated around three research areas: Graph Theory, Algorithms for Networked Systems and Combinatorics.

In *Graph Theory*, most of the works focuses on fundamental problems, for instance coloring, connectivity, domination, matchings, *etc*. The group also works on the structural properties of graphs related to the Hamiltonian problems, and on the design of algorithms, with applications in bioinformatic, wireless sensor networks and social networks (corresponding to colored graphs).

The *Algorithms for Networked Systems* axis has the global objective to design efficient modeling, control and performance optimization algorithms especially tailored for networked and distributed systems, as well as their applications. The scientific contributions are both theoretical and applied, with the development of the corresponding mathematical modeling techniques and tools.

The *Combinatorial* axis studies various algebraic and enumerative aspects (combinatorial Hopf algebras, representation theory, partitions and q-series, combinatorics of words) in relation to dynamic systems, systems of numeration, and complexity analysis.

Synthetic presentation

Nom du responsable de l'équipe : **Johanne Cohen, Yannis Manoussakis**

Effectifs de l'équipe
In January, 2013, the group had 13 permanent members: 10 university faculty (5 PR, 5 MCF) and 3 CNRS researchers (1 DR, 2 CR).

In June 2018, the GALaC team includes 19 permanent members: 11 university faculty (4 PR, 7 MCF), 3 CentraleSupelec faculty and 5 CNRS researchers (3 DR, 2 CR).

Personnels ayant quitté l'équipe pendant le contrat en cours

Since September 2015, Réza Naserasr (CR CNRS) left the LRI to join LIAFA, and Dominique Gouyau-Beauchamps (Professor, University Paris SUD) retired.

Nombre de recrutements réalisés au cours de la période considérée et origine des personnels Johanne Cohen moved from PRiSM, joined in September 2013 and Antoine Deza joined in January 2014. Since January 2015, the GALaC team was joined by Arpad Rimmel, Joanna Tomasik and Marc-Antoine Weisser (CentralSupelec). In January 2017, one researcher arrived: Antoine Lobstein (CR1 CNRS moved from LTCI). The LRI hired two maîtres de conférence : Viviane Pons in September 2014 and Benjamin Hellouin de Menibus (formerly ATER in University Paris Diderot) in September 2017.

Production scientifique au cours de la période écoulée

1. Our research activities in Algorithms for Networked Systems are focused on the design and analysis of distributed algorithms and protocols in emerging networks and systems. We have characterized a number of fundamental performance bounds of such systems. Based on our theoretical results, we developed efficient, adaptive, low-complexity and scalable algorithms for diverse applications in these systems. Using interdisciplinary approach spanning across computer science, electrical engineering, and operations research, our results include among others: channel rendezvous and neighbor discovery (A229, A22), opportunistic channel access (A285, A104), distributed learning, network planning and optimal content distribution (A85, A3, A267), path optimization and scheduling (A231, A256, A26), algorithm design and analysis in radio-frequency identification systems (A115, A290, A114).
2. Our activities in algorithmic and structural graph theory lie at the intersection of discrete mathematics, theoretical computer science, and their applications. They cover emerging theoretical and algorithmic problems arising from various areas including the study of the Internet through graphs, biology, social networks, and telecommunication networks. All these problems require the development of novel mathematical formulations and algorithmic approches. The graph theory group is currently developing a set of mathematical and algorithmic techniques for this type of problems. Their results are recognized worldwide, especially in the domain of edge-/vertex-colored graphs, cycles, paths, connectivity and related questions for graphs and digraphs.
3. The Maximin Latin Hypercube Design problem is widely used in sampling of complex systems. Despite its practical use, it was hardly studied from the theoretical point of view. We addressed this problem and devised the first approximation algorithm ever proposed to solve this problem for instances of any dimension and any size. This result is groundbreaking for the experimental design community as it casts light upon design construction from a theoretical perpective. It was published in Operations Research ((A64)).
4. The combinatorics theme obtained results around combinatorial Hopf algebras, monoids and groups and their representation theory, symmetries in combinatorics, decision problems on groups, and combinatorial structure of tilings. We also produced advances in computational mathematics software design and development (e.g. SageMath). Horizon 2020 European Research Infrastructure projet *OpenDreamKit* labelled by Systematic Pole brings together a range of projects, and associate software to create and strengthen virtual research environments. The most widely used research environment is the Jupyter Notebook from which computational research and data processing can be directed. The OpenDreamKit project provides interfaces to well established research codes and tools so that they can be used seamlessly and combined from within a Jupyter Notebook.

Bilan quantitatif des publications de l'équipe

- Articles de revues: majeure internationale: 92, autres: 91
- Article de conférences: majeures internationales: 20, autres: 90
- Édition de livres: 1
- Chapitres de livres: 0

5 publications majeures

- J. Cohen, A. Héliou, and P. Mertikopoulos. Learning with bandit feedback in potential games. In *NIPS '17: Proceedings of the 31st International Conference on Neural Information Processing Systems*, Long Beach, CA, United States, Dec. 2017.
- F. Hivert, A. Schilling, and N. M. Thiéry. The biHecke monoid of a finite Coxeter group and its representations. *Algebra & Number Theory*, 7(3):595–671, 2013. 57 pages, 6 figures.
- K. Le Guiban, A. Rimmel, M.-A. Weisser, and J. Tomasik. The First Approximation Algorithm for the Maximin Latin Hypercube Design Problem. *Operations Research*, 66(1), Mar. 2018.
- M. Mangili, F. Martignon, and A. Capone. Performance Analysis of Content-Centric and Content-Delivery Networks with Evolving Object Popularity. *Computer Networks*, 94:80–98, Jan. 2016. (best paper among 841 accepted papers and 2272 submitted papers), coauthored with M. Mangili and A. Capone.
- Q. Sun. *A contribution to the theory of (signed) graph homomorphism bound and Hamiltonicity*. Theses, Université Paris-Saclay, May 2016.

5 (max) documents majeurs (autres que publications)

- (with many coauthors): publication of one of the very first introductory book for SageMath: "Calcul Mathématique avec Sage" (2013, self-published) and translation in English "Computational Mathematics with SageMath" (2018, publisher: SIAM). http://sagebook.gforge.inria.fr/
- publication (in press) of a introductory book for SageMath: Alexandre Casamayou, Nathann Cohen, Guillaume Connan, Thierry Dumont, Laurent Fousse, et al.. "Mathematical Computation with SageMath (temporary title)". published by the authors, (see **https://hal.inria.fr/hal-01646401**)

5 (max) faits illustrant le rayonnement ou l'attractivité académique

- Lin Chen is the recipient of the CNRS Bronze Medal (2018) and is a junior member of IUF (2018-2021);
- Fabio Martignon is a junior member of IUF (2013 - 2018);
- Coordination of the Horizon 2020 European Research Infrastructure project (#676541) on open source computational tools and virtual research environments for mathematics (opendreamkit.org, 2015-2019, 15 sites, 50 participants);
- International invited professorship to GALaC (about five per year);
- Qiang Sun (2016) and George Manoussakis (2018) received the accessit of prix de thèse Graphes "Charles Delorme".

5 (max) faits illustrant les interactions de l'équipe avec son environnement socio-économique ou culturel

- Yannis Manoussakis is the director of LRI;
- Regular collaborations with Logilab (logilab.org) and Quantstack (http://quantstack.net/) on computational software development;
- Art & Science: collaboration with a professional juggler in particular with a joint popular science conference/show;
- Organisation de la Fête de la Science au LRI depuis 2013.

Principales contributions de l'équipe à des actions de formation

- Yannis Manoussakis is the co-founder of M2 Fondements de l'Informatique et Ingénierie du Logiciel - Foundations of Computer Science and Software Engineering (FIIL);
- (co)organization of a dozen one-week computational training workshops (Sage-Days, see **https://wiki.sagemath.org/Workshops**).

Research Group Members and evolution since 2013

Permanent Members				
Name	*First name*	*Position*	*Institution*	*Remarks*
CHEN	Lin	MCF	PARIS SUD	
COHEN	Johanne	DR2	CNRS	since 1st Sept. 2013
COHEN	Nathann	CR1	CNRS	
DELAËT	Sylvie	MCF	PARIS SUD	
DEZA	Antoine	DR2	CNRS	since 1st Jan. 2014
DJELLOUL	Selma	MCF	PARIS EST	
FIORENZI	Francesca	MCF	PARIS SUD	
FLANDRIN	Evelyne	PREM	PARIS 5	
FORGE	David	MCF	PARIS SUD	
GOUYOU-BEAUCHAMPS	Dominique	PR1	PARIS SUD	until 30th Sept. 2015
HELLOUIN de MENIBUS	Benjamin	MCF	PARIS SUD	since 1st Sept. 2017
HIVERT	Florent	PR1	PARIS SUD	
LI	Hao	DR2	CNRS	
LOBSTEIN	Antoine	CR1	CNRS	since 1st Jan. 2017
MANOUSSAKIS	Yannis	PREX	PARIS SUD	
MARTIGNON	Fabio	PR1	PARIS SUD	
NASERASR	Réza	CR1	CNRS	until 31th Aug. 2015
PONS	Viviane	MCF	PARIS SUD	since 1st Sept. 2014
RIMMEL	Arpad	MCF	CentraleSupelec	since 1st Jan. 2015
THIÉRY	Nicolas	PR2	PARIS SUD	
TOMASIK	Joanna	PR	CentraleSupelec	since 1st Jan. 2015
WEISSER	Marc-Antoine	MCF	CentraleSupelec	since 1st Jan. 2015

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PhD students				
Name	*First name*	*Funding*	*Institution*	*Remarks*
ANGLES D'AURIAC	Jean-Alexandre	Alloc. Ministère	PARIS SUD	01.10.2011 - 31.08.2015
ARALDO	Andrea Giuseppe	Bourse DIGICOSME	PARIS SUD	01.10.2013 - 30.09.2016
BAI	Yandong	Bourse CSC	PARIS SUD	01.09.2011 - 31.08.2015
BERGÉ	Pierre	Alloc. Ministère	PARIS SUD	01.01.2017 -
DAMBREVILLE	Alexandre	Bourse DIGICOSME	PARIS SUD	01.10.2014 -
FALQUE	Justine	Alloc. Ministère	PARIS SUD	01.01.2016 -
GAY	Joël	Alloc. Ministère	PARIS SUD	01.01.2016 -
HE	Weihua	Bourse CSC	PARIS SUD	01.10.2011 - 31.08.2015
LEGAY	Sylvain	Alloc. Ministère	PARIS SUD	01.10.2013 - 31.01.2017
LE GUIBAN	Kaourintin	Alloc. Ministère	PARIS SUD	01.01.2015 - 14.07.2018
MANO	Mattias	Bource ISN	PARIS SUD	01.09.2015 31.08.2018
MANGILI	Michele	Alloc. Ministère	PARIS SUD	01.10.2012 - 30.09.2015
MANOUSSAKIS	George	Bourse DIGITEO	PARIS SUD	01.12.2014 -30.11.2017
MORCOS	Mira	Bourse DIGICOSME	Telecom Sud-Paris	01.11.2015 -
PHAM	Hong Phong	Alloc. Ministère	PARIS SUD	01.11.2015 -
PRIEZ	Jean-Baptiste	Alloc. Ministère	PARIS SUD	01.10.2012 - 31.08.2016
SHI	Hehuan	Bourse CSC	PARIS SUD	05.12.2016 -
SUN	Qiang	Bourse CSC	PARIS SUD	01.10.2012 - 31.08.2015
VIRMAUX	Aladin	Digiteo	PARIS SUD	01.10.2012 - 31.08.2016
YANG	Weihua	Bourse CSC	PARIS SUD	24.01.2011 - 22.11.2013
YU	Jihong	Alloc. Ministère	PARIS SUD	01.10.2013 - 31.03.2017

Temporary personnel				
Name	*First name*	*Position*	*Institution*	*Remarks*
BRAY	ERIK	Engineer (Open-DreamKit)	PARIS SUD	since 1st Sept. 2016
DEMEYER	Jeroen	Engineer (Open-DreamKit)	PARIS SUD	since 1st Jan. 2016 until 31st Dec. 2017
HAENSEL	Alwin	Post-Doc	PARIS SUD	until 31st 2013
LUVIANO FLORES	Johana	Post-Doc	PARIS SUD	since 1st 2013 Dec. until 30th Nov 2014
METEL	Michael	Post-Doc	PARIS SUD	since 1st Aug. 2016 until 31st Dec. 2017
MONTERO	Leandro Pedro	Post-Doc	PARIS SUD	until 31st Aug 2015
PILORGET	Benoît	Engineer (Open-DreamKit)	PARIS SUD	since 1st Sept. 2016
TANG	Yangbin	Post-Doc	PARIS SUD	since 1st Sept 2013 until 10th Sept 2014
RABE	Florian	Post-Doc	PARIS SUD	since 1st Jan. 2018

4/ GALaC

Research Description

In this part, we will describe our work related to 3 axes.

Algorithms for networked systems.

During the last five years, the Algorithms for Networked Systems (ANS) research activity designed efficient modeling, control and performance optimization algorithms specially tailored for networked and distributed systems, as well as their applications. The research activities of the group focused on the design and analysis of distributed algorithms and protocols in emerging networks and systems, with a particular emphasis on efficient resource allocation, network planning, energy efficiency, security and resilience. In particular, we were interested in problems of both theoretical importance and practical application. Methodologically, we applied tools in distributed algorithms, stochastic control, game theory, convex/non-convex optimization, applied probability, in emerging real-world complex systems (A231, A256, A26) and networks, such as wireless (A229, A22) and content distribution networks (A85, A3, A267), Cyber-Physical Systems (CPS) (A285, A104), Internet-of-Things (IoT), and smart grids (A115, A290, A114). Our objective is to understand fundamental performance limits of such systems, and develop efficient, adaptive, low-complexity and scalable algorithms for diverse applications in these systems. We highlight hereafter some important results achieved in the last 5 years:

COMPUTING NASH EQUILIBRIA. One important issue is to be able to compute Nash equilibria. In several contexts related to our application fields, the equilibria are the results of a dynamic process in which players act on empirical information, based on the history of their strategies' performance over time. Computing Nash equilibrium is particularly important in many situations where distributed agents have only some local view. For instance, when deciding which route to assign to packets, a router may be typically unaware of how many other packets are travelling on a given route at any given moment, and consequently can rationally only base its decision on empirical past performances of the various available strategies. In fact, in situations of this kind, agents (players) may not even know that they are involved in a game to justify the Nash equilibrium prediction. Technically, we often focus on models such as the class of potential games that has found widespread applications in theoretical computer science. We used this settings in a general context (A193, A194), for wireless communications in several recent works such as (A261, A262, A244), biology (A12, A11), or for scheduling (A192, A24, A25, A195). In particular, in bioinformatic, in collaboration with PRiSM (Versailles), LIX (Ecole Polytechnique) and Bioinformatics team

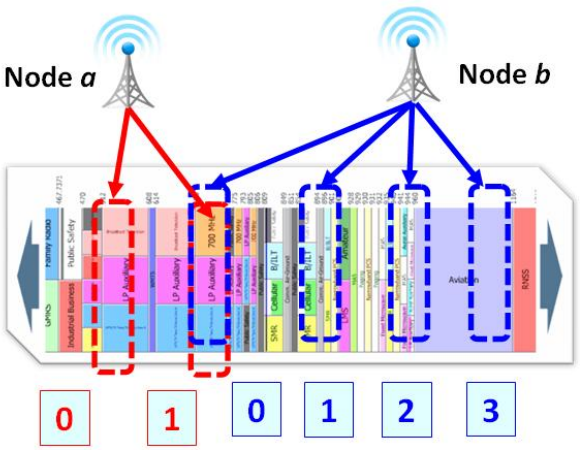

Figure 4.1: Illustration of heterogeneous channel rendez-vous in wireless network.

(LRI), we focus on the prediction of the three-dimensional structure of large RNA molecules. We decided to see the folding of the RNA structure as a game. Our hypothesis is to understand the 3D structure like an equilibrium in game theory (see Figure 4.2). To compute the Nash equilibrium (A12, A11), we use a regret minimization algorithm of prediction of the three-dimensional structure of large RNA molecules at a coarse grain level, given their secondary structure only. The resulting program is fully available at http://garn.lri.fr. This work was granted by the Digiteo JAPARIN-3D project. Moreover, we (collaboration with LIX (Ecole Polytechnique)) prove that the algorithms used in (A12, A11) converge towards a Nash equilibrium for the potential games (A194). In particular, several PhD theses (M. Boudard and A. Héliou) were competed on this topic.

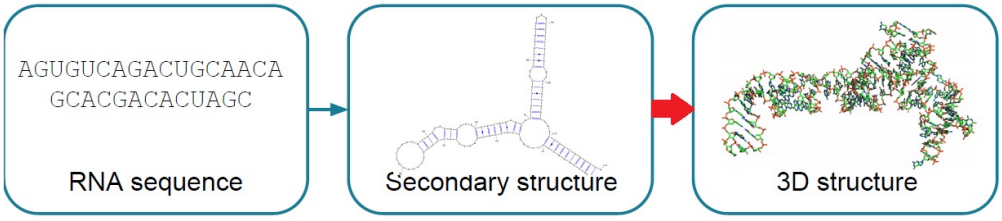

Figure 4.2: To fold RNA structure can be viewes as a game.

SELF-STABILIZING ALGORITHM DESIGN In the field of distributed algorithms, we focus on various self-stabilizing algorithms. Self-stabilizing algorithms are distributed algorithms that are robust to transient faults: whatever the system state is initially (or after a faulty behavior), they are guaranteed to come back to a legitimate state. In this context, we designed various algorithms, in particular matching algorithms for graphs for various communication models (anonymous network (A132), state model (A236), link-register model). Our motivation is to understand if it is possible to transform algorithms from a given communication model to another. In parallel, we studied matching problems in the context of approximation theory (A236) and game theory (A236) (presence of selfish agents (A142)). First, we designed on a first polynomial time self-stabilizing 2/3-approximation algorithm for the maximum matching problem in polynomial time (A236) – the best algorithm known is performed in exponential time. Second, we (collaboration with Parsys team (LRI)) recently design a self-stabilizing distributed algorithm (A142) for the stable marriage problem introduced by Gale and Shapley. This work received the best paper price of the conference SSS 2017. In particular, one PhD these (G. Manoussakis) was competed on this topic.

INFORMATION-CENTRIC NETWORKS. ICNs represent an alternative paradigm to enable efficient content delivery in the Internet. We contribute to this field, by tackling the general problem of supporting efficient digital content distribution. More in depth, we focused on three complementary problems, namely: (1) wireless resource sharing, (2) optimal caching and network planning and (3) security aspects for content delivery. Specifically, we took into account wireless scenarios, formulating a novel auction mechanism that is used to motivate wireless access point owners to lease their unused bandwidth and storage capacities, in exchange for economic incentives (A269, A85). This proposal improves the content distribution capabilities of the network, while making the operator save significant amount of costs to run the servers of the distribution infrastructure. We further studied the centralized, offline network planning problem,

in the presence of distributed caches and tackled (a) the optimal network design for the migration to an ICN, under a single-time slot, as well as the design of cost-aware caching strategies (A212, A3); (b) we then compared the performance bounds of the Content Delivery Network (CDN) paradigm with an ICN with evolving object popularity (A267, A83), further selecting the right available representation when caching videos (A184), and finally (c) we considered virtualized CDNs and studied the stochastic network planning problem of one such infrastructure (A203, A81). We further addressed the security implications on access control and content access tractability, and proposed a novel cache-aware mechanism to foster the efficient enforcement of these security requirements, in an ICN (A84). This work has been conducted within the framework of an IUF 5-year project (2013-2018).

DYNAMIC SPECTRUM AGGREGATION. The research group addressed the problem of dynamic spectrum aggregation, which has emerged in the cognitive radio network field, with many open important theoretical and technical problems waiting to be solved. In this context, we (1) developed a theoretical framework characterizing the tradeoff between spectrum and energy efficiencies in spectrum aggregation, and (2) designed green dynamic spectrum aggregation mechanisms that jointly optimize the spectrum sensing, spectrum aggregation and access so as to achieve a desired balance from both spectrum and energy perspectives. This research work has been conducted in the framework of the Green-Dyspan project (ANR Blanc International II, March 2013-September 2016), in cooperation with Zhejiang University.

MAXIMIN LATIN HYPERCUBES DESIGNS We worked on the combinatorial problem (Maximin Latin Hypercubes Designs) issued from the experimental design field which, despite the necessity of its efficient solving, has not been analyzed yet from the theoretical point of view. Our groundbreaking result is an approximation algorithm to solve it ((A64)). Actually, this is the first approximation algorithm ever designed to this problem for instances of any dimension and any size. To identify the difficulty of the problem under study we defined its generalization, the completion problem (measurements have been already taken, the goal is to terminate the sampling process). We still do not know whether the construction problem is NP-complete or just P but we found that the completion of the hypercube is NP-complete and the theoretical guaranty on the quality of its solution cannot be given ((A63)). In parallel, we have been working on state space exploration methods obtaining results better than those reported in the literature for both the construction ((A185)) and completion ((A253)) problems.

Algebraic combinatorics, computational mathematics software, and symbolic systems.

ALGEBRAIC COMBINATORICS. The algebraic combinatorics sub-axis achieved results around combinatorial Hopf algebras, representation theory of monoids and groups, and symmetries in combinatorics. Additionally, benefitting from Viviane Pons arrival, the creation of a joint weekly seminar with the Combinatorics Team of the LIX, and a PHC joint grant with Austria, geometrical aspects (polytopes) and partial orders are becoming increasingly important, with Coxeter theory playing a unifying role. This is a general trend in the international community, and many results (A7, A123, A124, A283) were obtained throught international collaborations (Canada, India, Scotland, USA). In particular, three PhD theses (Jean-Baptiste Priez, Aladin Virmaux, and Joël Gay) were competed, and one is currently underway (Justine Falque), as well as Master 2 internships.

COMPUTATIONAL MATHEMATICS SOFTWARE. The team has long been involved in the design and implementation of collaborative computational mathematics software, e.g. SageMath, as an essential research tool. The previous HCERES report pointed out that this activity has the potential to become a subject of research itself. This strategy was fruitful: the theme became a core topic for our combinatoric group, and received global visibility with international collaborations and invitations (PASCO, Codima, CRM,...). This resulted in the team-led 7.9M euros OpenDreamKit European H2020 Research Infrastructure Project http://opendreamkit.org. Consequently, three research engineers and one postdoctoral fellow were locally recruited. Results range from high performance computing for combinatorics to formalisation of mathematics for proofs, software design and interoperability.

SYMBOLIC SYSTEMS. Symbolic systems (words, tilings, cellular automata, ...) are matters of common interest in both computer science and mathematics (algorithmic and decidability questions, combinatorial tools, dynamics, group theory). In particular, we are interested in questions concerning entropy (calculation, inequalities) in classical symbolic dynamical systems. We also study ((A15)), decision problems for generalized cellular automata (on finitely generated groups or monoids). In (A14), we introduced a new model of computation and linked it to classical decision problems (word problem, etc.) of some finitely

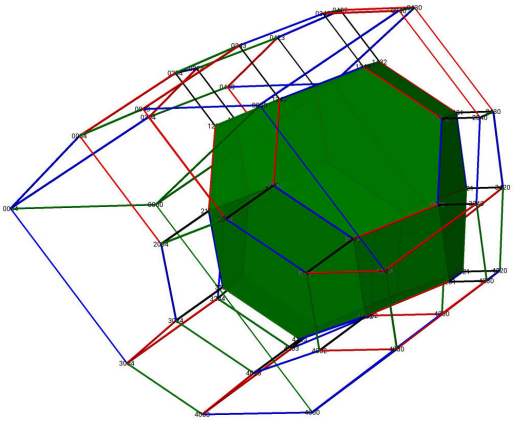

Figure 4.3: A 4-dimensional polytope with a 3 dimensional face, whose squeleton is a lattice and the Cayley graph of a monoid. This work related to rook placement was obtained by Gay-Hivert.

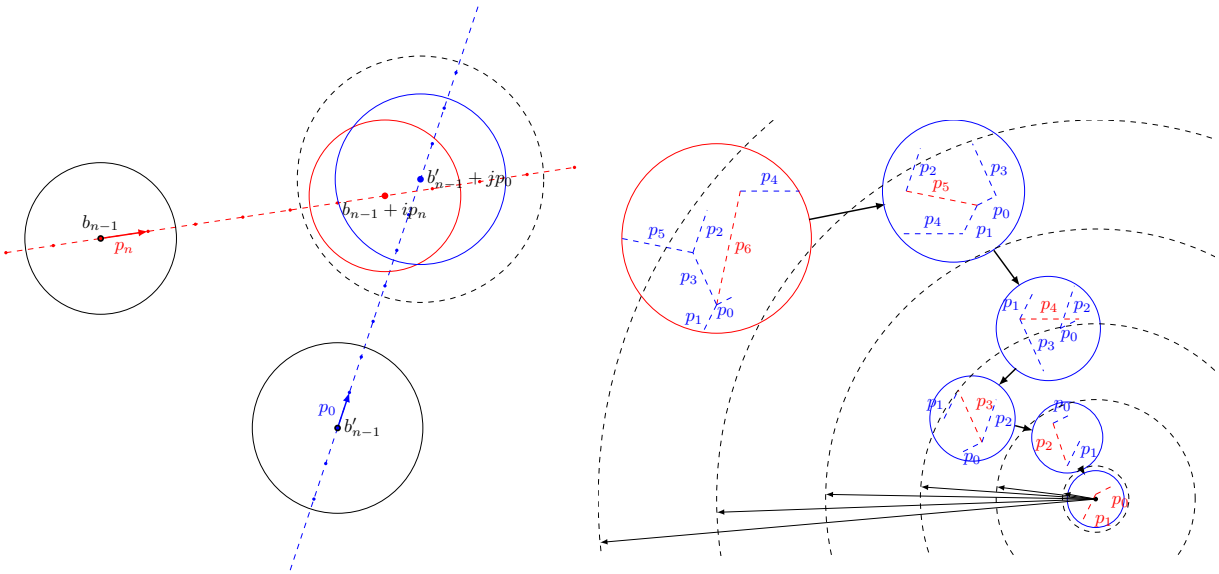

Figure 4.4: Spatial structure of period-breaking in aperiodic tilings (from the above-mentioned paper)

generated groups. This theme has been recently strengthened by the recruitment of Benjamin Hellouin de Menibus with expertise in computability and probabilistic approaches. This led to a result on the combinatorial structure of tilings with periodicity properties and its decidability consequences.

DISSEMINATION The team is strongly involved in dissemination activities via the organization of *circa* of development and training events centered about computational mathematics for research and teaching (SageMath, Jupyter, CoCalc, ...). Outreaching to a broader audience, the team coordinated since 2013 the Fête de la Science at LRI, **http://fetedelascience.lri.fr/** with many general-audience talks, and created a conference-show with a professional juggler that has been given in a variety of settings (schools, universities, theaters), and has been supported by fundings from two grants (JAC, JMaC).

Algorithmic and structural graph theory

Graphs are among the most classic structures for modeling various relations and processes in many research domains such as physics, chemistry, biology, economics, social systems, databases, networks, internet, and artificial intelligence (AI). In our group, during the 2013-2018 period, we worked on severals extensions on the basic structural and algorithmic graph theory. More precisely, we studied classical and fundamental problems of edge/vertex- colored graphs, Hamiltonian graph theory, cycles, extremal graph theory, colorings in graphs, structural properties of graphs, parameters of dominations and many related algorithmic problems. Our results are on various graph theory problems including rainbow/proper/tropical, subgraphs in edge-/vertex-colored graphs, circumference, pancyclic, cyclability,

pancyclability, dominating set, decomposition, and partition. We study almost all classes of undirected and directed graphs including very large graphs, bipartite graphs, line-graphs, tournaments, Cartesian products of graphs – and in particular prisms and generalized prisms.

EDGE/VERTEX COLORED GRAPHS Our group is among the world leading teams on this subject. Many of the fundamental concepts on this topic were first introduced and developed. Today, many research groups worldwide, including China, Spain, England, Denmark, Sweden, Germany, Japan, The Netherlands, are undertaken our works and maintain close collaboration with us on this domain. An important number of PhD thesis (about eight in our group) have been devoted to this domain.

In case of vertex-colored graphs, let us define a tropical subgraph as one where each color appears at least once. This recently introduced notion has direct applications notably for the Web study and in bioinformatics (Multiple Sequence Alignment Pipeline or for multiple protein-protein Interaction networks), and any graph invariant (e.g. the domination number, the vertex cover number, maximum matchings, independent sets, connected components, shortest paths) can be defined in the tropical setting. We have been pioneering the study of dominating tropical sets, tropical paths and cycles, tropical cliques and independent sets, tropical matchings, tropical connected subgraphs and tropical homomorphisms since 2015 (A235, A273, A52, A122, A17). As an example, we showed that the minimum tropical component problem is NP-Hard for trees, interval graphs and split graphs, but polynomial when the number of colors is logarithmic in terms of the order of the graph (A122). We then provide upper bounds for the order of the minimal connected tropical subgraph under various sufficient conditions. We finally study the problem of finding a connected tropical subgraph in a randomly vertex-colored random graph. As another unexpected result, we proved that the minimum tropical dominating set problem remains NP-complete even if the graph is reduced to simple path (A17). The previous two highly intractable problems on tropical connected components and tropical dominating sets are in complete contrast with the tropical maximum matching problem which, as we proved, admits a polynomial solution (A133).

Concerning edge-colored graphs, studies of spanning subgraphs with specified color patterns in edge-colored graphs has witnessed significant developments over the last decades from both theoretical and practical perspectives. The most natural pattern in such a context is that of a proper coloring, which entails adjacent edges/vertices having different colors. Petersen's pioneer very early works seems to be the first place where one can find applications of properly colored trails. Proper subgraphs are relevant to various applications including genetics, social sciences as well as in various other fields, as in VLSI for compacting a programmable logical array. Although a large body of work has already been done[1] on the subject, in most previous works the number of colors was restricted to two and only a few problems were studied for higher number of colors. For instance, while it is well known that properly edge-colored hamiltonian cycles can be found efficiently in 2-edge colored complete graphs, it is a long standing question whether there exists a polynomial algorithm for finding such hamiltonian cycles in edge-colored complete graphs with three colors or more. Our recent work on proper spanning trees yields algorithmic and structural results in edge-colored graphs (A89). As another example, we established sufficient conditions for a multigraph to have a proper Hamiltonian cycle/path, depending on several parameters such as the number of edges (A87, A293). As a last example we deal with rainbow subgraphs ie, subgraphs such that any pair of edges have distinct colors. We introduce examples to show that some classic problems can be transferred into problems on rainbow subgraphs. We obtained sufficient conditions for an edge colored graph to have a rainbow triangle or a rainbow cycle of length 4.

DISTRIBUTING PAIRS OF VERTICES ON HAMILTONIAN CYCLES By using the Regularity Lemma of Szemeredi and the Blow-up Lemma of Komlos et al., we give a proof of Enomoto's conjecture for graphs of sufficiently large order: there exists a positive integer n_0 such that for all $n \geq n_0$, if G is a graph of order n with minimum degree $\delta(G) \geq n/2 + 1$, then for any pair of vertices x, y in G, there is a Hamiltonian cycle C of G such that the distance of x and y on the cycle C is exactly $\lfloor n/2 \rfloor$.

PARTITION GRAPHS INTO DISJOINT CYCLES We show that if G is a graph on at least $3r+4s$ vertices with minimum degree at least $2r + 3s$, then G contains vertex disjoint cycles, where each of s of these cycles either contain two chords, or are of order 4 and contain one chord. This is a stronger result than a conjecture (2008) of Bialostochi, Finkel, and Gyárfás.

DOMINATION We study complexity problems related to dominating sets in graphs. For example: for a given subset X of vertices, the complexity of finding a minimum dominating set (domination in a given distance r) containing X. A set S is said to be an identifying code if every vertex u in the graph can be identified by the vertices of S that dominates u in distance r. We investigate the difference between the size of an

[1] see the book by Bang-Jensen and Guttin

optimal dominating set and an optimal identifying set.

TOURNAMENTS: An arc uv of a digraph D is called *universal* if uv and w are in a common cycle for any vertex w of D. We show that every arc of a tournament T is universal if and only if T is either 2-connected or has a cut-vertex v such that the in-and out-neighbors of v both induce strongly connected subtournaments. We try to find large digraphs inside of tournaments with sufficiently high outdegree . We are interested in the following related conjectures: 1) The vertex set of any digraph with sufficiently high outdegree can be partitioned into two sets, both inducing a graph of minimum outdegree ≥ 2 (Cf N. Alon). 2) Every directed graph with sufficiently high outdegree contains subdivision of the transitive tournament on 5 vertices (Mader).

Self Assessment

Strengths: The strengths of the GALAC team are in algorithms, graph theory, algebraic combinatorics, game theory, control of networked systems, and discrete, continuous, and stochastic optimization. The team aims to develop theoretical tools and formulations to investigate a wide spectrum of research problems of both fundamental and practical significance in science and engineering. GALAC fosters synergy between those recognized areas of expertise, and the lively and interactive discussions during GALAC seminar illustrate the complementarity between the different research subgroups. GALAC PhD students often interact with many researchers within the team and fellow graduate students. The scientific culture of GALAC has successfully prevented the creation of research silos within the team and contributes to nurture a healthy environment to produce high-caliber graduate students and research output. GALAC's excellent publication record and reputation as one of the leading research groups in France, are both key to attract top graduate students and post-doctoral fellows. The team nurtures multifaceted, multidisciplinary training that produces highly marketable, qualified personnel for both industrial and academic positions as illustrated by the highly successful placement of our graduate students and post-doctoral fellows.

Weaknesses: Teaching, research, grant proposal applications and grant management, administrative duties, and student supervision are getting increasingly time-consuming and demanding as deadlines are getting tighter and tighter, at a time when not responding to an email within a week might be considered as negligent. Reaching a critical mass is key to develop in-house experience and resources needed to efficiently and quickly respond to arising opportunities. While the team current size is not detrimental for its functioning, it may limit our ability to further develop and may lead to significant opportunity-loss.

Opportunities: The recognized role of theoretical computer science and algorithms in AI team offers an ideal opportunity for a healthy growth and to achieve the required visibility. The scientific expertise of GALAC is well positioned to address the challenge posed by the rapid developments triggered by machine learning and data science related initiatives. GALAC is concerned with developing models and formulations rooted in advanced theoretical foundations. This scientific culture not only warranties a successful synergy with partnership with other research group but will boost our ability to lead projects involving the collection, transformation, and analysis of data with different academic and industry partners.

Threats: While building on existing expertise is key to establish sound scientific foundations, research is a moving target and developing research silos may lead to over-specialized research activities. Computational paradigms and advanced software knowledge are thriving throughout the Saclay Campus and the need for computationally savvy students is equally acute for our industry partners. Not being able to attract and retain high-caliber students is a major threat in the current highly competitive environment. At a higher level, a key issue is the strategic funding commitment within the Saclay Campus to further support theoretical computer science and algorithms.

Strategy and five-year project

We present our strategy organized according to scientific directions, and not according to axes, since in the last five years, several thematics cooperations occurred between these axes.

Algebraic combinatorics, computational mathematics software, and symbolic systems. The combinatorics axis of GALaC is centered around three main thematics: algebraic combinatorics, computational mathematics software, and symbolic systems. The current strategy of the axis is to maintain combinatorics at its core while exploring new frontiers with geometry, dynamics, computations and formalization, fuelled by computer exploration and software development. This strategy aims to build upon the achieved momentum, to disseminate our results and engage in new partnerships with teams worldwide. In addition, GALaC has a recognized expertise in translating theoretical models, ranging from algorithmic and combinatorial data structures to abstract algebra, into efficient implementations. Use cases include research computer exploration (experimentation), practical applications, and teaching. While modelling abstract mathematics poses notoriously difficult design problems, GALaC has been successful at tackling challenging questions including large computational systems and proof systems. GALaC is also highly active in dissemination by leading and participating to international software development collaborations such as the OpenDreamKit H2020 European Project (opendreamkit.org) and the combinatorics library of SageMath (sagemath.org). This shared framework will foster the identification of new theoretical questions and solving methodologies.

Dynamics, computational models, and phase transitions. Computational questions are essential to GALaC and include combinatorics and dynamics of symbolic models of computation, learning power of neural networks, and computational power of distributed systems. Symbolic dynamical systems provide a framework for important intertwining between combinatorics on words and algorithmic and computational issues. This relationship leads to results on the computational complexity of combinatorial problems and, conversely, allows using combinatorial formulations or discrete probabilities for algorithmic problems. For example, enumeration tools, e.g. generating series, entropy, and symmetry considerations, find applications in statistical physics and analysis of algorithms. A change or jump in the computational difficulty of a problem may correspond to a phase transition in the system and to a change of its properties. GALaC combines these approaches on computational models – e.g. finite automata, cellular automata, Turing machines – and other symbolic models, such as words and tilings. These models have connections to dynamic systems, statistical physics, and group theory including groups of automata, tilings of groups, transformation groups and monoids, and algebraic study of algorithms.

Parameterized complexity. The concept of the parameterized complexity introduced by Downey and Fellows almost twenty years ago allows one to classify the difficult problems according to a computational effort needed to find their exact solution. More formally speaking, the idea consists in the parametrization of problem instances. Thanks to this approach, the algorithmic complexity depends not only upon the size of a problem n, but also upon the parameters associated with its instances. Thereby, if only parameter values are constant, the complexity expressed as a polynomial function of n and a computable function (typically exponential) of parameters is below the complexity written just as a computable function of n, as $n \leftarrow \infty$.

Almost one hundred years ago Menger, while establishing the conditions of the graph connectivity, laid the foundations for cuts (separators) studying. Put briefly, cutting a graph consists in partitioning its vertices by removing the edges (or vertices). Due to possible practical applications the family of multicut problems in which sources have to be separated from their destinations are studied intensively.

For instance, we consider the problem issued from a practical application: a fleet of k vehicles heads off to their destinations. The question asked is whether obstacles blocking less than a given (and relatively small) number p of paths from a source to a corresponding destination may prevent a certain number r of these vehicles (relatively small again) from arriving at their destinations.

A primordial notion when dealing with multicut problems is an important cut. The number of such cuts is known, an algorithm to find them is, however, missing. Its design is one of our objectives.

Algorithm design in various environment models. GALaC has an international expertise in game theory, specifically regarding the identification of Nash equilibria with applications such as bioinformatics and telecommunications. In such domains, the goals can formalized in terms of reaching equilibria; these equilibria can be characterized using regret minimization algorithms.. Research directions include the study of how techniques used for regret minimization can be adapted to resource allocation problems. For instance, in a regret minimization context, the model usually considers an adversary that provides

worst case instances dynamically. On the other hand, in an algorithm design context, the model usually consider a worst case analysis on inputs provided online. One interesting question is to investigate algorithms combining the two approaches where instances are provided online according to some assumed distribution.

Distributed algorithms. The design of distributed algorithms is one of the key focuses of GALaC. Within a of self-stabilization context, we aim to provide as automatic as possible operators, transforming algorithm from more abstract models to ones closer to message passing algorithms. For instance, we aim to transform a state model algorithm into a message passing one. While these questions have been studied at a computability level, we aim to analyze the efficiency in terms of complexity of such operators.

Optimization and control for networked and distributed systems. GALaC has expertise in the design of efficient modeling, control and performance optimization algorithms especially tailored for network and distributed systems, as well as their applications. The scientific contributions are therefore both theoretical, with the development of new mathematical modeling techniques and proofs, and applied, with the development of innovative tools for the optimal planning and resource allocation in networked, distributed systems. Methodologically, the team develops mathematical tools in stochastic optimization, game theory, distributed learning, algorithm design and analysis. Combinatorial optimization algorithms are applied to solve the formulated problems and analyze the structural properties of the solutions and the correspondent tradeoffs. Efficient heuristics are proposed to scale up to large networks and identify the asymptotic behavior and performances. Dynamical system analysis and *distributed learning methods* are further employed in the investigation of the convergence and stability properties of the proposed distributed algorithms for online network reconfiguration. Finally, game theory plays an essential role in the design of efficient and robust distributed algorithms and protocols, and their performance characterization and analysis.

Computational, combinatorial, and geometric aspects of linear optimization. Rational decision making through quantitative modelling and analysis is the guiding principle behind operations research, a field with several far-reaching applications across engineering, sciences, and industry. Finding optimal allocations of resources, scheduling tasks, and designing prototypes are a few of the areas operations research is concerned with. In many cases, these problems can be formulated or approximated as linear optimization problems, *i.e*,maximizing or minimizing a linear function over a domain defined by a set of linear inequalities. The simplex and primal-dual interior point methods are currently the most computationally successful algorithms for linear optimization. While the simplex methods follow an edge path, the interior point methods follow the central path. The algorithmic issues are closely related to the combinatorial and geometric structure of the feasible region. The study of linear optimization with respect to its computational, combinatorial, and geometric facets, firstly aims to characterize the worst-case and most computationally challenging problem instances. Another aim is to design new models well suited to specific applications. Research directions include optimization and machine learning that are increasingly intertwined: Optimization is mostly concerned with accuracy, computational efficiency, and robustness while machine learning focuses on achieving efficiency via possibly simpler formulations that are computationally efficient and scalable for a well-defined class of instances with potentiality less concerns about accuracy. While optimization is often at the heart of machine learning formulations, machine learning does more than revisiting and applying optimization tools. Machine learning explores new directions and develops novel approaches by combining a wide range of formulations originating not only in optimization but also statistics and probability, theoretical physics and electrical engineering. GALaC established expertise in discrete mathematics, algebraic combinatorics, and discrete, continuous, and stochastic optimization will contribute in cooperation with the A & O team, to further strengthen LRI's expertise in algorithms dedicated to machine learning formulations.

Connectivity to edge-colored graphs in terms of properly edge-colored paths. The aim is to gain insight into our proper connectivity problem from Menger's basic theorem that states that a graph is k-connected if and only if any pair of vertices is connected with k pairwise vertex-disjoint paths. However, difficulties arose very quickly, as we already have proved that proper local connectivity is not polynomial characterizable in edge-colored graphs. Thus, there can be no counterpart to Menger's Theorem as such, and even the notion of a connected component as an equivalence class (transitivity property) does not carry over to edge-colored graphs since the concatenation of two proper edge colored paths $x - y$ and $y - z$ does not necessarily define a $x - z$ proper path. Therefore, a new notion of connectivity needs to be defined, and/or some variations of the classical connectivity can be studied (for instance, find tropical paths between two given vertices or study the k-linking problem for both edge- or vertex-colored graphs). However, as these problems are NP-hard, another goal is to establish approximation

algorithms in the general case. Also find, if any, polynomial solutions for restricted versions of the problem or for specified classes of colored graphs (acyclic graphs, planar, complete). Note that none of the approximation methods used in the case of non-colored graphs or digraphs works here. Roughly speaking our feeling is that the expected results on this topic will be the fruit of persistent effort at systematizing results on the subjects mentioned in our outcomes for colored graphs by drawing upon analogous theorems from uncolored graphs. The task may seem daunting at first. However, from our experience, many results are surprisingly consistent with their counterparts from Graph Theory. It seems as though we can phrase the same theorems in their properly coloring versions and get valid theorems, except for the notable fact that the proofs are quite different. In the final analysis, it is remarkable that such Dirac's famous theorem on Hamiltonian cycles should carry over, almost word for word, to our results mentioned in the outcomes of the team. We also believe that our future activity will give rise to new conjectures of our own devising, which bears witness to the liveliness of this line of research

Annex 4

Collaborations

Participation to national and international collaborative research projects

International projects

- CAPES-COFECUB, Campus France, *CHOOSING: Cooperation on Hybrid cOmputing clOuds for energy SavING*, 2014-2018. Coordinator: **Johanne Cohen**. Partners: Alfredo Goldman (University USP, Sao Poalo, Brazil)
- PHC Amadeus, Campus France, Coordinator: **Viviane Pons**. Partners: Vincent Pilaud (CNRS, École Polytechnique), Arnau Padrol (Paris Diderot), Martin Rubey (TU Wien), Cesar Ceballos (Univ. of Vienna).
- PHC Orchid, Campus France, *Privacy-preserving auction-based resource allocation*, 2017-2018. **Lin Chen, Fabio Martignon**. Partners: UPSUD, Academia Sinica, National Chunghsing University (Taiwan).
- ANR Blanc International *Green-Dyspan: Green Dynamic Spectrum Aggregation*, 2012-2016. **Lin Chen, Fabio Martignon**. Partners: UPSUD, Zhejiang University (China).
- H2020 European Research Infrastructure *OpenDreamKit: Open Digital Research Environment Toolkit for the Advancement of Mathematics*, 2015-2019. Coordinator: **Nicolas M. Thiéry**, site leader: **Viviane Pons**, **Erik Bray, Florent Hivert, Florian Rabe**. Partners: France: UPSUD (coordinator), U. Grenoble Alpes, U. Bordeaux, UVSQ, Logilab, U. St Andrews; Great-Britain: U. Sheffield, U. St Andrews, U. Oxford, U. Warwick; Germany: XFEL, FAU Universität Erlangen-Nürnberg, U. Kaiserslautern: Norway: Simula, Belgium: U. Gent, Poland: U. Silesia.

National projects

- ANR INFRA project *NETLEARN (Orchestration d'algorithmes d'apprentissage distribués pour la gestion des ressources dans les réseaux mobiles*, 2013-2017, Coordinator: Marceaux Coupechoux, **Johanne Cohen** Partners: LTELECOM ParisTech, PRiSM, Alcatel-Lucent Bell Labs France, Orange, LAMSADE, Inria.
- ICAALG, JCJC INS2I 2015, Coordinator: **Viviane Pons**. Partners: Vincent Pilaud (CNRS, École Polytechnique).
- CNRS PEPS, *MIRFID: Management of Infrastructural RFID systems: algorithm design and implementation*, 2017-2018. **Lin Chen, Fabio Martignon**. Partners: LRI-UPSUD, Heudiasyc-UTC.
- CNRS PEPS ADOC du Défi Mastodons *ADOC : Agrégation des DOnnées par Comparaisons Stochastiques.* Coordinator: **Johanne Cohen**. Partners: LRI-UPSUD, UVSQ.

Collaborations with other laboratories leading to joint publications

International collaborations

- **Lin Chen, Fabio Martignon**, Marwan Krunz (University of Arizona, Tucson) ((A45))
- **Lin Chen**, Meng Zheng (Chinese Academy of Science) ((A119))
- **Lin Chen**, Shan Lin (Stony Brook University, US) ((A231, A256))
- **Lin Chen**, Wei Wang (Zhejiang University, China)
- **Johanne Cohen**, Daniel Cordeiro (USP, Brazil) ((A25, A192))
- **Nathann Cohen**, Raul Lopes (UFC, Brazil) ((A137))
- **Nathann Cohen**, Rudini Sampaio (UFC, Brazil) ((A30))
- **Nathann Cohen**, Raquel Águeda (Universidad de Castilla-La Mancha, Spain), Shinya Fujita (Yokohama City University, Japan), Yasuko Matsui (Tokai University, Japan), Yota Otachi (Japan Advanced Institute of Science and Technology), Tadashi Sakuma (Yamagata University, Japan), Zsolt Tuza (University of Pannonia, Hungary) ((A237))

- **Nathann Cohen**, Joergen Bang-Jensen (University of Southern Denmark) ((A9))
- **Nathann Cohen**, Dmitrii V. Pasechnik (University of Oxford, England) ((A31))
- **Nathann Cohen**, Ioannis Milis (Athens University of Economics and Business, Greece) ((A225))
- **Nathann Cohen**, Vassilis Zissimopoulos (University of Athens, Greece) ((A225))
- **Nathann Cohen**, Julio Araujo (Universidade Federal do Ceará, Brazil), Susanna F. De Rezende (Universidade de São Paulo, Brazil), Phablo Moura (Universidade de São Paulo, Brazil) ((A216))
- **Sylvie Delaët**, Shlomi Dolev (Beer-sheva University, Israël) ((A246))
- **Sylvie Delaët**, Tiziana Calamoneri (Sapienza University, Italie)
- **Antoine Deza**, Shmuel Onn (Technion, Israel) ((A86))
- **Antoine Deza**, Shinji Mizuno (Tokyo Institute of Technology, Japon) ((A40, A41))
- **Francesca Fiorenzi**, Tullio Ceccherini-Silberstein (University of Sannio, Italy) ((A14, A15))
- **Francesca Fiorenzi**, Zoran Šunić (Texas A&M University, USA) ((A15))
- **Francesca Fiorenzi**, Paul E. Schupp (University of Illinois at Urbana-Champaign, USA) ((A14))
- **Francesca Fiorenzi**, Nicholas W.M. Touikan (Stevens Institute of Technology, USA) ((A14))
- **Hao Li**, Paul Balister and Dichard Schelp, (University of Memphis, USA) ((A70))
- **Hao Li**, Hongjian Lai (West Virginia University, USA) and Xiaofeng Guo (Xiamen University, China) ((A109))
- **Hao Li**, Meirun Chen (Xiamen University of Technology), Lianzhu Zhang and Xiaofeng Guo (Xiamen University) ((A17), (A109))
- **Hao Li**, Fuji Zhang (Xiamen University) ((A158))
- **Hao Li**, Junqing Cai (Qufu Normal University) ((A13, A73, A71, A72, A155, A157))
- **Hao Li, Evelyne Flandrin, Jean-François Saclé**, Antoni Marczyk and Mariusz Wozniak (AGH University of Science and Technology) ((A159))
- **Hao Li**, Weisheng Zhao (Jianghan University ((A78))
- **Hao Li**, Binlong Li (Northwestern Polytechnical University) ((A68, A69))
- **Hao Li**, Lian Li (Lanzhou University) ((A175, A163))
- **Hao Li**, Shuofa Xiao (Guangdong University of Technology) ((A162, A163))
- **Hao Li**, Ralph Faudree (University of Memphis), Kiyoshi Yoshimoto. (Nihon University) ((A74))
- **Fabio Martignon**, Antonio Capone (Politecnico di Milano, Italy) ((A82, A81, A268, A221, A222, A198, A92, A85, A83, A10, A82, A81) and other articles in preparation)
- **Fabio Martignon**, Jianping Wang (City University of Hong Kong) ((A199, A47, A46))
- **Fabio Martignon**, Stefano Paraboschi (University of Bergamo, Italy) ((A84))
- **Fabio Martignon**, Sergio Palazzo (University of Catania, Italy) ((A42))
- **Viviane Pons**, Cesar Ceballos (Univ. of Vienna) (article in preparation)
- **Nicolas M. Thiéry**, Anne Schilling (University of California at Davis) ((A123, A7, A124))
- **Nicolas M. Thiéry**, Arvind Ayyer (Indian Institute of Science, Bangalore, India) ((A123, A7, A124, A101))
- **Nicolas M. Thiéry**, Nathann Williams (Université du Québec à Montréal) ((A101))
- **Nicolas M. Thiéry**, Graham White (Stanford University) ((A101))
- **Nicolas M. Thiéry**, Benjamin Steinberg (City College of New-York) ((A7, A123))
- **Nicolas M. Thiéry**, Paul-Olivier Dehaye (Zürich), Michael Kohlhase (Erlangen), Alexander Konovalov, Markus Pfeiffer (St Andrews) ((A283))
- **Nicolas M. Thiéry**, François Bergeron (Université du Québec à Montréal) (en préparation)
- **Nicolas M. Thiéry, Florent Hivert**, Anne Schilling (University of California at Davis) ((A146))

National collaborations

- **Lin Chen**, Jean Leneutre (Télécom ParisTech) ((A247, A59, A259, A260, A57, A258, A58))
- **Lin Chen, Fabio Martignon**, Tijani Chahed (Télécom SudParis) ((A93, A250, A274) and other articles in preparation)
- **Johanne Cohen**, Dominique Barth (DAVID, UVSQ) ((A11, A12, A125)), Jean-Michel Fourneau (DAVID, UVSQ) ((A234))
- **Johanne Cohen**, Julie Bernauer (LIX, Palaiseau) ((A11)), Olivier Bournez (LIX, Palaiseau) ((A128, A227, A128, A227))
- **Johanne Cohen**, Nihal Pekergin (LACL, Créteil) ((A234))
- **Johanne Cohen**, Kinda Khawam (LIParad, UVSQ) ((A262, A209, A261, A244)), Laurence Pilard, Devan Sohier (LIParad, UVSQ) ((A167, A132))
- **Johanne Cohen**, Mohamed Lamine Lamali (LABRI, Bordeaux) ((A202, A263))
- **Johanne Cohen**, Denis Trystram (LIG, Grenoble) ((A194)), Panayotis Mertikopoulos (LIG, Grenoble) ((A25, A192))
- **Nathann Cohen**, David Coudert, Frédéric Havet, William Lochet, Nicolas Nisse, Stéphane Pérennes (Laboratoire d'Informatique, Signaux et Systèmes, France) ((A242, A139, A28, A136))
- **Nathann Cohen**, Eun Jung Kim (Université Paris Dauphine, Paris), Christophe Paul (Université de Montpellier), Ignasi Sau (Université de Montpellier), Mathias Weller (Université de Montpellier), ((A29))
- **Antoine Deza**, Lionel Pournin (Université Paris 13) ((A144))
- **Benjamin Hellouin de Menibus**, Silvère Gangloff (IMT, Univ. Paul Sabatier) (article submitted to DCDS)
- **Benjamin Hellouin de Menibus**, Anael Grandjean, Pascal Vanier (LACL, Univ. Paris-Est Créteil) (article submitted to ICALP 2018)

- **Benjamin Hellouin de Menibus**, Yvan le Borgne (LaBRI, Université de Bordeaux) (article in preparation)
- **Antoine Lobstein**, Olivier Hudry (Télécom ParisTech) ((A147, A148, A149, A150, A151, A309) and other articles in preparation or in submission)
- **Fabio Martignon**, Dario Rossi (Télécom ParisTech & École Polytechnique) ((A4, A3, A184, A212, A215) and other articles in preparation)
- **Fabio Martignon**, Konstantin Avrachenkov (INRIA Sophia Antipolis) ((A6))
- **Viviane Pons**, Vincent Pilaud (École Polytechnique) ((A279) and other articles in preparation)
- **Joanna Tomasik**, Véronique Vèque (L2S) ((A255))
- **Joanna Tomasik**, Jean-Michel Dalle (CRG École Polytechnique, Paris 6) ((A270))
- **Marc-Antoine Weisser**, Dominique Barth (DAVID, UVSQ), Dimitri Watel (SAMOVAR, Télécom SudParis) ((A174, A108))
- **Francesca Fiorenzi**, Michel Coornaert (IRMA, University of Strasbourg) ((A15, A14))
- **Florent Hivert**, Jean Fromentin (LMPA, Université du Littoral Côte d'Opale) ((A54))
- **Florent Hivert**, Frédéric Chapoton (IRMA, Université de Strasbourg) ((A16))
- **Florent Hivert**, Jean-Christophe Novelli (IGM, Université de Marne-la-Vallée) ((A16))
- **Florent Hivert**, Jean-Christophe Aval, Adrien Boussicault, et Patxi Laborde-Zubieta (LaBRI, Université de Bordeaux) (A219))
- **Florent Hivert**, Bérénice Delcroix-Oger (IRIF, Université Paris-Diderot) (A219))
- **Nicolas M. Thiéry**, Maurice Pouzet (Université Lyon I) ((A169))

Visiting professors and students (more than one week)

- Raquel Agueda Mate (Assistant Professor, University of Castilla-La mancha, Spain, 18.06.2015 - 29.06.2015, Yannis Manoussakis)
- Kelly Rosa Braghetto (Assistant Professor, University of Sao Paolo, Brazil, 01.07.2015 - 31.07.2015, Johanne Cohen)
- Luiz Fernando Bittencourt (Assistant Professor, University of Sao Paolo, Brazil, 23.11.2015 - 11.12.2015, Johanne Cohen)
- Daniel Cordeiro (Post-doctoral, University of Sao Paolo, Brazil, 01.07.2015 - 31.07.2015, Johanne Cohen)
- Raquel Diaz (Assistant Professor, Universidad Complutense de Madrid, Spain, 12.01.2015 - 23.01.2015, Yannis Manoussakis)
- Daniel Cordeiro (Assistant Professor, University of Sao Paolo, Brazil, 03.09.2017- 18.09.2017, Johanne Cohen)
- Shlomi Dolev (Professor, University of Beer Sheva, 01.07.2014- 31.08.2014, Sylvie Delaët)
- Salvatore D'Oro (Ph.D. student, 1 month visit with Lin Chen and Fabio Martignon, 01-30 September 2013)
- Frantisek Franek (Professor, McMaster University, Canada, 19.08.2015 - 04.09.2015, Antoine Deza) ((A35, A36, A33, A34, A140)
- Gena Hahn (Professor, Université de Montréal, Canada, 01.12.2014 - 30.06.2015, Yannis Manoussakis)
- Pavol Hell (Professor, 03.04.2013 - 23.04.2013, Yannis Manoussakis)
- Giuseppe Italiano (Professor, Università di Roma "Tor Vergata", Italia, 10.09.2017 - 14.10.2017, Y. Manoussakis)
- Yasuko Matsui (Professor, Tokai University, Japan, 24.09.2014 - 12.03.2015, Yannis Manoussakis)
- Ioannis Milis (Professor, University of Athens, Greece, 02.11.2016 30.11l/2016, Johanne Cohen and Yannis Manoussakis)
- James Mitchell (Professor, University of St Andrews, 7.1.2018 -14.1.2018, Florent Hivert)
- Shinji Mizuno (Professor, Tokyo Institute of Technology, Japan, 11.07.2014 - 11.08.2014, Antoine Deza) ((A40, A41))
- Shinji Mizuno (Professor, Tokyo Institute of Technology, Japan, 30.07.2015 - 18.08.2015, Antoine Deza) ((A40, A41))
- Dmitrii Pasechnick (Professor, University of Oxford, UK, 23.10.2017 - 22.11.2017, Antoine Deza)
- Noriyoshi Sukegawa (Assistant Professor, Chuo University, Japan, 10/08/2015 – 18/08/2015, Antoine Deza) ((A40, A41))
- Wei Wang (Faculty at Zhejiang University, China, 1 month visit with Lin Chen, 01-30 August 2015)
- Shurong Zhang (Post-doctoral, Faculty at Taiyuan University of Technology, China, 24.08.2015 - 01.04.2016, Lin Chen)
- Anne Schilling (Professor, University of California at Davis, 2 weeks visit, August 2015)
- Zsolt Tuza (Professor, University of Pannonia & Hungarian Academy of Sciences, Hungary, 06.10.2015 - 4.10.2015, Yannis Manoussakis)
- Yitu Wang (Ph.D. student, Zhejiang University, 15.08.2014 - 15.11.2014, Lin Chen)
- Duzhong Zhang (Assistant professor, Southwestern University of Finance and Economics, 27.08.2013 - 26/08/2014, Lin Chen)
- Lihua Zhao (Ph.D. student, South China University of Technology, China, 27.10.2014 - 10.12.2016, Lin Chen)

Other Collaborations

- Lorenzo Maggi, Jérémie Leguay, Paolo Medagliani, Hawei: optimization in network (A26)
- Lamine Lamali, Pouyllau, Hélia, Alcatel-Lucent : optimization in network (A202)

Group seminar

- The seminar group **https://galac.lri.fr/pages/combi-seminar.html**
- Several members take part in several CNRS *groupes de travail* (for example, GDR Calcul, GDR-IM, GDR-jeux, GDR RO, . . .)

- Several members take part in *Plateau Saclay Combinatorics* seminar **https://galac.lri.fr/pages/combi-seminar.html**
- Several members took part in *Plateau Saclay Algorithms* seminar **https://galac.lri.fr/pages/plateau-seminar.html** (until 2015).

Volunteer Professional Service

Management Positions in Scientific Organisations

- GdR Calcul du CNRS: **Nicolas M. Thiéry**, membre du conseil scientifique, 2018-

Organisation of Conferences and Scientific Events

- COCOA (COmpetitive and COoperative Approaches for network resource management), 2016, 2017, 2018: **Fabio Martignon**, workshop co-chair.
- CRM semester "Algebra and Words in Combinatorics", CRM, Montréal, Spring 2017: **Nicolas M. Thiéry**: member of scientific committee, organizer of weekly computational math sessions
- ICERM Semester Program on "Automorphic Forms, Combinatorial Representation Theory and Multiple Dirichlet Series", Spring 2013: **Nicolas M. Thiéry** coorganizer
- JGA, *Journées Graphes et Algorithmes*, Orsay, France, 2013 : **Yannis Manoussakis**, workshop co-chair.
- Journées du GT Combinatoire Algébrique du GDR IM, 2015: **Viviane Pons**, organization team member.
- NetGCoop 2014 (NETwork Games, COntrol and OPtimization conference), Trento, 2014: **Fabio Martignon**, publicity chair.
- PODC, *33rd Annual ACM SIGACT-SIGOPS Symposium on Principles of Distributed Computing*, Paris, 2014: **Sylvie Delaët**, organizer.
- Sage Days 45, Brown, USA, Sage Days 49, Orsay, Sage Days 86, LaCIM, Montréal: **Nicolas Thiéry** coorganizer
- Sage developer Days, Cernay, France, 2014, 2016, 2017, 2018: **Nicolas Thiéry** (co)organizer
- Sage Days 78, Vancouver, 2016: **Viviane Pons**, organizer.
- Sage Days 67, Montreal, 2015: **Viviane Pons**, organizer.
- SLC78, Séminaire Lotharingien de Combinatoire 78, Ottrott, 2017: **Viviane Pons**, organization team member.
- VTC, *IEEE 86th Vehicular Technology Conference*, Toronto, Canada, 2017 : **Lin Chen**, Track chair (Cognitive Radio and Spectrum Management Track).
- Women in Sage Sage Days 82, Paris, 2017: **Viviane Pons**, organizer.
- Workshop on 5G Ultra Dense Networks at IEEE International Conference on Communications (ICC), 2017: **Lin Chen**, General chair.
- Workshop on Green and sustainable communication and networking (GSNC) at IEEE International Conference on Computer Communications (INFOCOM), 2016: **Lin Chen**, TPC chair.

Participation to editorial committees

- IEEE Special Interest Group (SIG) on Green and Sustainable Networking and Computing with Cognition and Cooperation: **Lin Chen**, chair from June 2015
- International conference Formal Power Series and Algebraic Combinatorics: **Nicolas M. Thiéry**, member of the permanent committee since 2014

Honors

Awards

- **Lin Chen**, *CNRS Bronze medal* (2018)
- **Lin Chen**, *Best paper at Conference on Decision and Game Theory for Security* (2017)
- **Johanne Cohen**, **George Manoussakis** *Best paper at 19th International Symposium on Stabilization, Safety, and Security of Distributed Systems SSS* (2017)
- **Nathann Cohen**, David Coudert, *Flinders Hamiltonian Cycle Project Challenge* (2016)
- **Qiang Sun**, *accessit of prix de thèse Graphes «Charles Delorme»* (2016)
- **Lin Chen**, S. D'Oro, F. Martignon, *Best Student Paper Award awarded by the Network of Excellence in Wireless Communications* (2015)
- **Johanne Cohen**, *Best paper at IEEE International Conference on Communications ICC* (2015)
- **Michele Mangili**, **Fabio Martignon**, *Best paper at the IEEE Globecom 2013 conference* (2013)
- **Michele Mangili**, **Fabio Martignon**, *Best 50 papers of the IEEE Globecom 2014 conference* (2014)
- **Michele Mangili**, **Fabio Martignon**, *Best paper at the IEEE Globecom 2013 conference* (2013)
- **Michele Mangili**, *Best Student Paper Award awarded by the IEEE Technical Committee on Simulation (TCSIM)* (2013)
- **George Manoussakis**, *accessit of prix de thèse Graphes «Charles Delorme»* (2018)
- **Thibaut Benjamin** (Master 2, internship with Florent Hivert), *Prix du Stage de recherche en Informatique de l'École Polytechnique*, *Une Formalisation des Représentations des Groupes Symétriques en Coq/SSReflect* (2016)

Keynote Addresses and invited talks

International

- **Johanne Cohen, Evelyne Flandrin, Antoine Lobstein, Yannis Manoussakis**, *International Conference on Graph theory and Combinatorics*, Xi'an, China, May 2018
- **Evelyne Flandrin**, keynote speaker of *25th Workshop 3in1* Doslonce, Poland (2016)
- **Florent Hivert**, *International Workshop on Parallel Symbolic Computation (PASCO 2017)* High Performance Computing Experiments in Enumerative and Algebraic Combinatorics, Kaiserslautern, Germany, July 23-24, 2017.
- **Yannis Manoussakis**, Visiting professor of McMaster University, Canada, Juin 2013
- **Yannis Manoussakis**, invited speaker, *Euler Summer School*, Universitat Politècnica de Catalunya, Spain, July 2013.
- **Yannis Manoussakis**, Visiting professor of Department of mathematics, Shandong University, Jinan Chine, May 2017.
- **Yannis Manoussakis**, *International Workshop On colored notions of connectivity in graphs*, Nankai, Chine, Mai 2017
- **Yannis Manoussakis**, *International Symposium on the Frontier of Graph Theory*, Qinghai, China, June 2017
- **Yannis Manoussakis**, *12th Athens Colloquium on Algorithms and Complexity (ACAV* , Athens, Greece August 2017
- **Nicolas M. Thiéry**, *9th Conference on Intelligent Computer Mathematics*, CICM 2016, Białystok, Poland: Keynote address: Infrastructure for generic code in SageMath: categories, axioms, constructions
- **Nicolas M. Thiéry**, *Sage Days 60, 64, 74, 97*: invited speaker
- **Nicolas M. Thiéry**, *Congrès SMAI*, Mini-symposium: «Du calcul symbolique à l'apprentissage, à bord du Python-Express», Les Karellis, June 2015;

France

- **Francesca Fiorenzi**, *Journées de clôture du projet « MealyM » (IRIF, Université Paris-Diderot)*, 2017: Entropy of strongly irreducible subshifts.
- **Benjamin Hellouin de Menibus**, *Journées de Combinatoire de Bordeaux (JCB, Université de Bordeaux)*, 2018: Mixing properties and growth rate in tiling spaces.
- **Benjamin Hellouin de Menibus**, *Algorithmic Questions in Dynamical Systems (Université de Toulouse III Paul Sabatier)*, 2018: A tour on computation, decision and prediction in symbolic dynamical systems.
- **Viviane Pons**, *Conférence CARMA (Algebraic Combinatorics, Resurgence, Moulds and Applications, CIRM)*, 2017: Lattice and Hopf algebra of integer relations.
- **Viviane Pons**, *Séminaire Philippe Flajolet (Séminaire bimestriel de combinatoire à l'Institut Henri Poincaré)*, 2017: Lattice and Hopf algebras of integer relations.
- **Nicolas M. Thiéry**, *Séminaire Philippe Flajolet (Séminaire bimestriel de combinatoire à l'Institut Henri Poincaré)*, 2016: Nombre moyen de tresses dans les mots réduits et tableaux justifiés à droite
- **Florent Hivert**, *Journées de Combinatoire de Bordeaux (JCB, Université de Bordeaux)*, 2015: Le monoïde semi-plaxique.

Evaluation of Research

Editorial Boards

- ComCom, *Computer Communications*, Elsevier: **Fabio Martignon** (Area Editor since 2016)
- DAM, *Discrete Applied Mathematics*, Elsevier: **Antoine Deza** (2012-now)
- JDA, *Journal of Discrete Algorithms*, Elsevier: **Antoine Deza** (2004-now)
- OJDM, *Open Journal of Discrete Mathematics*, Scientific Research Publishing : **Yannis Manoussakis**
- OPTL, *Optimization Letters*, Springer: **Antoine Deza** (2006-now)
- ISRN, *International Scholarly Research Notices Discrete Mathematics* : **Yannis Manoussakis** (until 2014)
- IJMS, *International Journal of Mathematics and Statistics* : **Yannis Manoussakis**
- APJM, *Asia Pacific Journal of Mathematics*: **Yannis Manoussakis**

Program Committees

Chair

- COCOA (COmpetitive and COoperative Approaches for network resource management), 2016, 2017, 2018: **Fabio Martignon**, workshop co-chair.
- JGA, *Journées Graphes et Algorithmes*, Orsay, France, 2013 : **Yannis Manoussakis**, workshop co-chair.
- Workshop on 5G Ultra Dense Networks at IEEE International Conference on Communications (ICC), 2017: **Lin Chen**, General chair.
- Workshop on Green and sustainable communication and networking (GSNC) at IEEE International Conference on Computer Communications (INFOCOM), 2016: **Lin Chen**, TPC chair.

Member (international events)

- AICT, *International Conference on Telecommunications* : **Johanne Cohen** (2014, 2015)
- CPAM - *CIMPA RESEARCH SCHOOL*, Vientiane, Laos : **Evelyne Flandrin** (2014)
- GLOBECOM, *IEEE Global Communications Conference* : **Johanne Cohen**, Best Paper committee member (2015)
- FPSAC: *International Conference on Formal Power Series and Algebraic Combinatorics*: **Nicolas Thiéry** (2016), **Viviane Pons** (2017)
- HiPC, *International Conference on High Performance Computing* : **Johanne Cohen** (2014, 2016)
- ICDCN, *International Conference on Distributed Computing and Networking*: **Sylvie Delaët** (2017, 2018)
- ICGT, *International colloquium on graph theory and combinatorics*: **Yannis Manoussakis** (2014, 2018)
- ICQT, *International Workshop on Internet Charging and QoS Technologies*: **Johanne Cohen** (2017)
- Infocom, *IEEE Conference on Computer Communications* : **Fabio Martignon** (2013-2018)
- SBAC-PAD, *International Symposium on Computer Architecture and High Performance Computing* : **Johanne Cohen** (2015)
- SSS, *International Symposium on Stabilization, Safety, and Security of Distributed Systems*: **Sylvie Delaët** (2013, 2014, 2016, 2017)
- VTC, *Vehicular Technology Conference* : **Fabio Martignon** (2017, 2018)
- WCNC, I*EEE Wireless Communications and Networking Conference* : **Fabio Martignon** (2014, 2015, 2016)
- WiOPT, *International Symposium on Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks* : **Fabio Martignon** (2017)

Member (national events)

- ALGOTEL, Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications : **Johanne Cohen** (2014), **Joanna Tomasik** (2016), **Sylvie Delaët** (2017, 2018)
- JGA, *Journées Graphes et Algorithmes*: **Yannis Manoussakis**, (2014, 2015)

Evaluation Committees and Invited Expertise

- Member of committee of "Mathématiques et Informatique théorique", ANR: **Johanne Cohen** (2015, 2016, 2017)
- Member of committee of jury "Prix de thése SIF": **Johanne Cohen** (2017, 2018)
- Member of revues de projets à mi-parcours, ANR: **Johanne Cohen** (2015, 2016)
- Review of EU research project: **Johanne Cohen** (2016, 2017)
- Remote evaluator of EU research project: **Johanne Cohen** (2015, 2016, 2017)
- Review of "Research Grants Council (RGC) of Hong Kong": **Hao Li** (2018)
- Review of Project "Overseas Assessor" of the Chinese Academy of Sciences: **Hao Li** (2016)
- Review of Project "Chang Jiang Scholars Program" of the Ministry of Education of China: **Hao Li** (2016, 2017)
- Review of ANR projects: **Joanna Tomasik** (2015)
- Member of committee of jury "Prix de thése Graphes *Charles Delorme*": **Hao Li** (2017)
- HCERES evaluation committees of LIMOS (Clermont-Ferrand): **Johanne Cohen** (2016)

Other evaluation activities

- Membership of the Committee of the Cluster 4 (Algorithms) of the Doctoral School STIC: **Joanna Tomasik** (PhD candidate selection, midterm thesis evaluation; since 2015)

Interactions with the social, economic and cultural environment

Interaction with the economic environment

Dissemination

- Talk at PyCon 2015 by **Viviane Pons**, "Experimental pure mathematics using Sage" also given at PyConFR 2014 and as a short talk at SciPy 2014.
- Conference/Show by **Florent Hivert** and Vincent de Lavenère (Le Chant des Balles) "Jonglerie musicale, automates et combinatoire" 1 hours wide audience popular science show. It was presented in several Festival:
  - "Fête de la Science", October 14th and 16th of 2016: 5 presentations for school students and 3 for the general public;
  - Festival "Curiositas", May 20th of 2017, organized by la Diagonale Paris Saclay;
  - Journée du Laboratoire de Recherche en Informatique, June 22th of 2017;
  - "Fête de la Science", October 13th and 15th of 2017: 5 presentations for school students and 3 for the general public;
  - Festival "Science à l'Opéra," November 18th of 2017, grande salle de l'Opéra de Massy (350 spectator), organized by the (S)cube association;
  - Mathématical week "Mathématique et mouvements", March 13th of 2018, Institut Henri Poincaré; Live on video on Youtube **https://www.youtube.com/watch?v=SKIzwP4OMqE**.
  - "Salon Culture et Jeu Mathématique" May 24th-27th of 2018.

- Fête de la Science au LRI (**https://fetedelascience.lri.fr/**), 2013: 300 yearly visitors; **Florent Hivert**: organization;
- Fête de la Science au LRI (**https://fetedelascience.lri.fr/**), 2014-: 300 yearly visitors; **Nicolas M. Thiéry**: organization and activity "Fabrique ton Robot";
- Beta test in primary school classes (8 mornings) of the computer science school book "1,2,3 Codez" by La Main à la Pâte (**Nicolas M. Thiéry**).
- One week internship of junior high school students: **Johanne Cohen** (six), **Nicolas M. Thiéry** (a dozen)
- Lectures in January 2015, to pupils of the lycée Condorcet, Montreuil on: layers and algorithms in computer networks (seconde), and computability (terminale) : **Johanne Cohen**, M.-C. Gaudel.

Popularisation of Research Results

- Publication of the article (A134) "*Le défi des 1001 graphes*", in the revue *Interstices* (2017), by **Nathann Cohen** and David Coudert.
- Publication of the article (A168) "*Ordonner les ordres : un treillis sur les ordres partiels*", in the revue *Interstices* (2017), by **Viviane Pons**.
- General audience course for Mathematik Park "Les Nombres de Catalan" by **Viviane Pons** (2017).
- Course for middle school students for "Maths en Jean" by **Viviane Pons** (2018).

Contracts and grants

Public contracts and grants (jan 2013 - jun 2018)

Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*		*Amount*
PEPS	Johanne Cohen	ADOC	CNRS		10	15
ANR	Lin Chen	Green-Dyspan	Université Paris-Sud	03.2013	42	190
CNRS	Lin Chen	MIRFID	Université Paris-Sud	03.2017	22	21
Diagonale	Florent Hivert	JAC	Université Paris-Sud	01.2017	12	5
Fondation Blaise	Florent Hivert	JMaC	Université Paris-Sud	01.2018	12	2.5
PHC	Lin Chen	PARA	Université Paris-Sud	01.2017	24	12
H2020	Nicolas M. Thiéry	OpenDreamKit	Université Paris-Sud	01.2017	48	1000
PEPS	Viviane Pons	ICAALG	Université Paris-Sud	04.2015	9	10
PHC	Viviane Pons	CAGWOQ	Université Paris-Sud	01.2018	12	2
DIGITEO	Antoine Deza	C&O	Université Paris-Sud	01.2015	36	300
DIGITEO	Florent Hivert	TRAGIC	Université Paris-Sud	10.2015	36	109

OpenDreamKit

Type: H2020 European Research Infrastructure
Amount: 1000 k€
Duration: 48 months
Scientific director for LRI: Nicolas M. Thiéry

Partners: 15 sites in France, Germany, Great-Britain, Poland, Norway

See **http://opendreamkit.org**

LRI is coordinator of this 7.8M€ European project that provides substantial funding to the open source computational mathematics ecosystem, and in particular popular tools such as LinBox, MPIR, SageMath, GAP, Pari/GP, LMFDB, Singular, MathHub, and the IPython/Jupyter interactive computing environment.

Jonglerie Automates et Combinatoire (JAC)

Type: La Diagonale Paris Saclay
Amount: 5 k€
Duration: 12 months
Scientific director for LRI: Florent Hivert

See **https://www.vincentdelavenere.com/conference**

Wide audience Conference/Show about juggling and the automaton theory. Common research project with the Compagnie (Le chant de Balles) whose aim is to find a way to write juggling music scores.

JMaC

Type: Fondation Blaise Pascal
Amount: 2.5 k€
Duration: 12 months
Scientific director for LRI: Florent Hivert

See **https://www.vincentdelavenere.com/conference**

Wide audience Conference/Show about juggling and the automaton theory aimed at children and students.

Green-Dyspan

Type: ANR Blanc International
Amount: 190 k€
Duration: 42 months
Scientific director for LRI: Lin Chen

Partners: UPSUD and Zhejiang University in China

See **http://green-dyspan.lri.fr/**

Green-Dyspan (Green Dynamic Spectrum Aggregation) is a research project funded by ANR, focusing on developing the fundamental building blocks for green dynamic spectrum aggregation. Key members of LRI involved in the project are Lin Chen and Fabio Martignon.

MIRFID

Type: CNRS PEPS
Amount: 22 k€
Duration: 21 months
Scientific director for LRI: Lin Chen

Partners: UPSUD and UTC

MIRFID is a CNRS PEPS research project coordinated by LRI investigating the management of large-scale infrastructural RFID systems from the perspective of algorithm design and implementation. Key members of LRI involved in the project are Lin Chen and Fabio Martignon.

PARA

Type: PHC Orchid
Amount: 24 k€
Duration: 12 months
Scientific director for LRI: Lin Chen

Partners: UPSUD, Academia Sinica, and National Chunghsing university in Taiwan

PARA is a PHC Orchid Franco-Taiwanese collaborative project focusing on the design of privacy-preserving auction-based resource allocation algorithms. Key members of LRI involved in the project are Lin Chen and Fabio Martignon.

ADOC

Type: PEPS CNRS Défi Mastodons en 2017.
Amount: 10 k€
Duration: 12 months
Scientific director for LRI: Johanne Cohen

Partners: LACL (university of Creteil), DAVID (university of Versailles), PRINTEMPS (university of Versailles)

See **https://www.lri.fr/~jcohen/ADOC.html**

The projet aims at design some algorithms on order to aggregate date. We focus on an approach to provide stochastic bounds for a large class of optimisation problems on graphs when the parameters (i.e. costs, weights or delays) for links are random variables. We consider the class of problems which are based on convex operators and whose complexity is polynomial, when the parameters are deterministic. Here, the parameters (for instance the delay of a link) are discrete random variables. Such an assumption drastically changes the complexity of the problem (typically, the problems turn out unfortunately to be NP-complete).

ICAALG

Type: PEPS CNRS JCJC.
Amount: 10 k€
Duration: 9 months
Scientific director for LRI: Viviane Pons

Partners: LIX (École Polytechnique)

The project aims at exploring links between the combinatorics of trees, algebra, and geometry. Our starting point is the Tamari lattice and its generalizations. We wish to better understand the link between certain geometric and combinatorial structures on one hand (polytopes, partial orders, lattices), and algebraic structures on the other hand (Hopf algebras, monoïds, groups, representation theory).

CAGWOQ

Type: PHP Amadeus.
Amount: 2 k€
Duration: 12 months
Scientific director for LRI: Viviane Pons

Partners: École Polytechnique, Univ. Paris 6, Univ. of Vienna, TU Wien

This project is concerned with topics in algebraic and geometric combinatorics. We are interested in links between three ubiquitous structures: lattices, polytopes, and combinatorial Hopf algebras. Our focus is on generalizations of the Tamari lattice, the weak order on permutations and Hopf algebras such as the Malvenuto & Reutenauer Hopf algebra on permutations and the Loday & Ronco Hopf algebra on binary trees.

C&O

Type: FCS Campus Paris-Saclay
Amount: 300 k€
Duration: 36 months
Scientific director for LRI: Antoine Deza

The focus of the IGITEO Chair in Combinatorics and Optimization is to build on and investigate recent results illustrating the significant interconnection between the most computationally successful algorithms for linear optimization and its generalizations, and the geometric and combinatorial structure of the input.

TRAGIC

Type: FCS Campus Paris-Saclay
Amount: 109 k€
Duration: 36 months
Scientific director for LRI: Florent Hivert

Théorie des représentations, Algèbre de Hopf, Géométrie et Interprétation Combinatoire. Funding (salary + mission expenses) for Joël Gay's PhD. This project is concerned with topics in algebraic and geometric combinatorics. The goal is to find representation theory interpretation of the Loday-Ronco Hopf algebra of binary search trees.

Training and Education

Master Internships (Master M2)

- Arpad Deak-Chevillard, *Cartan Matrix for modular representations of finite monoids*, March-July 2018, Advisor: Nicolas M. Thiéry
- Joël Gay, *Un analogue de l'algèbre de 0-Hecke sur les associaèdres ?*, March-July 2015, Advisor: Florent Hivert, Vincent Pilaud (LIX)
- Justine Falque, *Finite generation of the age algebra of permutation groups with linear profile*, March-July 2016, Advisor: Nicolas M. Thiéry
- Hugo Mlodecki *Structure d'ordre et auto-dualité de l'algèbre des mots tassés*, March-July 2018, Advisors: Florent Hivert, Viviane Pons

Internships

- Stage école d'ingénieur CentraleSupelec : Emmanuel Tran, *Algorithmes distribuée pour marriage stable et du consensus*, July-August 2018, Advisor: Johanne Cohen,
- Stage école d'ingénieur CentraleSupelec : Benjamin Mouscadet, *Méta-heuristiques dédiées au problème du voyageur canadien*, July-August 2018, Advisor: Joanna Tomasik,
- Stage école d'ingénieur CentraleSupelec : Alexandre Fauquette, *Convex Stochastic Bounds and Stochastic Optimisation on Graphs.*, July-August 2017, Advisor: Johanne Cohen
- Stage école d'ingénieur CentraleSupelec : Julien Hemery, *Design et évaluation de stratégies randomisées pour le problème du voyageur canadien pour des graphes* 2*- et* k*-partis*, July-August 2017, Advisor: Joanna Tomasik
- Stage école d'ingénieur CentraleSupelec : Camille L'Huillier, *Complétion d'hypercubes latins maximin par recherche tabu*, July-August 2017, Advisor: Joanna Tomasik
- Stage école d'ingénieur CentraleSupelec : Christian Hamelain, *Conception d'algorithmes pour résoudre le problème de la complétion des hypercubes latins Maximin*, July-August 2016, Advisor: Joanna Tomasik
- Stage école d'ingénieur CentraleSupelec : Pierre Bergé, *Applications d'algorithmes méta-heuristiques au problème des hypercubes latins MaxiMin*, July-August 2015, Advisor: Joanna Tomasik
- Stage école d'ingénieur CentraleSupelec : Fabien Dufoulon, *Applications d'algorithmes multi-arm bandits*, July-August 2015, Advisor: Johanne Cohen
- Stage école d'ingénieur Centravlesupelec (India): Krishna Swaroop, *MIS self-stabilization Algorithms*, July-August 2017, Advisor: Johanne Cohen
- Master (M1) : Stephan Kunne, *Conception d'algorithmes distribués* , February-August 2018 , Advisor: Johanne Cohen
- Master (M1) : Stephan Kunne, *Algorithmes pour l'analyse de données*, July 2017 (4 weeks), Advisor: Johanne Cohen
- TER Master (M1): Edgar Fournival, January - March 2017,

- TER Master (M1): Adrien Pavao et Thomas Foltête, *Exploration combinatoire avec Spark*, January - March 2017, Advisor: Nicolas M. Thiéry
- Master (M1): Thibaut Benjamin, April-July 2016, *Une Formalisation des Représentations des Groupes Symétriques en Coq/SSReflect* , Advisor: Florent Hivert, **Best research internship award from École Polytechnique**.
- Licence (L3) : Margot Ferré, *Problèmes d'atteignabilité dans les machines de Turing*, May-June 2018 (4 weeks), Advisor: Benjamin Hellouin de Menibus
- Licence (L3) : Damien Girault , *Application du problème "balls-into-bins" en ordonnancement*, June 2018 (4 weeks), Advisor: Johanne Cohen
- Licence (L3) : Guillaume Lasnier, *Reconfiguration de chemins de graphes*, June 2018 (3 weeks), Advisor: Benjamin Hellouin de Menibus
- Licence (L3) : Aloys Dufour, *Groupe de Coxeter et treillis cambriens*, June-July 2017, Advisor: Viviane Pons
- Licence (L3) : Doriann Albertin, *Marriage Stable*, July 2016 (4 weeks), Advisor: Johanne Cohen
- Licence (L3) : Rodolphe Picot, Mai-juin 2016, *Enumération parallèle d'un monoïde généralisant le tri à bulle*, Advisor: Florent Hivert.

Graduate Courses

- Master FIIL et Comasic, Université Paris-Sud/EcolePolytechnique, *Algorithmique répartie* : M. Sylvie Delaët, J.Burmann.
- Master FIIL, Université Paris-Saclay, *Génération d'objets combinatoires décrit par une grammaire* : Florent Hivert, Viviane Pons.
- Master ISD, Université Paris-Saclay, *Algorithmique avancée* : Florent Hivert, Nicolas Thiéry, Viviane Pons.
- Master SAR, CentraleSupélec, ENS-Cachan, Université Paris-Saclay *Queueing Theory* : Joanna Tomasik.
- Master SAR, CentraleSupélec, ENS-Cachan, Université Paris-Saclay *Network performance seminars* : Joanna Tomasik.
- Master CCN, Télécom Sud Paris, Université Paris-Saclay, *Evaluation of Network Algorithm Efficiency* : Joanna Tomasik.

Schools

- SageMath course, ECCO (Encuentro Colombiano de Combinatoria), Baranquilla Colombia 2018 : Viviane Pons.
- Semaine Séminaire Sport-Etude, ENS Lyon, 2018 : Viviane Pons
- SageMath course, ECCO (Encuentro Colombiano de Combinatoria), Medellin Colombia 2016 : Viviane Pons.
- École Combinatoire / SageMath, ENS Lyon, 2016 : Viviane Pons
- EAUMP (Eastern Africa Universities Mathematics Programme), Summer school on experimental mathematics, Kampala Uganda 2015 : Viviane Pons.

Other

- SageMath training session at EUROCOMB 2017 : Viviane Pons.
- SageMath / Cocalc training session at Codima 2016 : Viviane Pons.
- Cocalc training session at Jupyter Day Orsay 2016 : Viviane Pons.

Honors

Thesis

Habilitation à Diriger des Recherches	
Name	*Defense*
Sylvie DELAËT	8.11.2013
Lin CHEN	11.07.2017

Defended thesis (sorted by defense date)				
Name	*Start*	*Defense*	*Funding*	*Advisor*
Weihua YANG	01.2.2010	15.09.2013	Bourse CSC	H. Li
Yandong BAI	01.10.2011	28.11.2014	Bourse CSC	H. Li
Peva BLANCHARD	03.10.2011	24.09.2014	Bourse DIGITEO	J. Beauquier, S. Delaët
Weihua HE	01.10.2011	28.11.2014	Bourse CSC	H. Li
Stefano IELLAMO	01.10.2011	05.12.2014	Alloc. Ministère	L. Chen, M. Coupechoux
Mariem KRICHEN	01.1.2010	14.02.2014	projet AWARE	D. Barth, J. Cohen
Jean-Baptiste PRIEZ	01.10.2012	07.12.2015	Alloc. Ministère	F. Hivert
Michele MANGILI	01.10.2012	15.12.2015	Alloc. Ministère	F. Martignon, A. Capone
Fan HUANG	01.10.2012	16.12.2015	Pôle SYSTEMATIC, projet SOAPS	J. Tomasik, V. Vèque
Andrea Giuseppe ARALDO	01.10.2013	07.10.2016	Bourse DIGITEO	F. Martignon, D. Rossi
Mélanie BOUDARD	01.10.2012	29.04.2016	Bourse DIGITEO	D. Barth, J. Cohen, A. Denise
Aladin VIRMAUX	01.10.2012	29.04.2016	Bourse Paris Saclay	N. Thiéry
Lise RODIER	01.10.2012	12.07.2016	Alloc. Ministère	D. Auger, J. Cohen
Qiang SUN	01.10.2012	04.05.2016	Bourse CSC	H. Li, R. Naserasr
Jihong YU	01.11.2013	05.12.2016	project ANR Green-Dyspan	L. Chen
Amélie HÉLIOU	01.09.2014	31.10.2017	Alloc. X	J. Cohen
George MANOUSSAKIS	01.12.2014	30.11.2017	Bourse DIGITEO	J. Cohen, A. Deza
Kaourintin LE GUIBAN	01.10.2014	24.01.2018	Alloc. Ministère	J. Tomasik

Position after the thesis	
Name	*Position*
Andrea Giuseppe ARALDO	Post-doc, Civil and Environmental Engineering, USA
Yandong BAI	Assistant professor, China
Peva BLANCHARD	IT Consultant , OCTO Technology, Lausanne, Canton de Vaud, Suisse
Mélanie BOUDARD	IT Consultant , OCTO Technology, Paris, France
Amélie HÉLIOU	Research Engineer, Crypto, Grenoble
Fan HUANG	starts it own company in telecommunication, China
Mariem KRICHEN	Consultante technique, Courbevoie, France
George MANOUSSAKIS	Assistant professor, Université de Versailles, France
Lise RODIER	Software Engineer, Viveris, Boulogne Billancourt, France
Aladin VIRMAUX	Research Engineer, Huawei, Boulogne Billancourt , France
Weihua HE	Assistant professor, GuangDong University of Technology, Guangzhou, China

Thesis in progress			
Name	*Start*	*Funding*	*Advisor*
Pierre BERGÉ	01.01.2017	Alloc. Ministère	J. Tomasik
Alexandre DAMBREVILLE	01.10.2014	Digiteo/DigiCosme	J. Cohen, J. Tomasik
Justine FALQUE	01.10.2016	Alloc. Ministère	N. Thiery
Joël GAY	01.10.2015	Alloc. Ministère	F. Hivert
Alexandre LETOIS	01.07.2016	CDI EPITA	J. Tomasik
Mira MORCOS	01.11.2015	Bourse DIGICOSME	L. Chen, T. Chahed
Mattias MANO	01.10.2015	L'Institut de la Société Numérique	J.-M. Dalle, J. Tomasik
Stefi NOULEHO	01.10.2016	Bourse DIGICOSME	D. Barth, M. A. Weisser
Hong Phong PHAM	01.11.2015	Alloc. Ministère	Y. Manoussaskis
Zengxian TIAN	01.10.2017	Bourse CSC	H. Li
Hehuan SHI	01.11.2017	Bourse CSC	L. Chen

Software Licensing and Distribution

Coq-Combi - Algebraic combinatorics in Coq

https://github.com/hivert/Coq-Combi

Contact: Florent HIVERT

- the Littlewood-Richardson rule using Schützeberger approach, it includes the Robinson-Schensted correspondance the construction of the plastic monoïd the Littlewood-Richardson and Pieri rules using the

combinatorial (tableau definition of Schur polynomials). - basic theory of symmetric functions including Schur function and Kostka numbers and the equivalence of the combinatorial and algebraic (Jacobi) definition of Schur functions the classical bases, Newton formulas and various basis changes the scalar product and the Cauchy formula. - the character theory of the symmetric Groups. We do not use representations but rather goes as fast as possible to Frobenius isomorphism and then uses computations with symmetric polynomials. it includes cycle types for permutations (together with Thibaut Benjamin) The tower structure and the restriction and induction formulas for class indicator (together with Thibaut Benjamin) structure of the centralizer of a permutation Young character and Young Rule the theory of Frobenius characteristic and Frobenius character formula the Littlewood-Richardson rule for irreducible character - the Hook-Length Formula for standard Young tableaux (together with Christine Paulin and Olivier Stietel) - the Erdös Szekeres theorem about increasing and decreasing subsequences - various Combinatorial objects including totally and partially ordered types, integer partitions and compositions, tableaux, standard tableaux, skew tableaux, subsequences, integer vectors, standard words and permutations, Yamanouchi words - the Coxeter presentation of the symmetric group. - the factorization of the Vandermonde determinant as the product of differences.

GARN - Game Algorithms for RNa 3D sampling

http://garn.lri.fr/
Contact: Johanne COHEN, Alain DENISE

GARN is a software to compute a sampling of RNA 3D structure from a secondary structure. GARN can thus be a suitable starting point for large RNA molecular modelling and experimental structure resolution.

Sage-Combinat - To improve the open source mathematical system Sage

http://combinat.sagemath.org
Contact: Nicolas THIÉRY

Sage-Combinat is a software project whose mission is to improve the open source mathematical system Sage as an extensible toolbox for computer exploration in (algebraic) combinatorics, and foster code sharing between researchers in this area. In practice, Sage-combinat is a collection of experimental features (i.e. extensions) on top of Sage, developed by a community of researchers. The intent is that most of those features get eventually integrated into Sage as soon as they are mature enough, with a typical short life-cycle of a few months. In other words: just install Sage, and you will benefit from the mature Sage-combinat features.

SageMath - A free open-source mathematics software system

http://www.sagemath.org/
Contact: Nicolas THIÉRY

SageMath is a free open-source mathematics software system licensed under the GPL. It combines the power of many existing open-source packages into a common Python-based interface. Mission: Creating a viable free open source alternative to Magma, Maple, Mathematica and Matlab. SageMath is developed by an international community of 200 researchers, teachers and engineers. Four members of GALaC are contributors to the software and active promoters in the community. GALaC employs a full time Sage developer (Erik Bray) since 2016.

HP-Combi - High Performance Combinatorics

https://github.com/hivert/HPCombi
Contact: Florent HIVERT

High Performance Combinatorics in C++ using vector instructions v0.0.2 SSE and AVX instruction sets allows for very fast permutation manipulation for vectors or permutations of size smaller than 16. This repo contains some experiments around these ideas.

GALaC team publications (20 %)

Journal articles

Major international journals

(1) A. Araldo, D. Rossi, and F. Martignon. Cost-Aware Caching: Caching More (Costly Items) for Less (ISPs Operational Expenditures). *IEEE Transactions on Parallel and Distributed Systems*, 27(5):1316 – 1330, May 2016.

(2) A. Ayyer, A. Schilling, B. Steinberg, and N. M. Thiéry. Markov chains, $\mathscr{R}$-trivial monoids and representation theory. *International Journal of Algebra and Computation (IJAC)*, page 1540008, Mar. 2015. Dedicated to Stuart Margolis on the occasion of his sixtieth birthday; 71 pages; final version to appear in IJAC.

(3) Y. Bai, H. Li, and W. He. Complementary cycles in regular bipartite tournaments. *Discrete Mathematics*, 333:14–27, 2014.

(4) M. Boudard, D. Barth, J. Bernauer, A. Denise, and J. Cohen. GARN2: coarse-grained prediction of 3D structure of large RNA molecules by regret minimization. *Bioinformatics*, 16:2479–2486, 2017.

(5) M. Boudard, J. Bernauer, D. Barth, J. Cohen, and A. Denise. GARN: Sampling RNA 3D Structure Space with Game Theory and Knowledge-Based Scoring Strategies. *PLoS ONE*, 10(8):e0136444, Aug. 2015.

(6) J. Cai and H. Li. A new sufficient condition for pancyclability of graphs. *Discrete Applied Mathematics*, 162:142–148, 2014.

(7) T. Ceccherini-Silberstein, M. Coornaert, F. Fiorenzi, and P. E. Schupp. Multipass automata and group word problems. *Theoretical Computer Science*, 2015.

(8) T. Ceccherini-Silberstein, M. Coornaert, F. Fiorenzi, and Z. Sunic. Cellular automata between sofic tree shifts. *Theoretical Computer Science*, 506:79–101, 2013.

(9) L. Chen, Y. Li, and A. V. Vasilakos. On Oblivious Neighbor Discovery in Distributed Wireless Networks With Directional Antennas: Theoretical Foundation and Algorithm Design. *IEEE/ACM Transactions on Networking*, 25(4):1982 – 1993, Aug. 2017.

(10) N. Cohen. A Doubling Construction for 3-Uniform Friendship Hypergraphs with the Universal Pairs Property. *Journal of Combinatorial Designs*, 24(7):336–339, July 2016.

(11) N. Cohen, D. Coudert, G. Ducoffe, and A. Lancin. Applying clique-decomposition for computing Gromov hyperbolicity. *Theoretical Computer Science*, 690:114–139, 2017.

(12) N. Cohen, N. Martins, F. Mc Inerney, N. Nisse, S. Pérennes, and R. Sampaio. Spy-game on graphs: Complexity and simple topologies. *Theoretical Computer Science*, 725:1 – 15, May 2018.

(13) A. Deza and F. Franek. A d-step approach to the maximum number of distinct squares and runs in strings. *Discrete Applied Mathematics*, 163:268 – 274, Jan. 2014.

(14) A. Deza and F. Franek. Bannai et al. method proves the d-step conjecture for strings. *Discrete Applied Mathematics*, 217:488 – 494, Jan. 2017.

(15) A. Deza and F. Meunier. Preface: Linear optimization. *Discrete Applied Mathematics*, Feb. 2018.

(16) J. Elias, F. Martignon, L. Chen, and M. Krunz. Distributed Spectrum Management in TV White Space Networks. *IEEE Transactions on Vehicular Technology*, 66(5):4161 – 4172, May 2017.

(17) F. Foucaud, A. Harutyunyan, P. Hell, S. Legay, Y. Manoussakis, and R. Naserasr. The complexity of tropical graph homomorphisms. *Discrete Applied Mathematics*, May 2017.

(18) Z. Ismail, C. Kiennert, J. Leneutre, and L. Chen. Auditing a Cloud Provider's Compliance With Data Backup Requirements: A Game Theoretical Analysis. *IEEE Transactions on Information Forensics and Security*, 11(8):1685 – 1699, Aug. 2016.

(19) M. Koseoglu, E. Karasan, and L. Chen. Cross-Layer Energy Minimization for Underwater ALOHA Networks. *IEEE Systems Journal*, 11(2):551 – 561, June 2017.

(20) S. Legay and A. Harutyunyan. Linear time algorithms for weighted offensive and powerful alliances in trees. *Theoretical Computer Science*, 582:17–26, May 2015.

(21) K. Le Guiban, A. Rimmel, M.-A. Weisser, and J. Tomasik. Completion of partial Latin Hypercube Designs: NP-completeness and inapproximability. *Theoretical Computer Science*, 715:1 – 20, Mar. 2018.

(22) K. Le Guiban, A. Rimmel, M.-A. Weisser, and J. Tomasik. The First Approximation Algorithm for the Maximin Latin Hypercube Design Problem. *Operations Research*, 66(1), Mar. 2018.

(23) H. Li. Generalizations of Dirac's theorem in Hamiltonian graph theory-A survey. *Discrete Mathematics*, 313(19):2034 – 2053, Oct. 2013.

(24) H. Li, Y. Bai, W. He, and Q. Sun. Vertex-distinguishing proper arc colorings of digraphs. *Discrete Applied Mathematics*, 209:276 – 286, Aug. 2016.

(25) H. Li, R. Faudree, and K. Yoshimoto. Locating sets of vertices on Hamiltonian cycles. *Discrete Applied Mathematics*, 209:107 – 114, Aug. 2016.

(26) H. Li, W. Zhao, F. Wang, and X. Gao. Bondage number of the strong product of two trees. *Discrete Applied Mathematics*, 230:133 – 145, Oct. 2017.

(27) Y. Lu, W. Wang, L. Chen, and Z. Zhang. Distance-Based Energy-Efficient Opportunistic Broadcast Forwarding in Mobile Delay Tolerant Networks. *IEEE Transactions on Vehicular Technology*, July 2016.

(28) Y. Lu, W. Wang, L. Chen, Z. Zhang, and A. Huang. Distance-Based Energy-Efficient Opportunistic Broadcast Forwarding in Mobile Delay Tolerant Networks. *IEEE Transactions on Vehicular Technology*, page to appear, 2015.

(29) M. Mangili, J. Elias, F. Martignon, and A. Capone. Optimal Planning of Virtual Content Delivery Networks under Uncertain Traffic Demands. *Computer Networks*, 106:186–195, Sept. 2016.

(30) M. Mangili, F. Martignon, and S. Paraboschi. A cache-aware mechanism to enforce confidentiality, trackability and access policy evolution in Content-Centric Networks. *Computer Networks*, 76:126–145, Jan. 2015.

(31) M. Mangili, F. Martignon, S. Paris, and A. Capone. Bandwidth and Cache Leasing in Wireless Information Centric Networks: a Game Theoretic Study. *IEEE Transactions on Vehicular Technology*, 66(1):679–695, Jan. 2017.

(32) Y. Manoussakis, V. Borozan, R. Díaz, R. Águeda, and L. Montero. Proper Hamiltonian Cycles in Edge-Colored Multigraphs. *Discrete Mathematics*, 340(8):1897–1902, 2017.

(33) M. Mira, T. Chahed, L. Chen, J. Elias, and F. Martignon. A two-level auction for resource allocation in multi-tenant C-RAN. *Computer Networks*, pages 240–252, Apr. 2018.

(34) V. Pons and G. Chatel. Counting smaller elements in the Tamari and m-Tamari lattices. *Journal of Combinatorial Theory, Series A*, 134(58-97):39, Aug. 2015.

(35) W. Yang, Y. Tian, H. Li, H. Li, and X. Guo. The minimum restricted edge-connected graph and the minimum size of graphs with a given edge–degree. *Discrete Applied Mathematics*, 167:304–309, 2014.

(36) J. Yu, L. Chen, R. Zhang, and K. Wang. From Static to Dynamic Tag Population Estimation: An Extended Kalman Filter Perspective. *IEEE Transactions on Communications*, 64(11):4706 – 4719, Nov. 2016.

(37) J. Yu, L. Chen, R. Zhang, and K. Wang. Finding Needles in a Haystack: Missing Tag Detection in Large RFID Systems. *IEEE Transactions on Communications*, 65(5):2036 – 2047, May 2017.

Other journals

(38) F. Hivert, A. Schilling, and N. M. Thiéry. The biHecke monoid of a finite Coxeter group and its representations. *Algebra & Number Theory*, 7(3):595–671, 2013. 57 pages, 6 figures.

(39) O. Hudry and A. Lobstein. On the Complexity of Determining Whether there is a Unique Hamiltonian Cycle or Path. *Journal of Combinatorial Mathematics and Combinatorial Computing*, 2018.

Conference articles

Major international conferences and workshops

(40) Z. Chen, L. Chen, and Z. Hong. Towards Secure and Verifiable Database-Driven Spectrum Sharing. In *IEEE DSN*, Denver, United States, June 2017.

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(53) A. G. Araldo. *Design and Evaluation of Enhanced Network Caching Systems to Improve Content Delivery in the Internet.* Theses, Université Paris-Saclay, Oct. 2016.

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(55) L. Chen. *Algorithm design and analysis in wireless networks.* Habilitation à diriger des recherches, Paris-Sud XI, July 2017.

(56) S. Delaët. *Auto-stabilisation : Solution Elégante pour Lutter contre Les Fautes*. Habilitation à diriger des recherches, Université Paris Sud - Paris XI, Nov. 2013.

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(A312) A. G. Araldo. *Design and Evaluation of Enhanced Network Caching Systems to Improve Content Delivery in the Internet*. Theses, Université Paris-Saclay, Oct. 2016.

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(A314) L. Chen. *Algorithm design and analysis in wireless networks*. Habilitation à diriger des recherches, Paris-Sud XI, July 2017.

(A315) S. Delaët. *Auto-stabilisation : Solution Elégante pour Lutter contre Les Fautes*. Habilitation à diriger des recherches, Université Paris Sud - Paris XI, Nov. 2013.

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(A317) S. Legay. *A Few Problems of Algorithm and Complexity in Graph Theory*. Theses, Université Paris-Saclay, Feb. 2017.

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(A325) W. Yang. *Supereulerian graphs, Hamiltonicity of graphes and several extremal problems in graphs*. Theses, Université Paris Sud - Paris XI, Sept. 2013.

(A326) J. Yu. *Tag Counting and Monitoring in Large-scale RFID systems : Theoretical Foundation and Algorithm design*. Theses, Université Paris-Saclay, Dec. 2016.

(A327) X. Zeitoun. *Complexity of games dynamics*. Theses, Université Paris Sud - Paris XI, June 2013.

5/ HCC

Human-Centered Computing

équipe
Informatique Centrée sur l'Humain

Responsable: Michel Beaudouin-Lafon, Olivier Chapuis

L'équipe HCC est constituée de deux équipes-projets communes LRI-Inria, ExSitu et ILDA, et explore de nouvelles formes d'interaction humain-machine. Ses travaux sont organisés autour de six grands thèmes :

L'interaction en grand, pour permettre l'exploration de données complexes et/ou massives sur des dispositifs d'affichage de grande taille à l'aide de techniques d'interaction collaborative ;

L'interaction gestuelle, pour mieux tirer parti de la dextérité de la main, notamment pour les interfaces tactiles, mais aussi des capacités d'interaction via les mouvements du corps entier ;

L'interaction tangible, pour faciliter la manipulation de contenus numériques par l'utilisation d'objets physiques, en tirant parti des possibilités de la fabrication numérique;

La visualisation, pour créer des présentations visuelles de données complexes adaptées aux besoins des utilisateurs, mais aussi aux dispositifs d'affichage et d'interaction ;

L'exploration de données sémantiques, pour faciliter l'accès au web des données en fournissant des outils de navigation tirant parti de la sémantique des données ;

Les études empiriques, pour mieux comprendre les besoins des utilisateurs, qu'ils s'agissent d'utilisateurs experts, voire extrêmes, ou des usages quotidiens par le grand public.



Human-Centered Computing

Head: Michel Beaudouin-Lafon, Olivier Chapuis

The HCC group is composed of two joint LRI-Inria project-teams, ExSitu and ILDA, and explores new forms of human-computer communication. The research is organized around six main themes:

Room-size interaction, to support the exploration of massive and/or complex data on large display devices by using collaborative interaction techniques;

Gestural interaction, to take advantage of the dexterity of the human hand, in particular for touch-based interfaces, as well as of the ability to interact with the full body;

Tangible interaction, to facilitate the manipulation of digital content by using physical objects, taking advantage of the capabilities of digital fabrication;

Visualization, to create visual displays of complex data that are adapted to the needs of the users as well as the capabilities of the display device;

Semantic-driven data exploration, to enable access to the web of data by providing navigation tools that take advantage of the semantics of data;

Empirical studies, to better understand the needs of users, whether they are expert or even extreme users, or everyday users from the general public.

Synthetic presentation

Head of HCC: Michel Beaudouin-Lafon (deputy: Olivier Chapuis)

Members of the group
As of January, 2013, the group had 7 permanent members: 3 university faculty (1 PR, 2 MC), 2 Inria researchers (1 DR, 1 CR), 2 CNRS researchers (2 CR).

As of June 30, 2018, the team includes 11 permanent members: 3 university faculty (1 PR, 2 MC), 3 Inria researchers (2 DR, 1 CR), 4 CNRS researchers (3 CR, 1 emeritus DR). The team also includes a long-term invited professor (Inria international chair), 11 Ph.D. students, 2 post-doctoral students, 7 engineers and an Inria administrative assistant.

Permanent members who left the group:

- Stéphane Huot (MC) left in October 2014 to join Inria-Lille as Research Director.

Permanent members who joined the group:

- Cédric Fleury, Ph.D. University of Rennes, joined in September 2013 as assistant professor;
- Emmanuel Pietriga, from Inria-Chile, joined in July 2014 as Inria researcher (CR, then DR);
- Sarah Fdili Alaoui, Ph.D. Univ. Paris-Sud, joined in September 2015 as assistant professor;
- Yves Guiard joined in 2016 as emeritus DR CNRS from Telecom ParisTech;
- Baptiste Caramiaux, Ph.D. Univ. Paris 6 & IRCAM, joined in January 2018 as CNRS research scientist.

Highlights of the scientific activity

- HCC is recognized at the highest international level with many prizes (5 best papers and 6 honorable mentions in top conferences in the field), and hosts two ERC Advanced Grants.
- HCC made significant advances in research areas such as interaction in-the-large, co-located and remote collaboration, gesture-based and tangible interaction, support for creativity, and interaction with the semantic web.
- HCC leads the 22M€ DIGISCOPE project that deployed a network of 10 interactive rooms, and uses this infrastructure for its research.
- HCC applies its research to real-world projects such as the ALMA telescope, and to art-science projects.
- HCC develops advanced software that is heavily used within the group as well as by some outside labs.

Number of publications

- Articles in major international journals: 18 – Other journals: 5
- Articles in major international conferences: 69 – Other conferences: 31
- Books and book chapters: 8

Top ten publications

- C. Liu, O. Chapuis, M. Beaudouin-Lafon, E. Lecolinet, and W. E. Mackay. Effects of Display Size and Navigation Type on a Classification Task. In *Proceedings of the 32nd ACM Conference on Human Factors in Computing Systems*, CHI '14, pages 4147–4156, Toronto, Canada, April 2014. ACM. **Best of CHI paper award**. (DOI) (HAL)
- I. Avellino, C. Fleury, W. Mackay, and M. Beaudouin-Lafon. CamRay: Camera Arrays Support Remote Collaboration on Wall-Sized Displays. In *Proceedings of the 35th ACM Conference on Human Factors in Computing Systems*, CHI '17, pages 6718–6729, Denver, United States, May 2017. ACM. (DOI) (HAL)
- J. Alvina, C. Griggio, X. Bi, and W. E. Mackay. CommandBoard: Creating a General-Purpose Command Gesture Input Space for Soft Keyboards. In *Proceedings of the 30th ACM Symposium on User Interface Software and Technology*, UIST '17, pages 17–28, Quebec City, Canada, October 2017. ACM. (DOI) (HAL)
- V. Rusňák, C. Appert, O. Chapuis, and E. Pietriga. Designing Coherent Gesture Sets for Multi-scale Navigation on Tabletops. In *Proceedings of the 36th ACM Conference on Human Factors in Computing Systems*, CHI '18, Article 142, 12 pages, Montreal, Canada, April 2018. ACM. (DOI) (HAL)
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- T. Tsandilas, A. Bezerianos, and T. Jacob. SketchSliders: Sketching Widgets for Visual Exploration on Wall Displays. In *Proceedings of the 33rd ACM Conference on Human Factors in Computing Systems*, CHI '15, pages 3255–3264, Seoul, South Korea, April 2015. ACM. **Honorable Mention award**. (DOI) (HAL)

- M.-J. Lobo, C. Appert, and E. Pietriga. Animation Plans for Before-and-After Satellite Images. *IEEE Transactions on Visualization and Computer Graphics*, 24, 14 pages, January 2018. (DOI) (HAL)
- E. Dimara, A. Bezerianos, and P. Dragicevic. The Attraction Effect in Information Visualization. *IEEE Transactions on Visualization and Computer Graphics*, 23(1):471–480, 2017. **Honorable Mention award**. (DOI) (HAL)
- M. Ciolfi Felice, S. Fdili Alaoui, and W. Mackay. Knotation: Exploring and Documenting Choreographic Processes. In *Proceedings of the 36th ACM Conference on Human Factors in Computing Systems*, CHI '18, Article 448, 12 pages, Montreal, Canada, April 2018. ACM. (DOI) (HAL)
- W. Liu, O. Rioul, J. McGrenere, W. Mackay, and M. Beaudouin-Lafon. BIGFile: Bayesian Information Gain for Fast File Retrieval. In *Proceedings of the 36th ACM Conference on Human Factors in Computing Systems*, CHI '18, Article 385, 13 pages, Montreal QC, Canada, April 2018. ACM Press. **Honorable Mention award**. (DOI) (HAL)

Top five documents (other than publications)

- Patent on the CommandBoard gesture-based interface.
- Software tools for wall displays: Smarties, WildOS, ZVTM.
- Advanced tools for geo-visualization.
- TouchTokens tangible interface.
- Article on 50 years of HCI on the Interstices web site.

Top five facts illustrating the scientific visibility

- Wendy Mackay was awarded an ERC Advanced Grant that started in June, 2013, entitled "CREATIV: Creating Human Computer Partnerships".
- Michel Beaudouin-Lafon was awarded an ERC Advanced Grant that started in October, 2016, entitled "ONE – Unified Principles of Interaction".
- HCC received five best paper awards (3 at ACM CHI, 1 at INTERACT, 1 at VRST) and six honorable mention at ACM CHI. Our Ph.D. students also received 3 prizes related to their Ph.D. work.
- Wendy Mackay received a Doctorate Honoris Causa from University of Aarhus, Denmark.
- Members of the team were general chair and program chair of the the largest conference in the field (ACM CHI 2013 in Paris, 1000 presentations, 3500 attendees) and participated in over 70 program committes of major conferences, including papers chair at CHI 2017, several papers sub-committee chairs at CHI, chair at ACM EICS 2018, or papers chair at IHM 2014.

Top five facts illustrating the interactions with the socio-economic and cultural environment

- Since 2009, the team has been collaborating with international organizations such as ESO (European Southern Observatory) on the design and development of advanced user interfaces for operations monitoring and control of major next-generation telescopes, including: ALMA, CTA and LSST; as well as Institut d'Astrophysique Spatiale and the Millenium Institute for Astrophysics on the use of ultra-high-resolution wall displays for the interactive, exploratory analysis of astronomical data.
- Members of the group have been interviewed on radio and TV on multiple occasions, about topics such as future interfaces, keyboard design, or augmented glasses.
- The group participates in the Fête de la Science every year.
- Members of the group have been involved in several art-science projects and public events, including the creation and performance of choreographic pieces.
- Sarah Fdili Alaoui gave a talk at the Paris-Saclay TEDx event.

Top five contributions to teaching and training

- The group created and chairs the second-year Research Master Specialty in Interaction (M2R Interaction), the only such program in France (taught in English).
- The group participated in the creation of the Human-Computer Interaction and Design (HCID) major of the EIT Digital Master School and chairs the Paris-Sud branch of this international Master program.
- The group uses software developed in the group for teaching students in both Masters programs, including the Touchstone platform for designing and running controlled experiments, and the SwingStates toolkit for developing graphical user interfaces.
- The group uses the Digiscope FabLab for several courses and course projects, including a Creative Design class and a Digital Fabrication class.
- Group members supervised over 60 research Masters students and 24 Ph.D. students (12 defended theses, 12 ongoing) during the period.

Research Group Members and evolution since 2013

As of June 30, 2018, the team includes:

- 11 permanent members: 3 university faculty (1 PR, 2 MC), 3 Inria researchers (2 DR, 1 CR), 4 CNRS researchers (3 CR, 1 emeritus DR);
- A long-term invited professor (Inria international chair);
- 11 Ph.D. students, 2 post-doctoral students and 7 engineers;
- An Inria administrative assistant.

Permanent Members				
Name	*First name*	*Position*	*Institution*	*Remarks*
APPERT	Caroline	CRCN	CNRS	
BEAUDOUIN-LAFON	Michel	PREX	Paris-Sud	
BEZERIANOS	Anastasia	MCF	Paris-Sud	
CARAMIAUX	Baptiste	CRCN	CNRS	since 04/12/2018
CHAPUIS	Olivier	CRCN	CNRS	
FDILI ALAOUI	Sarah	MCF	Paris-Sud	since 01/09/2015
FLEURY	Cédric	MCF	Paris-Sud	since 02/09/2013
GUIARD	Yves	DR emeritus	CNRS	since 01/12/2016
HUOT	Stéphane	MCF	Paris-Sud	until 30/09/2014
MACKAY	Wendy	DR0	Inria	
MERLIN	Alexandra	ADMIN	Inria	
PIETRIGA	Emmanuel	DR2	Inria	since 01/07/2014
TSANDILAS	Theophanis	CRCN	Inria	

PhD students				
Name	*First name*	*Funding*	*Institution*	*Remarks*
ALVINA	Jessalyn	ERC CREATIV	Inria	01/10/2014 - 31/05/2018
AVELLINO MARTINEZ	Ignacio Martin	CORDI	Inria	01/09/2014 - 31/12/2017
BONNET	David	EDIPS	Paris-Sud	01/10/2011 - 30/09/201
CIOLFI FELICE	Marianela	EDSTIC	Paris-Sud	01/02/2015 -
DESTANDAU	Marie	CORDI	Inria	01/10/2017 -
DIMARA	Evanthia	Labex DigiCosme	Inria	02/04/2013 - 31/11/2017
FRUCHARD	Bruno	Labex DigiCosme	Telecom	01/10/2015 -
GARCIA	Jérémie	EDIPS	Paris-Sud	01/09/2010 - 31/08/2014
GOGOLOU	Anna	CORDI	Inria	01/10/2016 -
GRIGGIO	Carla	ERC CREATIV	Inria	01/10/2015 -
HSUEH	Shu-Huan	EDSTIC	Paris-Sud	01/10/2016 -
JALAL	Ghita	ERC CREATIV	Inria	01/01/2012 - 31/08/2017
LEIVA	Germán	CORDI	Inria	01/10/2015 -
LIU	Can	Labex DigiCosme	Paris-Sud	01/10/2012 - 29/02/2016
LIU	Wanyu	Labex DigiCosme	Telecom	07/12/2015 -
LOBO	Maria	ANR	Inria	01/10/2014 - 31/12/2017
MATHEW	Justin	CIFRE	DMS	01/04/2013 - move to Inria Lille 01/10/2014
MAUDET	Nolwenn	EDSTIC	Paris-Sud	01/10/2014 - 31/03/2018
MORALES GONZALEZ	Rafael	Labex DigiCosme	Inria	01/11/2014 - 31/10/2017
OKUYA	Yujiro	Labex DigiCosme	Paris-Sud	01/10/2015 -
PINDAT	Cyprien	EDIPS	Paris-Sud	01/09/2010 - 31/12/2013
PROUZEAU	Arnaud	EDSTIC	Paris-Sud	01/10/2014 - 31/12/2017
RIVIERE	Jean-Philippe	EDSTIC	Paris-Sud	15/10/2017 -
ROMAT	Hugo	CIFRE	Inria	30/05/2016 -
STRAZZULLA	Daniel	CORDI	Inria	01/09/2012 - 31/01/2015
TCHERNAVSKIJ	Philip	ERC ONE	Paris-Sud	1/10/2017 -
WESSELY	Michaël	ERC CREATIV	Inria	01/11/2015 -
ZINENKO	Oleksandr	CORDI	Inria	16/09/2013 - 15/11/2016

Note: EDIPS = Ecole Doctorale d'Informatique de Paris-Sud; EDSTIC = Ecole Doctorale STIC, Paris-Saclay.

Temporary Personnel					
Name	*First name*	*Position*	*Institution*	*Arrival*	*Departure*
DI VOZZO	Romain	Engineer	Inria then U. Paris-Saclay	12.2013	
FYFE	Lawrence	Engineer	CNRS then Inria	09.2016	
GARCIA	Jérémie	ATER	Paris-Sud	09.2013	08.2014
GLADIN	Olivier	Engineer	Inria	01.2014	
GOZUKAN	Hande	Engineer	Inria	02.2015	
HELLEQUIN	Rémi	Engineer	CNRS	09.2014	12.2016
KOOLI	Amani	Engineer	CNRS	10.2013	12.2016
LEBOUT	Dylan	Engineer	Inria	09.2016	
MACCALLUM	John	Post-doc	Inria	12.2016	
MALLOCH	Joseph	Post-doc	Inria	03.2014	08.2017
OEHLBERG	Lora	Post-doc	Inria	12.2012	09.2013
OLAFSDOTTIR	Halla	Post-doc	Paris-Sud	01.2013	12.2013
PRIMET	Romain	Engineer	Inria	01.2014	
SANAEI	Monireh	Engineer	Inria	02.2013	01.2015
SPELMEZAN	Daniel	Post-doc	Inria	09.2011	07.2013
TAFFIN	Nicolas	Engineer	Inria	09.2017	
TEZIER	Gabriel	Engineer	CNRS	06.2012	02.2014
THORPE	Jonathan	Engineer	CNRS	10.2013	12.2016
WEBB	Andrew	Post-Doc	Inria	01.2017	

Invited Professors					
Name	*First name*	*Position*	*Institution*	*Arrival*	*Departure*
BERNARDOS	Ana	PR Invité	Univ. Politécnica Madrid	09.2015	12.2015
BØDKER	Susanne	PR Invité	Univ. Aarhus	03.2017	04.2017
HOLLAN	James	PR Invité	Univ. Californa San Diego	04.2016	06.2016
MCGRENERE	Joanna	PR (Chair)	Univ. British Columbia	multiple	visits*

*Joanna McGrenere visited in August 2014, during her sabbatical from July 2015 to June 2016, and as Inria international chair in June-July 2017 and June-July 2018.

Group evolution

Permanent members who left the group

- Stéphane Huot (MC) left in October 2014 to join Inria-Lille as Research Director.

Permanent members who joined the group

- Cédric Fleury, Ph.D. University of Rennes, joined in September 2013 as assistant professor;
- Emmanuel Pietriga, from Inria-Chile, joined in July 2014 as Inria researcher (CR, then DR);
- Sarah Fdili Alaoui, Ph.D. Univ. Paris-Sud, joined in September 2015 as assistant professor;
- Yves Guiard joined in 2016 as emeritus DR CNRS from Telecom ParisTech;
- Baptiste Caramiaux, Ph.D. University Paris 6 & IRCAM, joined in January 2018 as CNRS research scientist.

Research Description

The Human-Centered Computing (HCC) group is the follow-up to the Inria/LRI InSitu group, which ran from 2002 to 2014 and explored advanced forms of Human-Computer Interaction that place particular emphasis on *situated interaction*, acknowledging the critical role of context in the design of interactive systems. At the end of this 12-year period, the members of InSitu decided to create two new groups to reflect the respective interests of their members : ExSitu – Extreme Situated Interaction, and ILDA – Interacting with large data. As part of the reorganization of the LRI laboratory at the end of the previous evaluation period, the Human-Centered Computing group was created as the union of ExSitu and ILDA.

ExSitu explores the limits of interaction — how extreme users interact with technology in extreme situations. Rather than beginning with novice users and adding complexity, we begin with expert users who already face extreme interaction requirements. We are particularly interested in creative professionals, artists and designers who rewrite the rules as they create new works, and scientists who seek to understand complex phenomena through creative exploration of large quantities of data. Studying these advanced users today will not only help us to anticipate the routine tasks of tomorrow, but to advance our understanding of interaction itself. We seek to create effective human-computer partnerships, in which expert users control their interaction with technology. Our goal is to advance our understanding of interaction as a phenomenon, with a corresponding paradigm shift in how we design, implement and use interactive systems. Based on our work on instrumental interaction and co-adaptive systems, we hope to create a foundation for the design of all interactive technology — to create a *physics of interaction*.

ILDA explores "Data-centric Interactive Systems" that provide users with the right information at the right time, presenting it in the most meaningful manner, and letting users efficiently manipulate, edit and share these data with others. This entails minimizing the effort required to retrieve and relate data from relevant sources; displaying data using visual presentation techniques that match the data's characteristics and the users' tasks; and providing users with means of interacting with the data that effectively support their train of thought. Our approach is based on the idea of bringing the fields of Web data management and Human-Computer Interaction closer together, based on the strong belief that they have the potential to cross-fertilize one another. User interface design is essential to the management and understanding of large, interlinked datasets. Interlinked datasets enriched with even a small amount of semantics have the potential to help create interfaces that let users analyze and manipulate data in a more efficient manner by providing them with, e.g., more relevant query results and giving them efficient means to navigate and relate those results. Our ultimate, long-term goal is to design interactive systems that make it as straightforward to manipulate large webs of data as spreadsheets do for tabular data.

In this report, we do not separate the work of each group[1]. Instead, we present the work performed by HCC along six main themes: room-size interaction & collaboration, gestural interaction, tangible interfaces and digital fabrication, visualization, semantic-driven data exploration, and empirical studies of users.

Room-size Interaction & Collaboration



Figure 5.1: Precise pointing, collaborative graph exploration, cooperative gestures, deictic gestures for telepresence.

Ultra-high-resolution wall displays feature a very high pixel density over a large physical surface, making them well-suited to collaborative, exploratory visualization of large and complex datasets. We have conducted intensive work on the design, implementation and evaluation of interaction, visualization and collaboration techniques for such "ultra-walls", including studies of wall-sized displays vs. traditional setups, creation of interaction and collaboration techniques, and development of real-world applications and of supporting tools and toolkits (Fig. 5.1). Three theses were defended on these topics during the period (A167, A159, A163).

[1] annual Inria reports of each group can be found online at **https://raweb.inria.fr**

Our research is conducted on the WILD and WILDER ultra-high-resolution interactive environments featuring large tiled wall-sized displays: 5m50 x 1m80 for WILD, made of 32 30" LCD screens displaying 20 480 x 6 400 = 131 million pixels, powered by a 16-computer cluster and two front-end computers; 5m90 x 2m, touch-enabled for WILDER, made of 75 20" LCD screens displaying 14 400 x 4 800 = 69 million pixels, powered by a 10-computer cluster and two front-end computers. Each platform also features a camera-based motion tracking system and three large touch-screens that can be oriented from a horizontal table position to a vertical board, as well as multi-channel and 3D audio systems, multiple HD and 4K cameras, and an 8-camera array integrated into each wall display to support telepresence. Some work is also conducted in collaboration with LIMSI's EVE immersive CAVE. All three platforms are part of the larger Digiscope "equipment of excellence" project.

Studies of wall-sized displays

We conducted a series of studies to assess the value of large wall-sized displays for tasks that involve the manipulation of shared data and for collaborative tasks. While previous work has mostly addressed search, visualization and sense-making tasks, we designed and evaluated an abstract classification task that involves explicit data manipulation, and conducted a controlled experiment comparing physical navigation in front of a wall-size display with virtual navigation using pan-and-zoom on the desktop (A63). We found that while the desktop can be faster than the wall for simple tasks, the wall gains a sizable advantage as the task becomes more difficult.

We also studied whether wall displays provide an advantage over more classic collaboration setups, such as multiple desktops (A84). We compared the wall with two desktops when pairs of users learn to perform a path-planning task. We found that participants adopted different task strategies and that quality was more consistent in the wall setup. We also investigated how pairs explore graphs on a touch-enabled wall-sized display (A17), using two selection techniques adapted for collaboration. We found that interaction techniques with strong visual footprint can improve collaboration and synchronization among the participants.

We studied users' sense of presence in immersive Virtual Environments. We used the Immersive Interactive Virtual Cabin model to create a virtual representation of the user's physical environment and showed how this representation can be used in a collaborative navigation task (A10). This work also addressed asymmetrical collaborative configurations between 2D and 3D immersive environments.

Finally, with colleagues from the Inria AVIZ, we studied how visual perception of content displayed on a large wall may change depending on distance and viewing angle as collaborators change their perspective on the information they view (A143, A103). We found that being close to the wall can distort information in unexpected ways, but that walking helps people avoid this distortion. We then attempted to take advantage of the fact that collaborating colleagues can move freely. We introduced hybrid-image visualizations that blend two different visual representations into a single static view, such that each representation can be perceived at a different viewing distance (A13). Our work is motivated by data analysis scenarios that incorporate multiple analysts working together at various distances from the wall.

Interaction techniques

We conducted extensive studies of precision pointing on ultra-walls, from techniques that only use a small device such as a smartphone to those using multiple body parts, including the orientation of the head (A75). We explored the limits of existing single-mode remote pointing techniques and demonstrated theoretically that they do not support high-precision pointing on ultra-walls. We then explored solutions to improve mid-air pointing efficiency: a tunable acceleration function and a framework for dual-precision (DP) techniques, both with precise tuning guidelines (A16).

We also introduced the *GlideCursor*, a relative pointing technique that lets the cursor continue to move during clutching gestures (A33). We showed that gliding reduces clutching and can improve pointing performance for large distances, making it particularly appropriate for wall-sized displays.

We explored touch-based 3D interaction when interacting with a 3D virtual environment on a large multi-touch wall-sized display. We designed *In(SITE)* (A68), a bimanual touch-based technique combined with object teleportation that enables users to perform 3D object manipulation on a large 2D display. In collaboration with the Inria REVES group in Sophia Antipolis, we proposed a framework for analyzing 3D object manipulation in immersive environments (A107), described in the section on tangible interaction.

Collaboration support

Large wall-sized displays afford collaborative exploration of large datasets and re-organization of digital content. However, standard interactions, such as dragging to move content, do not scale well to large surfaces and were not designed to support collaboration, such as passing objects around.

We started by studying how interaction techniques affect collaboration. We used the same data-manipulation task as above (A63) in five collaborative situations with increasing levels of coupling (A61). The results show the benefits of shared interaction for close collaboration: it encourages collaborative manipulation, it is more efficient and preferred by users, and it reduces physical navigation and fatigue.

We then created a set of collaborative gestures that combine input from multiple users in order to manipulate content, facilitate data exchange and support communication (A62). For example, *Throw-and-catch* lets users send digital objects to each other, *Preview* lets one user show content to another, and *SharedClipboard* lets users gather content. A controlled study showed that these gestures reduce physical fatigue and facilitate collaboration when compared with traditional multi-touch gestures.

As described above we also investigated multi-user exploration of graphs on wall-displays (A17), showing the importance of choosing appropriate interaction techniques to support collaboration. While many command-and-control rooms feature wall-sized displays, these are usually not interactive. We showed how interaction with such wall-sized displays can be useful in such contexts (A167).

Telepresence

In addition to co-located collaboration support, we have investigated how to support remote collaboration with telepresence systems providing audio-video links among large, heterogeneous interactive spaces (A153, A111, A159). We first studied how accurately a user can interpret deictic gestures in a video feed of a remote user (A28). Deictic gestures are important for conveying non-verbal cues for communication between remote users.

We then created *CamRay* (7), a platform that uses camera arrays embedded in wall-sized displays to capture video of users and present it on remote displays according to the users' positions. We investigated two settings: in *Follow-Remote*, the position of the video window follows the position of the remote user; in *Follow-Local*, the video window always appears in front of the local user. We showed the respective advantages of each technique in an asymmetric collaborative task based on the same manipulation task as described above.

Applications

In order to validate our work and get input from real users, we have developed a number of real-world applications based on wall-sized displays.

For the ACM CHI 2013 conference in Paris, we created an interactive schedule (A87) linked with a back-end conflict resolution software (A58, A97) to help organizers fine-tune the conference program. All 200 sessions and 500 long papers presented at the conference could be displayed simultaneously, and edited collaboratively through a tablet interface.

We created *WallTweet* (A126), a tweet visualization designed for wall-sized displays to improve the situation awareness of users monitoring a crisis event, such as tornados or terrorist attacks, through tweets.

Another application is the monitoring of road traffic data (A129, A82). Road traffic is a complex system that can be very unstable. To avoid such situations, researchers attempt to model traffic in order to prevent congestion and optimize traffic flow. After several visits to control rooms and interviews with controllers, we designed an interactive system to monitor traffic on a wall-sized display coupled with traffic modeling algorithms. The system lets users interactively adjust traffic parameter settings and visualize the impact of these adjustments at both a local and global scale.

Finally we created *FITS-OW* (A23), an application that enables astronomers to navigate large collections of FITS images, query astronomical databases, and display detailed, complementary data and documents about multiple sources simultaneously on a wall-size display. The application was designed in collaboration with astronomers from the Millenium Institute of Astrophysics in Chile, and is deployed on the wall display at Inria Chile in Santiago.

Tools and toolkits

In order to support the development of applications running on multi-surface environments featuring tiled wall-sized displays, we have developed a number of tools and toolkits that have been heavily used in the projects described above (see full description in Annex 4).

Smarties (A37) is a system that lets developers easily add interactive support to their wall-sized display applications by using mobile devices such as tablets. The interface features multiple cursor controllers, as well as a keyboard, widgets and clipboards, and can be customized by the application itself without programming the mobile device. Multiple devices can be connected simultaneously, thereby supporting collaboration. Libraries in different programming languages facilitate integration with the rest of the application.

SketchSliders (A92) is another tablet-based interface that lets users explore multi-dimensional datasets on wall-sized displays by sketching on the fly the interactive controllers they require. Using sketches and gestures, users can create complex interactive sliders such as circular sliders for periodic data, slider branches for detailed interaction, and fisheye transformation sliders.

Webstrates (A59, A121, A99), developed in collaboration with Université of Aarhus (Denmark) and Telecom ParisTech, is a web-based system that supports real-time sharing of any web content across multiple devices, including on tiled wall-sized displays such as WILD and WILDER. It is an example of our concept of *information substrate* that blurs the distinction between tools, documents and applications so as to support generalized sharing and end-user appropriation.

Hydrascope (A120) and its successor *WildOS* support the creation of web-based applications on tiled wall-sized displays, while *ZVTM* targets Java-based applications. Finally, *Digiscape* is a middleware that facilitates the development of remote collaborative application across heterogeneous platforms by supporting real-time sharing of audio, video and data streams among the connected sites.

Gestural Interaction

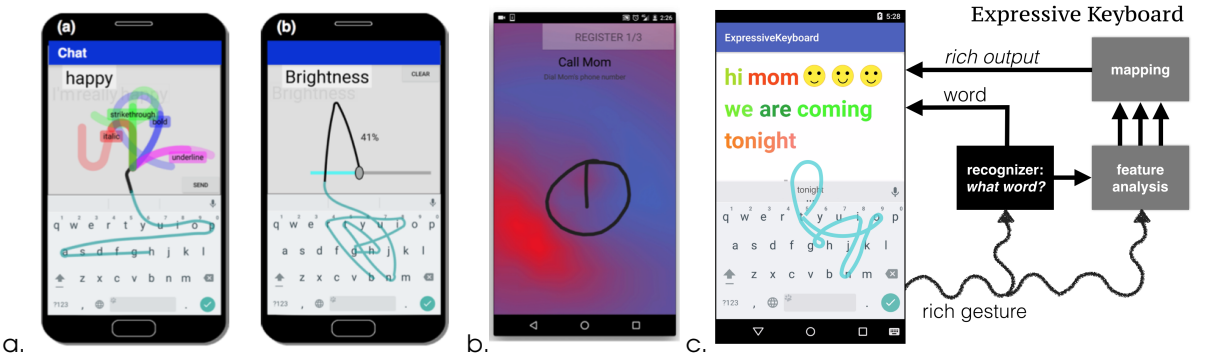

Figure 5.2: (a) CommandBoard*: Specifying complex commands with gestures; (b)* Fieldward*: Defining new gestures with feedforward about their recognizability; (c)* Expressive Keyboard*: Entering text with user-controlled variations.*

One of the primary forms of interaction is gestures, including two-dimensional movements on a flat surface and three-dimensional movements in space. HCC investigates fundamental aspects of human movement and uses this knowledge to design novel interaction techniques, including touch-based interaction on mobile devices and tabletops and full-body gestures for embodied interaction.

Theory and concepts

The group has a long history of studying pointing and Fitts' law. Our recent work, in collaboration with Telecom ParisTech, has studied the theoretical underpinnings of Fitts' law through information theory (A52, A53, A54), revealing a number of issues with the current design of Fitts' law experiments and with the common interpretation and application of the law. In a similar vein, we have analyzed the methods used in gesture elicitation studies and made recommendations to avoid misinterpreting the significance of the results (A18).

We also conducted fundamental work on multitouch interaction. We systematically studied how users adapt their grasp when asked to translate and rotate virtual objects on a multitouch tabletop (A79) and analyzed the results in the light of the most recent models of planning for manipulating physical objects. We showed how these results can inform the design of tabletop applications.

Mobile and tabletop interaction

We studied the problem of designing large vocabularies of gestures for small touch surfaces (smartphones and tablets) that are easy to memorize and perform. We wanted to keep the shapes of the gestures simple and instead rely on other characteristics such as simple finger tip movements (rolling (A34), staying still (A112)), or additional input channels (tilt (A91), pressure (A89) and proximity (A88)). These gesture vocabularies are simple to perform while offering at least as much expressivity as graphical widgets without consuming any screen space. For all these projects, we designed gesture primitives and implemented the associated recognizer either on a regular smartphone with built-in sensors (accelerometers and gyroscopes) or on a smartphone that we equipped with extra sensors (pressure or proximity) while preserving the device's form factor.

Tabletop devices let multiple users navigate and manipulate a shared information space. For navigation, multi-foci techniques are especially relevant as they enable users to navigate either individually or collaboratively. However, designing coherent and easy-to-learn multitouch gestures for these techniques is difficult. We introduced two solutions that are easy to learn while being based exclusively on the ubiquitous *slide*, *pinch* and *turn* gestures (A86). For content manipulation, we created a design space of discrete and continuous multitouch gestures (A78) and a real-time recognition engine. These gestures offer a rich power of expression while relying only on circular and linear shapes. Finally, chord gestures can complement multitouch interaction for discrete commands. We created *Arpège* (A50), a progressive multitouch input technique for learning chords that features a robust recognizer, a dynamic guide to learn chords, and guidelines for building large chord vocabularies.

We conducted a series of projects that explore how to increase discoverability, appropriability, and expressivity when issuing gesture commands on mobile phones and tablets. To support discoverability, we designed *CommandBoard* (A25), which lets users access the full set of available commands through gestures on a soft keyboard. *CommandBoard* transforms the area above the keyboard into a command-gesture input space that lets users draw unique command gestures or type command names followed by the *execute* command (Fig. 5.2a). Novices can pause to see an in-context dynamic guide, whereas experts simply draw the full gesture. *CommandBoard* is almost twice as fast for text editing than using Markdown symbols and significantly preferred by users. We filed a patent for *CommandBoard*.

To support appropriability, we developed two dynamic guides, *Pathward* (Fig. 5.2b) and *Fieldward* to help users create their own custom gesture-based commands that are both personally memorable and reliably recognizable by the system (A69). Each uses progressive feedforward to interactively visualize the "negative space" of unused gestures. Our experiments showed that *Fieldward* was the most successful strategy for creating memorable gestures linked to commands.

To support expressivity, we developed the *Expressive Keyboard* (A26), in which the user "gesture-types" words by drawing over the letters of a soft keyboard. We take advantage of the existing recognition algorithms to detect the correct word. However, we also detect individual variations in the user's gestures, based on curviness, speed variation and inflation, and map it to rich output, such as the full RGB color space, type variations, or the expression on an emoji (Fig. 5.2c). We demonstrated that users can easily control their gestures to control this rich output. These projects led to a Ph.D. thesis on the expressive power of gesture-based interaction on mobile devices (A157).

Full-body interaction

Our studies of gesture-based interaction extend to situations that involve the full body. The *BodyScape* design space (A95) explores the relationship between users and their environment, specifically how different body parts enhance or restrict movement for specific interactions. We used *BodysScape* for example to design and compare two free-hand techniques, on-body touch and mid-air pointing.

We also designed and evaluated computational models of movement's expressive qualities as defined in the Laban Efforts framework (A45) for dancers and movement practitioners. We worked with experts in Laban Movement Analysis (LMA) to select a set of suitable multimodal sensors and to compute features that closely correlate to the definitions of efforts in LMA. Evaluation of our model showed that multimodal data combining positional, dynamic and physiological information better characterize Laban Efforts. Inspired by movement practices and dance, we designed an interactive sound installation that supports kinesthetic awareness of a participant's micro-movements (A113) and discussed the perspectives of such an installation for somatic practices and embodied cognition (A106). We also discussed (A124) the ethical and aesthetic implications of the appropriation of biomedical sensors in artistic practices, in particular dance, and traced the history and new perspective of HCI in dance and body-based practices (A20).

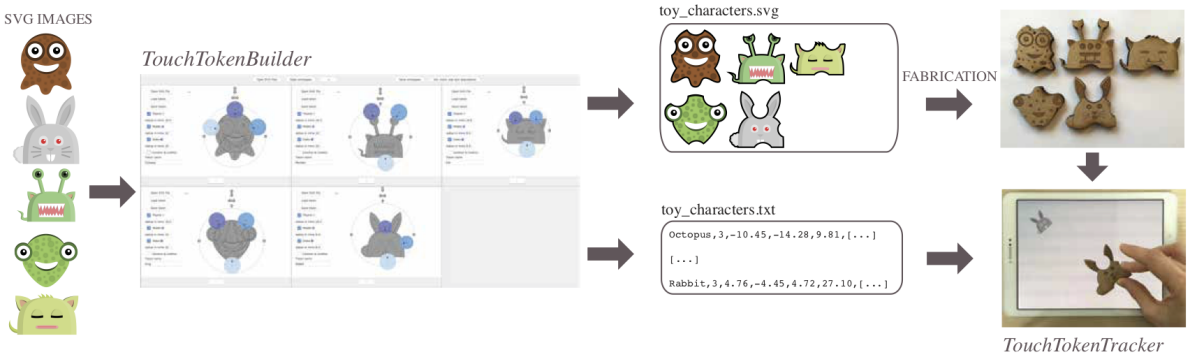

Figure 5.3: Creating TouchTokens *with* TouchTokenBuilder *and testing them with* TouchTokenTracker.

HCC studies tangible interfaces that combine digital and physical object manipulations, and pursues the long line of work on interactive paper. We have also started studying how casual users can benefit from the promises of digital fabrication.

Tangible interfaces

TouchTokens are a new way of implementing tangible interfaces that requires only passive tokens and a regular multi-touch surface (A165). The tokens feature notches that guide users' grasp, and thus, the relative spatial configuration of fingers on the surface, making it possible to design algorithms that can recognize the resulting touch patterns. We designed a first set of tokens (A73) with basic geometrical shapes and a recognition algorithm that can classify the resulting patterns with a high level of accuracy (>95%) without training. We then added laser-cut lattice hinges to make *TouchTokens* flexible (A74), enabling manipulations that go beyond the basic two-state model of touch interaction. A new recognizer detects when a token is taken off the surface rather than left on it by analyzing the micro-movements of the fingers that hold the token. It also detects bend events that can be mapped to commands, and a squeezed state that can be used for quasi-modal interaction. Finally, we showed that *TouchTokens* are not limited to basic geometrical shapes and that the approach also works with arbitrarily-shaped tokens (A27). The *TouchTokenBuilder* (Fig. 5.3) application assists designers in placing notches on arbitrarily-shaped vector contours for creating conflict-free token sets, and our software library can track these tokens' full geometry. With these tools, designers can easily create sets of up to five custom-made tokens.

In collaboration with the Inria REVES group in Sophia Antipolis, we introduced a framework for analyzing 3D object manipulation in both physical and immersive environments (A107). We decomposed 3D object manipulation into the component movements, taking into account both physical constraints and mechanics. We then fabricated five physical devices that simulate these movements in a measurable way under experimental conditions. We implemented the devices in an immersive environment and conducted an experiment to evaluate direct finger-based vs. ray-based object manipulation. We identified the compromises involved when designing devices that (i) are reproducible in both real and virtual settings, and (ii) can be used in experiments to measure user performance.

Interactive Paper

We continued our work on interactive paper for artistic creation. We created *PaperComposer* (A98), a graphical interface builder for creating personal interactive-paper applications for musical creation, and an API that facilitates the development of interactive paper components with PaperComposer. Using this tool, we designed *Polyphony* (A49), a novel interface for systematically studying the phases of computer-aided composition. *Polyphony* is a unified user interface that integrates interactive paper and electronic user interfaces for composing music. We asked 12 composers to use it to compose an electronic accompaniment to a 20-second instrumental composition by Anton Webern. The resulting snapshots of the composition process reveal how composers both adapt and appropriate tools in their own way.

In collaboration with IRCAM, we conducted a longitudinal study with composer Philippe Leroux (A118) for the creation of his piece *Quid sit musicus*. The composer used our interfaces based on interactive paper along with an OpenMusic library to generate compositional material for this work.

We also conducted interviews with four professional illustrators to understand how they mix digital and physical tools in their work process. We further studied the evolution of the work of one of them over two

years. In collaboration with the artist, we designed *BricoSketch* (A94), which lets illustrators interactively create partial views of their drawings directly on paper. Such views can be transposed and rescaled. Artists can then use them to create variations of their illustrations or add higher-precision details.

Digital fabrication

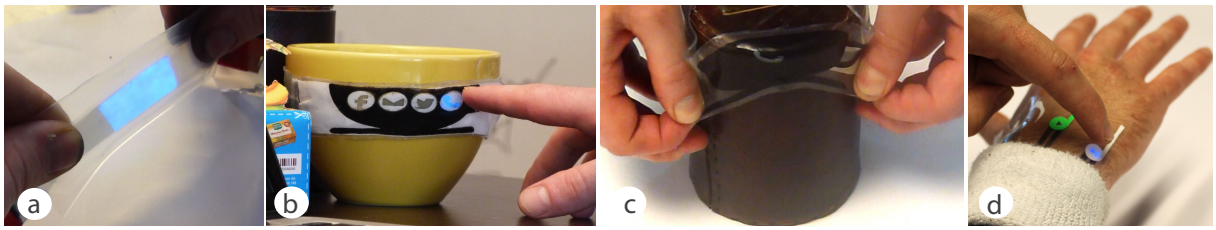

Figure 5.4: (a) Stretchis *are stretchable substrates with touch and proximity sensors and electroluminescent displays. (b)* Stretchis *are transparent, (c) can fit the geometry of physical objects, and (d) can act as on-skin user interfaces.*

We are interested in how casual makers use digital fabrication tools. We investigated (A77) how makers remix digital designs for physical objects on "Thingiverse", a well-known online 3D-printing maker community. We collected metadata from over 175,000 digital designs and analyzed the *remixing graph* —where edges represent links between sources and remixes— to show that it exhibits a tree-like inheritance structure. We used this data to identify particularly influential and surprising "Things", which we further examined via qualitative case studies. We concluded with specific suggestions for online design repositories and design software so as to provide better support for remixing and thus build stronger communities.

We also studied how to help teams of novice crafters prototype physical objects. We conducted a study (A35) framed around two all-day design "charrettes" where novices performed a complete design process: ideation sketching, concept development and presentation, fabrication planning, documentation, and collaborative fabrication of hand-crafted prototypes. Participants used a variety of drawing techniques to convey 3D concepts. They also extensively manipulated physical materials such as paper, foam and cardboard, both to support concept exploration and communication with design partners. Based on these observations, we proposed design guidelines for CAD tools targeted at novice crafters.

For non-expert makers, we developed an inexpensive method for fabricating *Stretchis* (Fig. 5.4), highly stretchable interfaces that combine sensing and display capabilities (A96). This method enables designers and casual makers to embed transparent conductors and electroluminescent displays in stretchable PDMS substrates. We showed how to prototype stretchable user interfaces for a range of application scenarios by using standard design software and screen-printing techniques. Despite the use of inexpensive equipment, our results demonstrate that we can produce durable and highly stretchable sensors and displays that remain functional under strain levels of more than 100%. We also collaborated with Saarland University, TU Berlin and MIT to digitally fabricate *directional screens*, surfaces that maximize perceived image quality such as resolution, brightness and color reproduction for large audiences (A127). Finally, we participated and then were invited to write a report on the *MIT Summer School on Computational Fabrication and Smart Matter* (A22).

Visualization

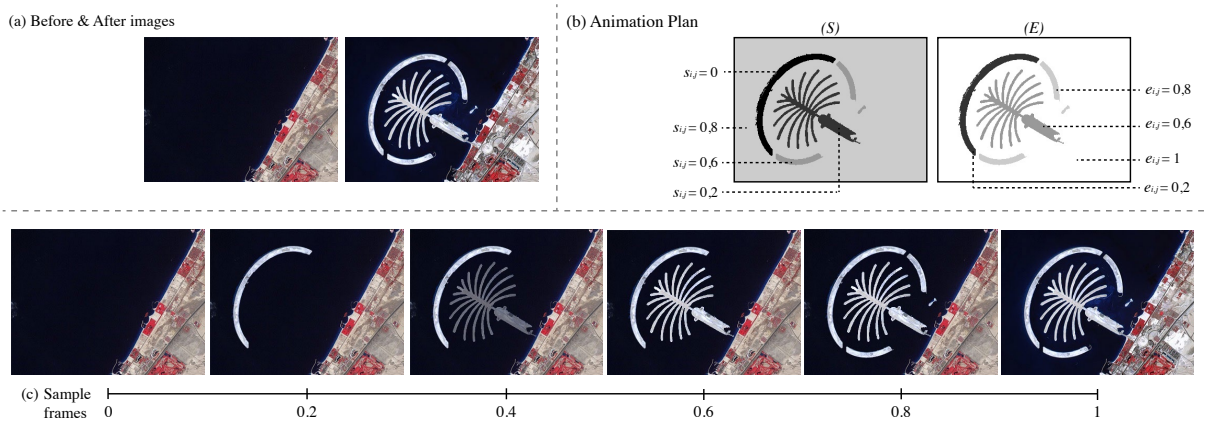

Figure 5.5: A Baia animation plan for creating elaborate transitions between before-and-after satellite images.

HCC studies how to best visualize and explore large quantities of information (A142). We have worked on interactive visualizations for geographical data, graphs and multidimensional data, and have also studies how visualization can help or affect decision making.

Geographical data

In the context of the ANR-funded collaborative project MapMuxing, we investigated several geovisualization techniques. We first ran an empirical study of different map comparison techniques (A67). From an HCI perspective, one of the main challenges in geovisualization systems is to design interactive compositions that optimize the legibility of layered maps and facilitate their comparison.

We characterized five representative techniques and empirically evaluated them using a set of real-world maps. We then designed a novel dynamic map compositing technique called *MapMosaic* (A14), based on dynamic visual compositing. The technique enables users to interactively create and manipulate local composites of multiple vector and raster map layers.

Our more recent contribution in this area is *Baia*, a framework for creating before-and-after satellite images (A15). Before-and-after images show how entities in a given region have evolved over a specific period of time. *Baia* enables users to create advanced animated transitions, called animation plans, between before-and-after images (Fig. 5.5).

Graphs

Another active research area in the team is graph visualization. As part of a collaboration with the Inria AVIZ group, we investigated novel visualization techniques for dynamic networks. *GraphDiaries* (A2) is a visual interface designed to improve support for tasks related to tracking and understanding changes in any node-link based graph visualization. It relies on animated transitions that highlight changes in the network between time steps.

We then investigated another technique,*Matrix Cubes* (A30), aimed more specifically at dense networks and inspired by the way people comprehend and manipulate physical cubes. Users can change their perspective on the data by rotating or decomposing the 3D cube. These manipulations can produce a range of 2D visualizations that emphasize specific aspects of the dynamic network.

Finally, we recently performed an investigation (A85) of the potential of animated particles flowing along edges to visually encode network edge data attributes. The motion-related properties of these particles open a large design space of animated edge textures. These additional visual encodings have potential not only in terms of visual mapping capabilities but also for their playful and aesthetic qualities.

Multidimensional data

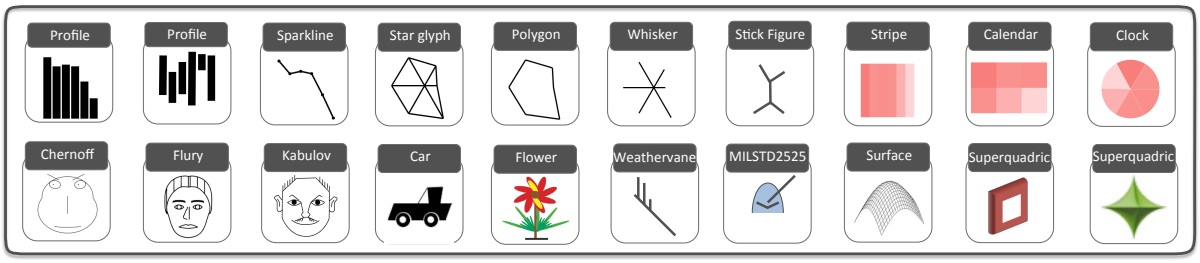

Figure 5.6: Data glyphs considered in the review paper (A12). The star data glyphs (4th, 5th and 6th glyph on the first row) were compared in our study (A11).

We also examined compact multi-dimensional visualizations, called *glyphs* (Fig. 5.6). Data glyphs encode a single data point by assigning its dimensions to one or more marks and their visual variables, and are meant to be seen in groups of small multiples. With collaborators from the University of Konstanz we conducted a literature survey (A12) and found that there are many gaps in our knowledge of how different glyphs fair against each other. We also conducted our own study of three variations of star-glyphs, some of the most common data glyphs (A11). Our results show that glyphs without contours make the detection of data similarity much easier.

For the exploration of multi-dimensional data with large numbers of dimensions, we have combined machine learning methods (interactive genetic algorithms) and a scatterplot visualization to help users

explore complex multi-dimensional data. In an ongoing collaboration with colleagues from INRA we have first introduced this system, called *EVE* (A36), that learns from the user's exploration in order to propose new views of the data. Understanding the utility, and more generally evaluating the effectiveness of such tools is challenging, as both the system and the user goals evolve over time. We propose a new methodology (A4, A105) that combines an analysis of the algorithmic behavior (A36) with an evaluation of the system under real use conditions (e.g., with expert users (A5)).

Visualization and decision making

Finally, we studied how visualizations can help or affect how people make decisions (Fig. 5.7). We first considered how to best support analysts present their work in the business domain, in order to help decision makers take action. Through a series of participatory design sessions we designed and developed a prototype for business intelligence analysts to move from their analysis visualization dashboard (collection of visualizations), to an environment where they can structure and present their analysis results to decision makers (A43).

When making decisions, people often use approximations and unconscious heuristic strategies or rules of thumb. Imperfections of these heuristics manifest themselves as cognitive biases. As part of another collaboration with the Inria AVIZ group we identified some of the biases that appear when making decisions using visualizations (A42). We were the first to prove that a known bias, called the *attraction effect* indeed exists in visualizations (A8, A152), confirming that information can be well visualized and understood, yet the decision based on this information can be irrational.

We also explored how to best study decision making tasks in visualization systems by proposing methodological guidelines (A143). Finally, we explored how the framing and instructions given when conducting decision making tasks can affect participants' accuracy (A41).

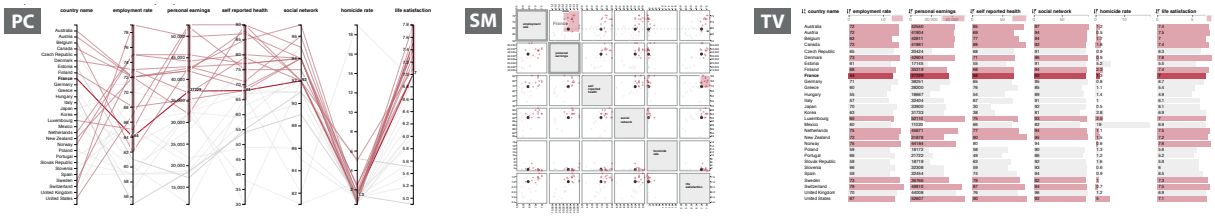

Figure 5.7: Three visualizations compared for both analytic and decision making tasks (A143).

Semantic-driven Data Exploration

Most efforts on user interfaces for the Web of data have focused on tools for software developers or subject-matter experts who create ontologies and populate them. Tools designed for end-users are starting to appear, including the so-called *linked data browsers*. However, most of these browsers are based on conventional point-and-click hypertext interfaces that present data to users in a very page-centric manner that is ill-suited to navigating and manipulating webs of data.

Members of HCC are working on interaction paradigms that let users navigate and manipulate data on the Web of data, where users directly interact with the data rather than with monolithic documents as on the classic Web of documents. The general research question is how to design novel interaction techniques that help users manipulate their data more efficiently (A7). This is a relatively new research area for the team, which is gaining momentum. Results in this area include a visualization technique called *OntoTrix* for visualizing instance data populating ontologies, an interactive visualization technique for comparing ontology alignments produced by different algorithms, and *LODAtlas*, an interface for discovering and monitoring open datasets in the Linked Open Data cloud.

OntoTrix (A3) enables users to visualize large instance sets and the relations that connect them. This visualization uses both node-link and adjacency matrix representations of graphs to visualize different parts of the data set depending on its semantics and local structural properties. The technique was originally devised for simple social network visualization. *OntoTrix* extends it to handle the richer and more complex graph structures of populated ontologies, exploiting ontological knowledge to drive the layout of the representation and navigate it in a smooth zoomable environment.

Alignment Cubes (A56) focus on the ontology level rather than the instance level. They are an extension of *Matrix Cubes*, used for visualizing dense dynamic networks. Ontology alignment is an area of active research where many algorithms and approaches are being developed. Their performance is

usually evaluated by comparing the produced alignments to a reference alignment in terms of precision, recall and F-measure. These measures, however, only provide an overall assessment of the quality of the alignments, but do not reveal differences and commonalities between alignments at a finer grain such as regions or individual mappings. Furthermore, reference alignments are often unavailable, which makes the comparative exploration of alignments at different levels of granularity even more important. Making such comparisons efficient calls for a so-called "human-in-the-loop" approach, best supported through interactive visual representations of alignments.

Empirical Studies of Users

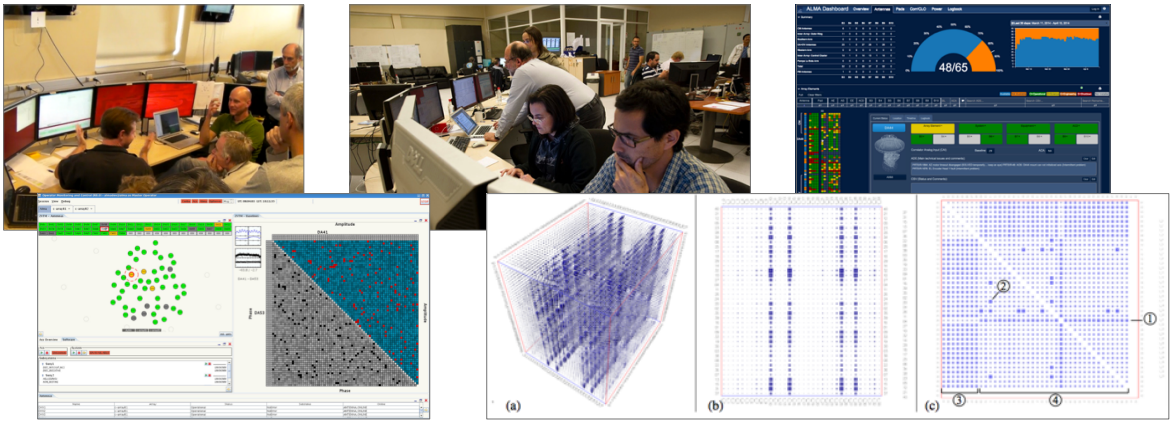

Figure 5.8: Design and testing of operations monitoring and control UIs with ALMA astronomers and engineers.

Creating effective interactive systems requires working closely with users, using a variety of empirical techniques. We observe and interview users to understand their work practices and specific needs, and often conduct participatory design sessions with them during the design process, to challenge and refine our ideas. Finally, we use a variety of quantitative and qualitative methods to evaluate our technology. Although we sometimes work with novice users, we are primarily interested in expert users who have more extreme needs, and push the limits of our designs. Finally, although we borrow many empirical research methods, we also create our own to address specific needs that arise with particular user groups.

Scientists

Astronomers and astrophysicists: Team members have been involved in multiple projects related to visualization for Astronomy. We have worked on the design and development of advanced user interfaces for operations monitoring and control of highly-advanced instruments, which include the ALMA radio-observatory (2019-2016), the Cherenkov Telescope Array (CTA) since 2016, and the Large Synoptic Survey Telescope (LSST) since 2017. We have also worked on the use of an ultra-high resolution wall-sized display for the interactive visual exploration of observation data, in collaboration with the Millenium Institute of Astrophysics in Chile and the Institut d'Astrophysique Spatiale at Université Paris-Sud.

The long-lasting collaboration with ALMA and the more recent one with CTA have led to multiple publications in both HCI and Astronomy venues (A132, A133). In both cases, the iterative design of novel visualization techniques has been informed by interviews and participatory design workshops with end-users, including astronomers and engineers in charge of operating the above-mentioned telescopes, followed by field deployments (several of the developed components are in actual use for operations). *FITS-OW* (A23), an application designed for ultra-high-resolution wall displays, was iteratively designed in tight collaboration with astronomers involved in the analysis of data from surveys about variable stars. The application enables astronomers to navigate large collections of FITS images (a high-dynamic range data exchange format used in Astronomy), query astronomical databases, and display detailed, complementary data and documents about multiple sources simultaneously.

Creative Professionals

Early interactive systems focused on increasing productivity, with an emphasis on creating tools that increase performance and reduce errors for well-defined tasks. We are interested in supporting the earlier, more creative phase of a design process, helping users explore and develop novel ideas. We have worked extensively with a diverse set of creative professionals, including composers, choreographers, artists and designers, to better understand their creative work practices and to provide flexible, interactive tools that enable them to generate and execute new ideas.

Professional designers: Our interviews and design workshops with artists and designers revealed how current color selection tools support only a tiny fraction of their needs. We created the *Color Portraits* design space and a series of interactive color tools, including *Color Partner*, *Palette Explorer*, *Color Compositor*, and *Color Revealer* (A57). We also studied how designers align and distribute graphical objects. In conjunction with the principles of *Instrumental Interaction*, we designed *StickyLines* (A39), which is over 40% faster than traditional alignment tools. Our studies of how designers create dynamic web layouts led to the concept of *graphical substrates*, illustrated with three prototypes: *Contexify* for tailoring layouts according to the reader's context, *Linkify* for creating dynamic layouts based on relationships among content properties, and *GraphStrates*, which reifies graphical substrates into fully interactive structures. We also studied and identified the key breakdowns that arise between designers and developers of mobile applications, with corresponding implications for design (A72). We ran an international workshop on supporting the creative design process (A40), and two Ph.D. theses explored how the principles of *co-adaptive systems, instrumental interaction* and *information substrates*, when combined with in-depth empirical observation and participatory design can lead to innovative design tools (A162, **?**).

Professional musicians: We conducted an extensive series of empirical studies of musicians and contemporary music composers, primarily at IRCAM, in Paris (A137, A32). We studied how audio professionals control 3D audio, based on a morphological analysis of audio objects (A70). We also created *SoundGuides*, which adapts continuous auditory feedback to users (A114). We developed a series of interactive paper composition tools for contemporary music composers: *PaperTonnetz* lets musicians explore and compose music with Tonnetz representations by making gestures on interactive paper (A117); *pOM* links the composer's pen gestures to computer-aided composition tools (A118); *Polyphony* offers a unified user interface that integrates interactive paper and electronic user interfaces for composing music, with fluid transitions between informal sketches and formal computer-based representations (A49). Finally, we worked with music composer Philippe LeRoux for 18 months, creating interactive paper technology to help him compose and conduct the work "Quid Sit Musicus", based on transforming the hand-written gestures from a 13th-century musical scores into novel musical forms.

Professional choreographers: We have been exploring movement with professional choreographers, including the problems of designing for "choreographer-technology" partnerships (A108), and how variability in practice affects learning motor and timing skills (A6). We conducted three studies of choreographers that revealed diverse strategies for recording choreographic fragments. These results, combined with our concept of *information substrates*, led to the design of *Knotation* (A38), a mobile pen-based tool that lets choreographers sketch their own representations of choreographic ideas and make them interactive. Subsequent studies showed how *Knotation* easily supported both dance-then-record and record-then-dance strategies. We also conducted several workshops (A110) and collaborated on a series of performance that explored the use of biosensors in artistic practice (A124).

General Public

We also occasionally work with non-expert users. We studied the challenges they face as they try to cope with changing technology and found significant barriers that made people reluctant to upgrade their software (A136). We explored the technical and social barriers that make it difficult for apps to conform to the COPPA (Children's Online Privacy Protection Act) rules, and the problems parents have in understanding, monitoring and granting access to their children's data (A122). We also studied how people use the increasing number of communication apps to define their own, personal "app ecosystem" and create communication places according to the complex dictates of the users' social networks (A76).

Theory and Methodology

The field of Human-Computer Interaction borrows theories and empirical methods from a variety of scientific, engineering and design disciplines, as well as creates its own to address particular needs. We both contribute and keep a critical eye on these theories and methods. In the context of concerns about p-hacking, we offered a tongue-in-cheek critique of how experimenters report p-values (A109). We also made recommendations to avoid misinterpreting the significance of the results of gesture elicitation studies (A18). On the other hand we contribute to soma-based design, i.e. movement-based designs and design practices specifically engaging with aesthetics (A21), and to strategies and best practices for designing, evaluating, and sharing technical HCI toolkits (A155). We have also introduced an approach called "designeering interaction" (A161), which links design and engineering principles.

In collaboration with Telecom ParisTech, we use Information Theory to both better analyze the performance of interactive tasks (A65) and create novel interfaces. In our Bayesian Information Gain (BIG)

approach (A64, A66), the system responds to user input by providing an output that maximizes the expected system information gain from the next user input. We have shown that this approach can lead to up to a 40% gain in performance, opening the way to new types of human-computer partnerships.

Building up on our previous work on instrumental interaction and co-adaptive systems, we are developing new concepts around the notions of *information substrates* and *human-computer partnerships* (A102). Information substrates make digital content more appropriable and are exemplified by work described in previous sections such as *Polyphony*'s paper substrates (A49), *Webstrates* (A121), graphical substrates (A71) or *StickyLines* (A39). Human-computer partnerships seek to shift from a "human-in-the-loop" approach, where the user is expected to improve the machine's algorithms, to a "computer-in-the-loop" one where the computer actively assists the users and expand their expressive and creative capabilities (A51). It is exemplified by our work on discoverability, appropriability and expressivity in gesture-based interfaces (A25, A69, A26), and the BIG framework (A64, A66) just described. Our long-term goal is to create unifying principles of interaction (A101) that inform the design of future interactive systems for both novice and extreme users in a variety of contexts of use.

Team Organisation

The HCC team is composed of two joint Inria-LRI project-teams, ExSitu and ILDA. Each group runs regular meetings and the two groups coordinate their actions with respect to administrative tasks, hiring new faculty and students, and applying to calls for projects. They also host invited seminars announced on the Paris local chapter of ACM SIGCHI, and participate in all aspects of the local scientific life of the site.

HCC manages three platforms of the Digiscope project: WILD and WILDER, described in the previous section, and FabLab Digiscope, a fabrication laboratory equipped with 3D printers, laser-cutters, a circuit-board plotter, a vinyl-cutter and many electronic devices, providing the necessary facilities to create new hardware for interaction devices. Fablab Digiscope abides to the official Fablab Charter and welcomes audiences from campus and beyond. All three platforms are heavily used for research projects as well as for demonstrations and visits, requiring proper engineering support and coordinated scheduling.

5/ HCC

Self Assessment

Strengths:

- HCC has high international visibility, and attracts students and visitiors from around the world.
- We have access to unique platforms (WILD, WILDER, FabLab) that allow us to conduct state-of-the-art research.
- We cover a wide spectrum of research in HCI, enabling fruitful cross-fertilization among the members of the group.

Weaknesses:

- HCI is still underdeveloped in France, particularly in industry. As a consequence, our links with industry are weak.
- We have fruitful, long-term collaborations with the Venise group at LIMSI as well as the VIA and information theory groups at Telecom, but there are other potential collaborations on the Paris-Saclay site that we should develop.
- The software we develop could have a wider impact, however this requires technical as well as management support that we do not have.

Opportunities:

- HCI is recognized as a key strength of research in computer science and information technology at Paris-Sud / Paris-Saclay. This puts us in a good position to further develop this area.
- The plan to join forces between LRI and LIMSI, as well as with the Inria team AVIZ (which is a spin-off of the earlier InSitu group), would create a cluster of 6 groups in HCI with about 35 faculty and close to 100 researchers, making it one of the largest HCI lab worldwide.

- The current push for AI creates new opportunities to combine HCI with AI in novel ways. We also believe that future AI systems will only be successful if they are designed with human users in mind, and therefore strong AI-HCI collaborations should be developed.

Threats:

- We do not have sufficient teaching faculty to support the teaching program in HCI that we would like to develop, and the existing programs already involve a large administrative overhead, in part due to their international reach.
- Finding good students, with proper HCI training, is difficult. Combined with the constraint that Ph.D. theses must be completed in three years, it sometimes makes it difficult to address cutting-edge research topics.
- Depending on high-end platforms to pursue our research consumes significant energy to ensure proper engineering support, as well as maintenance and renewal costs for the platforms so that they stay current and operational.

5/ HCC

Strategy and five-year project

Scientific outlook

Research in Human-Computer Interaction is becoming increasingly diverse and complex. On one hand, technological advances constantly shift the ground. For example, the advent of FabLabs (fabrication laboratories) and the ability to create hardware at low cost makes it possible to design not only interactive software but also interactive objects, networked through the "Internet of Things". On the other hand, the social impact of computer technology has never been so high, determined in large part by the interactive capabilities of modern computers but also the hidden capabilities enabled by cloud computing and AI techniques. New uses challenge researchers even more than new technology, requiring truly multidisciplinary approaches to understand how people adopt, adapt and adapt to technology.

The two groups that constitute HCC, ExSitu and ILDA, were created four years ago as a follow-up to the InSitu group that lasted for 12 years. Each group is addressing a rich set of topics, and we feel that much work is left to do in these areas. Our plan is therefore to pursue these topics to capitalize on our results, and to explore the corresponding research questions more deeply.

We will continue to explore advanced interaction techniques, especially in the context of interactive rooms and with more advanced uses of gesture-based and embodied techniques. We will also continue to study and develop advanced visualization techniques that take advantage of large displays, as well as collaborative and telepresence technologies to support group work in both co-located and remote settings, especially for heterogeneous settings. Finally we will keep developing dedicated applications to understand and address the needs of specific user groups, as well as generic tools and toolkits, based on strong theoretical concepts, to facilitate the creation of such applications.

In terms of more specific topics, the focus on extreme users, creativity and human-computer partnerships has proven fruitful for the ExSitu group, and we will continue to explore interaction through these approaches while developing appropriate methodology. Similarly, the focus of ILDA group members on visual exploration techniques for highly-distributed, interlinked, hetorogeneous data such as found on the Web of Data is starting to gain momentum. The group is only at the beginning of its investigations in this direction.

Strategy

We plan to join forces with three of LIMSI's research group (AMI – Architecture and Models for Interaction; CPU – Cognition, Perception, Usage; and Venise – Virtual and Augmented Environments) as well as Inria's AVIZ group (Visualization Analytics) and create a large center for research in HCI at Université Paris-Saclay, with close to 35 faculty and 100 researchers.

At the time of this writing, the process and timing for this merge is still under discussion, making it difficult to outline a strategy for the next five years. Our expectation is that the resulting merge will foster collaborations, increase visibility, and help develop new multidisciplinary projects.

Annex 4

Collaborations

Participation to national and international collaborative research projects

International projects

- VCoRE - *Next-Generation Visual Computing Platform*, Inria (2011-2014), Coordinator for HCC: Stéphane Huot. Partners: Inria (Grenoble, Lille, Rennes, Saclay, Sophia Antipolis), IGD Fraunhofer Institute
- Massive Data team at Inria Chile / CIRIC. Funded by Inria (2012-). Emmanuel Pietriga is the scientific leader of team, working on projects in collaboration with the ALMA radio-telescope and the Millenium Institute of Astrophysics.
- MIDWAY - *Musical Interaction Design Workbench And technologY*, Inria Associate Team (2014-2016), Coordinator for HCC: Stéphane Huot. Partners: Inria and McGill University (Canada).
- DECibel - *Discover, Express, Create – Interaction Technologies For Creative Collaboration*, Inria Associate Team (2016-), Coordinator for HCC: Wendy Mackay. Partners: Inria and University of California Berkeley (United States).
- Air Quality Monitoring in Korean Metropolises on Ultra-high-resolution Wall Displays. Transfer project funded by the Korea Institute of Science and Technology Information (KISTI). 2017. Emmanuel Pietriga (PI), Olivier Chapuis.

National projects

- DigiPods - *Remote Collaborative Interaction Among Heterogeneous Visualization Platforms*, Région Île-de-France (2012-2015). Coordinator: Stéphane Huot. Partners: Digiteo/Univ. Paris-Saclay, Univ. Paris-Sud, Inria, CNRS, CEA, Telecom ParisTech
- DRAO - *Interactive Graphics Tools to Support Sketching*, ANR (2012-2015). Coordinator: Adrien Bousseau (Inria Sophia). Partners: HCC, Inria-Sophia, Inria-Bordeaux. Participants: Theophanis Tsandilas and Wendy Mackay.
- MapMuxing - *Multi-dimensional Map Multiplexing*, ANR (2014-2018). Collaboration with IGN (Institut National de l'Information Géographique et Forestière): 208Keuros/499Keuros. Participants: Emmanuel Pietriga (PI), Caroline Appert, Olivier Chapuis, María-Jesús Lobo. **http://mapmuxing.ign.fr**
- CorTextViz - *Interactive visualization of medium-scale multi-level networks, supporting data storytelling on wall displays*. (2015-2016) Funded by INRA (Institut National de la Recherche Agronomique) (2015-2016). In collaboration with project-team Aviz at Inria Saclay (Jean-Daniel Fekete) and INRA (Jean-Philippe Cointet, Guy Riba). Participants: Emmanuel Pietriga (PI), André Spritzer.
- data.bnf.fr - *Exploratory visualization of linked data for the Bibliothèque nationale de France*, (2018). Funded by Ministère de la Culture / BnF. Participants: Emmanuel Pietriga (PI), Caroline Appert, Hande Gözükan, Marie Destandau.
- iCoda - *Knowledge-mediated Content and Data Analytics*, (2017). Inria Project Lab. Participants: Anastasia Bezerianos, Emmanuel Pietriga.

RTRA Digiteo / Labex Digicosme projects (funding for joint Ph.D. students):

- DigiZoom (2013-2016) – *Multi-scale navigation: from mobile devices to collaborative wall-sized displays*. Funded by Digicosme. In collaboration with Telecom ParisTech (E. Lecolinet). Participants: Olivier Chapuis, Michel Beaudouin-Lafon, Can Liu (Ph.D. student).
- MultiVis (2014-2015) – *Novel Interaction Models for Multi-surface Visualization*. Funded by Digiteo. In collaboration with Telecom ParisTech (J. Eagan). Participants: Michel Beaudouin-Lafon, Marc-Emmanuel Perrin (Ph.D. student).
- ScaleGest (2014-2017) – *Surface Gestures for Advanced Graphical Interfaces: Which Gesture for What*. Funded by Digiteo. In collaboration with Telecom ParisTech (G. Bailly). Participants: Caroline Appert (PI), Rafael Morales Gonzalez (Ph.D. student), Emmanuel Pietriga.
- DeciVis (2014-2017) – *Information Visualization for Decision Making - Identifying Biases & Moving Beyond the Visual Analysis Paradigm*. Funded by Digiteo. In collaboration with Inria AVIZ (P. Dragicevic). Participants: Anastasia Bezerianos, Evanthia Dimara (Ph.D. student).
- MemSpace (2015-2018) – *Interaction Techniques that Use the Spatial Memory to Facilitate Fast Access to Commands and Data*. In collaboration with Institut Mines-Telecom (E. Lecolinet). Participants: Olivier Chapuis, Bruno Fruchard (Ph.D. student).
- MoveIT (2015-2018) – *Modeling the Speed/Accuracy Trade-Off of Human Aimed Movement with the Tools of Information Theory*. In collaboration with Institut Mines Telecom (Olivier Rioul). Participants: Michel Beaudouin-Lafon, Wanyu Liu (Ph.D. student).
- SensoMotorCVE (2014-2017) – *Sensor-motor Interface for Collaborative Virtual Environments with Heterogeneous Devices: Application to Industrial Design*. In collaboration with LIMSI-CNRS (Patrick Bourdot). Participants: Cédric Fleury, Yujiro Okuya (Ph.D. student).

Collaborations with other laboratories leading to joint publications

- Université of British Columbia, Canada: Joanna McGrenere spent a sabbatical year in the group in 2015-2016, leading to several joint publications (A136, A69, A66) and to an Inria international chair.
- University of Aarhus, Denmark: Clemens Klokmose on Webstrates (A121), which received a best paper award at ACM UIST'15. Participants: Michel Beaudouin-Lafon and Wendy Mackay.
- Google, Mountain View, USA: Shumin Zhai and Stony Brook University, New York, USA: Xiaojun Bi on "expressive keyboards" (A25). Participants: Jessalyn Alvina, Carla Griggio, Wendy Mackay.
- Inria Sophia Antipolis: George Drettakis on the study of object manipulation in VR environments (A107). Participants: Theophanis Tsandilas, Lora Oehlberg, and Wendy Mackay, 2015
- Ircam: Carlos Agon and Jean Bresson on interactive paper for music composition. Co-supervision of the PhD thesis of Jérémie Garcia (2011 - 2014), leading to several joint publications (A49, A117, A118, A98). Participants: Jérémie Garcia, Theophanis Tsandilas, and Wendy Mackay
- Linköpings universitet, Sweden, on the interactive, comparative visualization of ontology alignment algorithms (A56). Participant: Emmanuel Pietriga.

International collaborations

- Japan Advanced Institute of Science and Technology (JAIST): René Vestergaard on the interactive visualization of complex networks in molecular biology.
- University of Konstanz: Daniel Keim and Johannes Fuchs on mapping out the design space for visualization glyphs (A12, A11). Participant: Anastasia Bezerianos.
- Microsoft Research: Bongshin Lee on perceptual studies on smartwatches (under submission). Participant: Anastasia Bezerianos.
- Northwestern University: Steven Franconeri on identifying biases in decision making (under submission). Participant: Anastasia Bezerianos.
- University of Monash: Tim Dwyer and Maxime Cordeil on immersive visual analytics (under submission). Participants: Anastasia Bezerianos, Olivier Chapuis.
- Universidad Carlos III de Madrid: Teresa Onorati and Paloma Diaz on the visualization of tweet feeds related to crisis events using a wall display, so as to help crisis monitoring and management. Participants: Anastasia Bezerianos, Emmanuel Pietriga.
- Goldsmith's college in London, U.K.: Marco Gilles, Rebbecca Fiebrink and Atau Tanaka on Human-Centered Machine Learning. We ran a workshop together in 2016. Participants: Michel Beaudouin-Lafon and Wendy Mackay.
- European Southern Observatory (ESO): ALMA Operations Monitoring and Control - design and implementation of state-of-the-art interactive visualization components for the operations monitoring and control software that runs the ALMA radio-observatory in Chile. Participant: Emmanuel Pietriga.
- Deutsches Elektronen-Synchrotron (DESY): Scientific collaboration on the design and implementation of user interfaces for array operations monitoring and control for the Cherenkov Telescope Array (CTA) project (A132), to be built in the Canary Islands (Spain) and in the Atacama desert (Chile). Participant: Emmanuel Pietriga.
- Large Synoptic Survey Telescope (LSST): Design and development of all user interfaces for operations monitoring and control of this new instrument, currently under construction in Chile. Participant: Emmanuel Pietriga.

National collaborations

- Université Paris Descartes: Themis Palpanas on designing interactive visualization tools for large collections of data series. Co-supervision of the Ph.D. thesis of Anna Gogolou (2016-2019). Participants: Anastasia Bezerianos and Theophanis Tsandilas.
- INRA GMPA: Nadia Boukhelifa and Evelyne Lutton on combined automatic learning methods (interactive genetic algorithms) and visualizations to help analysts explore their data (A36, A4, A105, A5). Participant: Anastasia Bezerianos.

Visiting professors and students (more than one week)

- Joanna McGrenere, Professor at University of British Columbia, Canada (August 2014, sabbatical from July 2015 to June 2016, Inria international chair in June-July 2017 and June-July 2018).
- Steve Feiner, Professor of Computer Science, head of the Computer Graphics and User Interfaces Lab at Columbia University, USA (March 2015).
- Deb Agarwal and David Brown, Senior scientists at LBNL, University of California at Berkeley, USA (June 2015).
- Ana Bernardos, Professor at Universidad Politécnica de Madrid, Spain (September to December 2015).
- Jim Hollan, Professor at University of California at San Diego, USA (April to June, 2016).
- Clemens Klokmose, Assistant Professor at Aarhus University, Denmark (April, 2016).
- Susanne Bødker, Professor at Aarhus University, Denmark (April, 2017).
- Jingyi Li, Master student with Prof. Bjoern Hartmann, University of California, Berkeley, USA (July 2017).
- Jiannan Li, PhD student of Prof. Ravin Balakrishnan at University of Toronto, Canada (June-October 2018).
- Alexander Eiselmayer, M2 student with Chat Wacharamanotham at the University of Zurich, Switzerland (July 2017, September 2017, February 2018).

Group seminar

The group runs a seminar with invited speakers, whose talks are announced on the SIGCHI Paris Local Chapter mailing list (**http://paris.sigchi.acm.org**). Together with the Inria AVIZ group, we invited 32 speakers over the period: Steve Haroz, Raimund Dachselt, Antti Oulasvirta, Margit Pohl, Catherine Plaisant, Pierre Tchounikine, Susanne Bødker, Jules Françoise, Fabrice Matulic, Sean Follmer, Christopher Collins, Uta Hinrichs, Arvind Satyanarayan, Barry Brown, Brygg Ullmer, Daniel Wigdor, Steven Feiner, Joanna McGrenere, François Osiurak, Jeremy Carpendale, Melanie Tory, Shumin Zhai, Chat Wacharamanotham, Stéphane Ducasse, Sylvain Malacria, Michael Gleicher, Wesley Willett, Geoff Cumming, Ted Selker, Karon MacLean, Hélène Gauchou, George Drettakis.

Participation to national and international networks

- "Equipement d'Excellence" Digiscope - *Collaborative Interaction with Complex Data and Computation*, Coordinator: Michel Beaudouin-Lafon. Partners: Digiteo/FCS Campus Paris-Saclay, Univ. Paris-Sud, CNRS, CEA, Inria, Telecom ParisTech, CentraleSupelec, Univ. Versailles-Saint-Quentin, ENS Paris-Saclay, Maison de la Simulation.
- "Laboratoire d'Excellence" Digicosme - *Distributed data, programs and architectures*, Coordinator for the Interaction and Visualization task of the DataSense theme: Michel Beaudouin-Lafon. Members of this task: HCC, Inria AVIZ, LIMSI-CNRS, Telecom ParisTech VIA, CEA LIST.

Volunteer Professional Service

Management Positions in Scientific Organisations

- Université Paris-Saclay, *Conseil Académique*: Emmanuel Pietriga, member (2015-2017)
- Université Paris-Saclay, *Direction de la recherche*: Michel Beaudouin-Lafon, advisor for digital science, "Chargé de mission pour le numérique" (2018-)
- Université Paris-Saclay, *Département STIC*: Michel Beaudouin-Lafon, chair (2018-), Wendy Mackay, member (2016-)
- Université Paris-Saclay, *Ecole Doctorale STIC*: Michel Beaudouin-Lafon (2013-2018) and Caroline Appert (2018-), deputy directory for theme 3 (Data, Knowledge, Learning and Interaction)
- Laboratoire de Recherche en Informatique: Olivier Chapuis, deputy director (2017-)
- Laboratoire de Recherche en Informatique, *Conseil de Laboratoire*: Wendy Mackay and Cédric Fleury, members (2015-)
- Laboratoire de Recherche en Informatique, *Conseil Scientifique*: Michel Beaudouin-Lafon, member (2015-)
- Laboratoire de Recherche en Informatique, *Space allocation comittee*: Caroline Appert, President (2010-)
- Laboratoire de Recherche en Informatique, *Commission Matériel*: Anastasia Bezerianos, member (2012-)
- Inria Saclay: Emmanuel Pietriga, member of Bureau du Comité des Projets (2016-)
- Inria Saclay, *Commission Scientifique*: Theophanis Tsandilas, member (2017-)
- Inria Saclay, *Commission for Technological Development*: Emmanuel Pietriga, President (2015-), Theophanis Tsandilas, member (2012-2016)
- Université Paris-Sud, *Computer Science department*: Michel Beaudouin-Lafon, vice-president for research (2018-)
- Université Paris-Sud, *Computer Science department, CCSU, "Commission Consultative de Spécialistes de l'Université"*: Caroline Appert, Michel Beaudouin-Lafon and Wendy Mackay, members (2015-)

Organisation of Conferences and Scientific Events

- CHI 2013, *ACM Conference on Human Factors in Computing Systems*, Paris, 2013: Wendy Mackay (General Chair), Michel Beaudouin-Lafon (Technical Program Co-Chair)
- ECRC 2013, *First ACM European Computer Research Congress*, Paris, 2013: Michel Beaudouin-Lafon (Organizing Committee member)
- IHM 2013, *Conférence Francophone d'Interaction Homme-Machine*: Stéphane Huot (Program co-chair)
- UIST 2014, *ACM Symposium on User Interface Software and Technology*, Hawaii, 2014: Stéphane Huot (Video Previews co-chair)
- Paper Electronics Workshop, February 2015: Wendy Mackay (organizer)
- MIDWAY Workshop, May 2015: Michel Beaudouin-Lafon, Wendy Mackay, Joe Malloch (co-organizers)
- MOCO 2015, *International Workshop on Movement and Computing*: Sarah Fdili Alaoui (organizing committee)
- C&C, *ACM Conference on Creativity and Cognition*, 2015, Workshop on *Supporting Creative Design Processes in Blended Interaction Spaces*: Wendy Mackay (organizing committee)
- IHM 2016, *Conférence Francophone d'Interaction Homme-Machine*: Michel Beaudouin-Lafon (Doctoral Consortium co-chair), Wendy Mackay (jury member)
- NIME 2016, *New Interfaces for Musical Expression*: Joseph Malloch (Workshops chair)
- ACM CHI 2016, *Workshop on Music and HCI* at the ACM Conference on Human Factors in Computing Systems: Wendy Mackay, Joseph Malloch (co-organizers)

- ACM CHI 2016, *Workshop on Human-Centered Machine Learning* at the ACM Conference on Human Factors in Computing Systems: Wendy Mackay (co-organizer)
- ERC *CREATIV* Workshop: Wendy Mackay (organizer)
- MOCO 2016, *International Symposium on Movement and Computing*: Sarah Fdili Alaoui (Steering Committee member)
- ACM CHI 2017, *ACM Conference on Human Factors in Computing Systems*: Theophanis Tsandilas (Late-Breaking Work co-chair)
- ACM CHI 2017 & 2018, *ACM Conference on Human Factors in Computing Systems*: Carla Griggio (Video-Previews chair)
- IEEE VIS 2017, *IEEE Conference on Visualization*: Anastasia Bezerianos (Community co-chair)
- ACM CHI 2018, *ACM Conference on Human Factors in Computing Systems*: Ignacio Avellino (Web co-chair)
- EICS 2018, *10th ACM SIGCHI Symposium on Engineering Interactive Computing Systems*: Emmanuel Pietriga (General co-chair), Caroline Appert (Doctoral Consortium co-chair)
- ACM ISMIR 2018, *19th International Society for Music Information Retreival Conference*: Wendy Mackay (Interactive Machine-Learning for Music Exhibition co-chair)

Working Group

- Alliance des Sciences et Technologies du Numérique (ALLISTENE), Working group "Knowledge, Content and Interaction": Wendy Mackay and Michel Beaudouin-Lafon, Members (2013-2014)
- Alliance des Sciences et Technologies du Numérique (ALLISTENE), Working group "Interactions des mondes physiques, de l'humain et du monde numérique" for the National Research Strategy agenda: Michel Beaudouin-Lafon, Co-chair (2013-2014)
- Working Group of the future Computer Science Department of Université Paris-Saclay: Michel Beaudouin-Lafon, member (2014)
- AFIHM Working Group on Ethics: Wendy Mackay, chair (2015)
- Systematic competitivity cluster, Working group on Information Systems: Michel Beaudouin-Lafon, member of steering committee (2017-)

Participation to editorial committees

- ACM New Publications Board, ACM: Wendy Mackay (2015-)
- IJHCS, *International Journal of Human-Computer Study*, Elsevier: Michel Beaudouin-Lafon (Member of the Advisory Board, 2009-)
- JCSCW, *Journal of Computer Supported Cooperative Work*, Springer: Michel Beaudouin-Lafon (Member of the Advisory Board, 2010-)

Honors

Awards

Grants and honors

- Wendy Mackay: *ERC Advanced Grant* "CREATIV: Creating Human Computer Partnerships", started on June 1, 2013
- Wendy Mackay: *ACM SIGCHI Lifetime Service Award* (2014), which "goes to individuals who have contributed to the growth and success of SIGCHI in a variety of capacities. This award is for extended services to the community at large over a number of years" (**http://www.sigchi.org/about/awards/2015-sigchi-awards**)
- Michel Beaudouin-Lafon: *ACM SIGCHI Lifetime Service Award* (2015)
- Michel Beaudouin-Lafon: *ERC Advanced Grant* "ONE – Unified Principles of Interaction", started on October 1, 2016
- Wendy Mackay: *Doctor Honoris Causa*, Aarhus University (Denmark), September 2017

Best paper awards

HCC members received 5 Best paper and 6 Honorable mention awards at top conferences in the field (CHI, UIST, InfoVis, INTERACT, VRST):

- Anastasia Bezerianos: *Best paper award (Brian Shackel Award) at INTERACT 2013* for "Storytelling in Visual Analytics Tools for Business Intelligence" (A43)
- Cyprien Pindat, Emmanuel Pietriga, Olivier Chapuis, and Claude Puech: *Best paper award at VRST 2013* for "Drilling into Complex 3D Models with Gimlenses" (A81)
- Can Liu, Olivier Chapuis, Michel Beaudouin-Lafon, Eric Lecolinet, and Wendy E. Mackay: *"Best of CHI" paper award at ACM CHI 2014* for "Effects of display size and navigation type on a classification task" (A63)
- Lobo María-Jesús, Pietriga Emmanuel, Appert Caroline: *Honorable mention award at ACM CHI 2015* for "Evaluation of Interactive Map Comparison Techniques" (A67)
- Ghita Jalal, Nolwenn Maudet, and Wendy E. Mackay: *Honorable mention award at ACM CHI 2015* for "Color Portraits:

From Color Picking to Interacting with Color" (A57)

- Theophanis Tsandilas, Anastasia Bezerianos, and Thibaut Jacob: *Honorable Mention award at ACM CHI 2015* for "SketchSliders: Sketching Widgets for Visual Exploration on Wall Displays" (A92)
- Clemens Klokmose, James Eagan, Simon Baader, Michel Beaudouin-Lafon and Wendy E. Mackay: *Best paper award at UIST 2015* for "Webstrates: Shareable Dynamic Media" (A59)
- Morales Gonzalez Rafael, Appert Caroline, Bailly Gilles, Pietriga Emmanuel: *Honorable Mention Award at ACM CHI 2016* for "TouchTokens: Guiding Touch Patterns with Passive Tokens" (A74)
- Dimara Evanthia, Bezerianos Anastasia, Dragicevic Pierre: *Honorable Mention Award at IEEE InfoVis 2016* for "The Attraction Effect in Information Visualization" (A8)
- Wanyu Liu, Rafael Lucas D'Oliveira, Michel Beaudouin-Lafon, Olivier Rioul: *"Best of CHI" paper award at ACM CHI 2017* for "BIGnav: Bayesian Information Gain for Guiding Multiscale Navigation" (A64)
- Wanyu Liu, Olivier Rioul, Joanna McGrenere, Wendy E. Mackay, Michel Beaudouin-Lafon: *Honorable Mention award at ACM CHI 2018* for "BIGFile: Bayesian Information Gain for Fast File Retrieval" (A66)

Ph.D. students Prizes

- Benjamin Bach: *Honourable mention at the IEEE VGTC VPG Doctoral Dissertation Competition* (2014), supervised by Jean-Daniel Fekete and Emmanuel Pietriga
- Jérémie Garcia: *"Prix Jeune Chercheur Science et Musique"* (2015), a best thesis award organized by IRISA (Rennes) and sponsored by the Association Française d'Informatique Musicale for his thesis *"Le papier interactif pour la composition musicale"*, supervised by Wendy Mackay, Theophanis Tsandilas and Carlos Agon (IRCAM)
- Nolwenn Maudet: *"Prix Spécial du Jury du premier concours EDUCNUM Opération Vie privée"* (2015), organized by CNIL (national commission for informatics and freedom), for her project *Data Fiction* with Thomas Thibault. This online game is designed to help teenagers better understand how their personal data can be exposed online and how to protect it
- Wanyu Liu: *"1er Prix Doctorants ED STIC"* of Université Paris-Saclay, November 2017, for "BIGNav: Information Theory meets Human-Computer Interaction"

Keynote Addresses and invited talks

International

- Keynote address at ACM/TEI'15 (Tangible, Embedded and Embodied Interaction), "*Interactive Paper: Tangible Computing from the Digital Desk to Music Composition*", 19 January 2015: Wendy Mackay
- Keynote address at LTM21C (Learning and Teaching Music in the Twenty-First Century: The Contribution of Science and Technology), "*Supporting Creative Expression with Co-Adaptive Human-Computer Partnerships*", 5 November 2015: Wendy Mackay
- Keynote address at Paper Electronics Workshop, "*Interactive Paper: A Whirlwind Tour of Tangible Computing from the Digital Desk to Music Composition*", 20 February 2015: Wendy Mackay
- ERC Comics Invited Address at ICCC International Conference on Computational Creativity 2016, "*Creating CoAdaptive partnerships*", 29 June 2016: Wendy Mackay
- Opening Keynote, 12th Biannual Conference of the Italian SIGCHI Chapter (CHItaly 17), "*Towards Unified Principles of Interaction*", 19 September 2017: Michel Beaudouin-Lafon
- Keynote address at Asia Data Week 2017, "*Monitoring Air Quality in Korea's Metropolises on Ultra-High Resolution Wall-Sized Displays*", November 2017, Jeju, South Korea: Emmanuel Pietriga and Olivier Chapuis

HCC members also gave also about 30 invited seminars or talks at international venues and foreign laboratories (such as MIT, University of British Columbia, University of Munich, Dagstuhl seminars, etc.)

France

- Journée d'étude Scénariser la danse par le numérique, "*Étude du mouvement expressif dans les interactions incorporée pour la danse*", 18 May 2016, Université de Strasbourg: Sarah Fdili Alaoui
- CNRS Innovatives Big Data Forum, "*L'équipement d'excellence Digiscope: un réseau de plateformes pour la visualisation interactive*", October 2016, Paris: Olivier Chapuis
- TEDx Saclay, "*Dancing in digital*", 30 November 2016: Sarah Fdili Alaoui
- Rencontres Jeunes Cherchers en Interaction Homme-Machine, "*Ethics and Experimental Protocols*", 4 July 2017: Wendy Mackay
- SIFED 2018 : Symposium International Francophone sur l'Ecrit et le Document, "*Interactions à base d'esquisses sur papier et ordinateur*", session invitée, 31 mai et 1er Juin 2018, Tours, France: Theophanis Tsandilas

HCC members also gave 60 invited seminars or talks at French venues and laboratories.

Evaluation of Research

Editorial Boards

- TOCHI, Transactions on Computer Human Interaction, ACM: Michel Beaudouin-Lafon (2009-), Wendy Mackay (2016-), Caroline Appert (2017-)
- CACM, Communications of the ACM Web Editorial Board, ACM: Wendy Mackay (2008-)
- ACM Books Series, Editor for the Human-Computer Interaction area: Michel Beaudouin-Lafon (2013-)
- SWJ, Semantic Web Journal: Emmanuel Pietriga 2015-2016 (guest editor, special issue on Visual Exploration and Analysis of Linked Data)
- JIPS, Journal d'Interaction Personne-Système, AFIHM: Michel Beaudouin-Lafon (2009-)

Program Committees

HCC members chaired 4 program committees and participated in 67 program committees of international conferences and 6 national ones:

Chair

- CHI, ACM SIGCHI Conference on Human Factors in Computing Systems: Caroline Appert (Subcommittee chair, 2015, 2016; Papers and notes co-chair, 2017), Emmanuel Pietriga (Subcommittee chair, 2017, 2018)
- IHM, *Conférence Francophone d'Interaction Homme-Machine*: Olivier Chapuis (Papers co-chair, 2014)

Member (international events)

- CHI, *ACM Conference on Human Factors in Computing*: Caroline Appert (2013), Michel Beaudouin-Lafon (2016, 2017, 2018), Anastasia Bezerianos (2015, 2016, 2017, 2018), Stéphane Huot (2013), Wendy Mackay (2015, 2016, 2017, 2018), Emmanuel Pietriga (2013, 2015, 2016), Theophanis Tsandilas (2015, 2018),
- UIST, *ACM Symposium on User Interface Software and Technology*: Caroline Appert (2013, 2016), Michel Beaudouin-Lafon (2017, 2018), Anastasia Bezerianos (2016, 2017), Wendy Mackay (2016, 2017, 2018)
- InfoVis, *IEEE Information Visualization Conference*: Anastasia Bezerianos (2015, 2016, 2017)
- PacificVis, *IEEE Pacific Visualization Symposium*: Anastasia Bezerianos (2013)
- IEEE VR, *Virtual Reality Conference*: Cédric Fleury (2016)
- GI, *Graphics Interface Conference*: Cédric Fleury (2016)
- Mobile HCI, *ACM SIGCHI International Conference on Human-Computer Interaction with Mobile Devices and Services*: Caroline Appert (2015)
- DIS, *ACM conference on Designing Interactive Systems*: Wendy Mackay (2014)
- IUI, *ACM IUI Conference on Intelligent User Interfaces*: Wendy Mackay (2018)
- C&C, *ACM Conference on Creativity and Cognition*: Andrew Webb (2017)
- INTERACT, *IFIP TC13 Conference in Human-Computer Interaction*: Caroline Appert (2013), Olivier Chapuis (2013), Stéphane Huot (2013)
- EICS, *ACM SIGCHI Symposium on Engineering Interactive Computing Systems*: Emmanuel Pietriga (2016, 2017, 2018)
- Eurographics, *Annual Conference of the European Association for Computer Graphics*: Theophanis Tsandilas (2013)
- NIME, *New interfaces for Musical Expression*: Sarah Fdili Alaoui (2015), Stéphane Huot (2014), Theophanis Tsandilas (2014, 2015)
- MOCO, *International Workshop on Movement and Computing*: Sarah Fdili Alaoui (2015, 2016), Michel Beaudouin-Lafon (2014, 2015)
- VL/HCC, *IEEE Symposium on Visual Languages and Human-Centric Computing*: Emmanuel Pietriga (2015)
- WWW, *Web Conference*, research track Web Content Analysis, Semantics, and Knowledge: Emmanuel Pietriga (2018)
- ISWC, *International Semantic Web Conference*: Emmanuel Pietriga (2017, 2018)
- DI, *International Conference Digital Intelligence*: Michel Beaudouin-Lafon (2014)
- GD, *International Symposium on Graph Drawing*: Anastasia Bezerianos (2014)
- GRAPP, *International Conference on Computer Graphics Theory and Applications*: Cédric Fleury (2014, 2015, 2016)
- 3DCVE, *IEEE VR Workshop on Collaborative Virtual Environments*: Cédric Fleury (2015, 2016)
- EuroVR, *European Virtual Reality Conference*: Cédric Fleury (2017)
- DocEng, *ACM SIGWEB International Symposium on Document Engineering*: Emmanuel Pietriga (2015)
- MobiSys, *Future Mobile User Interfaces workshop*, ACM SIGCHI International Conference on Mobile Systems, Applications, and Services: Caroline Appert (2015)
- SSDBM, *International Conference on Scientific and Statistical Database Management*: Emmanuel Pietriga (2016)

Member (national events)

- IHM, *Conférence Francophone d'Interaction Homme-Machine*: Olivier Chapuis (2013, 2015, 2016), Theophanis Tsandilas (2014, 2015), Michel Beaudouin-Lafon (2018)

Evaluation Committees and Invited Expertise

International

- European Research Council (ERC), Avanced Grants panel PE6: Michel Beaudouin-Lafon, external expert (2015)
- European Research Council (ERC), Starting Grants panel PE6: Michel Beaudouin-Lafon, panel member (2016, 2017)
- H2020, Future and Emerging Technologies Open Scheme RIA: Emmanuel Pietriga, evaluator (2015)
- H2020, Leadership in Enabling and Industrial Technologies - Space RIA: Emmanuel Pietriga (2017)
- FWF, Austrian Science Fund: Wendy Mackay, external expert (2015)
- Sapere Aude Starting Grant, Danish Council for Independent Research, International Advisory Board: Wendy Mackay, external expert (2015)
- ACM Nominating committee : Michel Beaudouin-Lafon, member (2015)
- ACM/CHI Best Paper Award Committee: Wendy Mackay and Emmanuel Pietriga, members (2016)
- ACM SIGCHI "Lifetime Service Award" committee: Wendy Mackay (2016), Michel Beaudouin-Lafon (2017), members
- ACM "Policy Award" committee: Michel Beaudouin-Lafon, member (2017)
- ERC Generator program, Univ. Lille: Michel Beaudouin-Lafon, expert (2018)

National

- AERES Evaluation Committee of Laboratoire d'Informatique de Grenoble (LIG): Michel Beaudouin-Lafon, President (2014)
- Agence Nationale de la Recherche (ANR)
  - CES "Contenus, connaissances, interactions": Caroline Appert, Evaluation Committee member (2014, 2015)
  - CES "Interaction, Robotique": Caroline Appert, vice-chair (2017)
  - "Contenus et Interactions" program: Michel Beaudouin-Lafon, steering committee member (2013)
  - "Projets génériques": Emmanuel Pietriga, referee (2015), Theophanis Tsandilas, Cédric Fleury, reviewers (2015)
  - "Blanc" program: Caroline Appert and Theophanis Tsandilas, reviewers (2013, 2014)
  - "Blanc International" and "Jeunes Chercheuses Jeunes Chercheurs" programs: Caroline Appert, reviewer (2013)
  - "Jeunes Chercheuses et Jeunes Chercheurs": Theophanis Tsandilas, reviewer (2018)
- CNRS Mission pour l'Interdisciplinarité, "Sciences Sociales et Cognitives des Comportements Collectifs": Michel Beaudouin-Lafon, panel member (2015-)
- CNRS INS2I, "Cellule ERC": Michel Beaudouin-Lafon, member (2017)
- Sponsored Program for Industrial Data Science (EDF & Thales) - Fondation Mathématique Jacques Hadamard/IRSDI: Emmanuel Pietriga, evaluator (2016)

Other evaluation activities

HCC members participated in 25 academic hiring and promotion committees, 7 Habilitation committees, and 42 Ph.D. committees (other than HCC graduates):

Hiring committees

- Directeur de Recherche positions, IRCAM, Paris: Michel Beaudouin-Lafon, member (2018)
- Professor position, Univ. Paris-Sud: Michel Beaudouin-Lafon (2014), Wendy Mackay (2015, 2017), members
- Professor position, Univ. Bordeaux: Michel Beaudouin-Lafon, member (2016), president (2018)
- Assistant Professor position, Univ. Paris-Sud: Caroline Appert (2014, 2015, 2016, 2017), Michel Beaudouin-Lafon (2013, 2015, 2017), Anastasia Bezerianos (2015), Stéphane Huot (2013, 2014), Wendy Mackay (2013, 2014), Emmanuel Pietriga (2018), members
- Junior Researcher (*Chargé de Recherche*), Inria Saclay: Wendy Mackay, member (2017)
- Assistant Professor position, Univ. Nantes: Wendy Mackay, member (2016)
- PRCE/PRAG English Professor, Univ. Paris-Sud: Anastasia Bezerianos, member (2016)
- Professor promotion, Télécom ParisTech: Wendy Mackay, member (2018)
- Professor promotion, Ludwig-Maximilians-Universität (LMU): Wendy Mackay, member (2016)
- Inria Senior PES (bonus for scientific excellence) committee: Wendy Mackay, member (2014)

Habilitation committees

- Olivier Beaudoux (ESEO, Angers): Michel Beaudouin-Lafon, examiner (2014)
- Christophe Hurter (ENAC, Toulouse): Michel Beaudouin-Lafon, president (2014)
- Frédéric Bevilacqua (IRCAM, Paris): Michel Beaudouin-Lafon, reviewer (2014)
- Caroline Appert (LRI, Orsay): Michel Beaudouin-Lafon, examiner (2017)
- Gilles Bailly (ISIR, Paris): Michel Beaudouin-Lafon, examiner (2017)
- Jean-Julien Aucouturier (IRCAM, Paris): Michel Beaudouin-Lafon, president (2017)
- Guillaume Touya (IGN/Université Paris-Est): Emmanuel Pietriga, examiner (2017)

PhD committees (other than HCC graduates)

2013

- Simon Perrault (Télécom ParisTech, Paris): Olivier Chapuis, reviewer (2013)
- Sebastien Rufiange (École de Technology Supérieure, Canada): Anastasia Bezerianos, reviewer (2013)
- Raphaël Hoarau (ENAC, Toulouse): Michel Beaudouin-Lafon, reviewer and president (2013)
- Joseph Malloch (McGill University, Canada): Michel Beaudouin-Lafon, reviewer (2013)
- Eakachai Charoenchaimonkon (AIT, Bangkok): Michel Beaudouin-Lafon, reviewer (2013)
- Dong-Bach Vo (Télécom ParisTech, Paris): Stéphane Huot, jury member (2013)

2014

- Riad Akrour (LRI): Michel Beaudouin-Lafon, examiner (2014)
- Jérémie Gilliot (Université de Lille, Lille): Stéphane Huot, reviewer (2014)
- Samuel Huron (Université Paris-Sud): Wendy Mackay, jury member (2014)
- Yvonne Jansen (Inria Saclay): Michel Beaudouin-Lafon, president (2014)
- Cédric Mivielle (Télécom Paris): Wendy Mackay, jury member (2014)
- Maria Cristina Riff Rojas (Université Paris-Sud): Wendy Mackay, examiner (2014)
- Charles Perrin (Inria): Michel Beaudouin-Lafon, president (2014)
- Thomas Vincent (Université de Grenoble, Grenoble): Stéphane Huot, reviewer (2014)
- Jean-Luc Vinot (Université Toulouse III - Paul Sabatier): Wendy Mackay, reviewer (2014)

2015

- Jules Françoise (Université Pierre et Marie Curie, advisors: S. Hanneton & F. Bevilacqua), Olivier Chapuis, examiner (2015)
- Carl Unanader-Sharin (KTH Royal Institute of Technology, Stockholm, advisor: K. Hook): Wendy Mackay, opponent examiner (2015)
- Jérémie Boy (Inria / Univ. Paris-Sud, advisors: Françoise Detienne and Jean-Daniel Fekete): Wendy Mackay, president (2015)
- Olivier Perrotin (LIMSI, advisor: Ch. d'Alessandro): Michel Beaudouin-Lafon, president (2015)
- Jonathan Aceituno (Inria Lille, advisor: Nicolas Roussel): Michel Beaudouin-Lafon, reviewer (2015)
- William Delamare (LIG Grenoble, advisor: Laurence Nigay): Michel Beaudouin-Lafon, president (2015)
- Quentin Roy (Telecom ParisTech, advisor: Y. Guiard & E. Lecolinet): Michel Beaudouin-Lafon, president (2015)
- Weiya Chen (LIMSI, advisor: P. Bourdot): Michel Beaudouin-Lafon, president (2015)

2016

- Mathieu Le Goc (Inria Saclay, advisor: Jean-Daniel Fekete): Michel Beaudouin-Lafon, president (2016)
- Alex Goguey (Inria Lille, advisor: Géry Casiez): Michel Beaudouin-Lafon, reviewer (2016)
- Andéol Evain (IRISA, advisor: Anatole Lécuyer): Michel Beaudouin-Lafon, reviewer (2016)
- Emiline Brulé (Télécom Paris, advisor: Annie Gentes): Wendy Mackay, reviewer (2016)
- Rémy Dautriche (Université Grenoble-Alpes): Emmanuel Pietriga, reviewer (2016)
- Pascal Goffin (Inria / Université Paris-Saclay): Emmanuel Pietriga, president (2016)

2017

- Andrew Bluff (University of Technology Sydney, advisor: Andrew Johnston): Sarah Fdili Alaoui, examiner (2017)
- Bart Potsma (LIMSI-CNRS, advisor: Brian Katz): Michel Beaudouin-Lafon, president (2017)
- Samuel Delalez (Université Paris-Saclay, advisor: Christophe d'Alessandro): Wendy Mackay, president (2017)
- Lili Tong PhD (Université de Lyon & INSA, advisor: S. Audrey, A. Tabard): Olivier Chapuis, examiner (2017)
- Maxime Guillon (LIG, advisor: Laurence Nigay): Michel Beaudouin-Lafon, reviewer (2017)
- Hèlene Unaninski (Université de Toulouse, advisor: Stéphane Conversy): Wendy Mackay, reviewer (2017)
- Justin Mathew (Inria / Université Paris-Saclay): Emmanuel Pietriga, president (2017)
- Lonni Besançon (Inria / Université Paris-Saclay): Emmanuel Pietriga, president (2017)
- Hanaë Rateau (Inria / Université Lille 1): Caroline Appert, examiner (2017)
- Maxime Guillon (Université Grenoble Alpes): Caroline Appert, examiner (2017)
- Antoine Lhuillier (ENAC/Université Toulouse III): Caroline Appert, examiner (2017)
- Amira Chalbi (Inria / Université Lille 1, advisor: Nicolas Roussel): Anastasia Bezerianos, examiner (2017)

2018

- Ulrich von Zadow (Technische Universität Dresden, Advisor: R. Dachselt): Olivier Chapuis, reviewer (2018)

Miscellaneous

- Tenure and promotion cases in North America and Europe: Michel Beaudouin-Lafon, reviewer (2013, 2014, 2016, 2017), Wendy Mackay, reviewer (2016, 2017, 2018)
- University of Munich Doctoral Consortium: Wendy Mackay, jury member (2014)

Members of the group review submissions for all the major journals in the field, including HCI Journal, ACM TOCHI, Int. Jal. Human-Computer Studies, CSCW Journal, as well as for the main conferences, including ACM CHI, ACM UIST, ACM CSCW, IEEE InfoVis, Interact, AVI, ACM DIS, ACM TEI. Some members are also involved in the Semantic Web community: SWJ, ISWC, TheWebConf (formerly ACM WWW).

Interactions with the social, economic and cultural environment

Interaction with the economic environment

- Digiscope FabLab: The digital fabrication laboratory of the Digiscope project is used by a number of start-ups and companies.
- Systematic competitivity cluster: Michel Beaudouin-Lafon, member of working group on information systems.

Dissemination and Popularisation of Research Results

2013

- Interviews on *France Culture* radio shows "Place de la Toile" on the topic of tomorrow's computers ("l'ordinateur de demain"), 7 September 2013 and "Science Publique" on the topic of whether augmented reality will change our vision of the world ("La réalité augmentée va-t-elle changer notre vision du monde?"), 1 November 2013: Wendy Mackay.
- Interview as "Savant du jour" (scientist of the day) on the *France Inter* radio show "On va tous y passer": Wendy Mackay, 30 October 2013 and Michel Beaudouin-Lafon, 30 November 2013.
- Scientific committee of the S-Cube association (Scientipole-Savoirs-Société) on the Saclay campus for an exhibit on the brain, 2013-2104: Michel Beaudouin-Lafon.

2014

- Interview on Arte Television Future Mag, "*L'homme doit contrôler l'ordinateur, pas l'inverse*", Interview on Arte Television Future Mag, February 2014: Wendy Mackay
  http://www.futuremag.fr/interview-integrale/lunettes-connectees-interview-avec-wendy-mackay
- Public Exhibition at Futur-en-Seine festival, "*PaperTonnetz*" and "*Dessines moi un paysage*", June 2014: Jérémie Garcia. The demonstration was covered by the online news site 01net.com.
- World premiere at IRCAM, "*Quid sit musicus*", composed and directed by Philippe Leroux, 18 June 2014 : Jérémie Garcia designed and developed technology and tools used in the composition and perfomance of the piece.
- Interview by Serge Abiteboul and Claire Mathieu, "*L'être humain au coeur de la recherche en IHM*", SIF Blog, Le Monde, July 2014: Wendy Mackay.
- Conference at Université du Temps Libre Essonne, "*Interfaces de demain, la fin du tactile ?*", December 2014: Michel Beaudouin-Lafon.

2015

- Publication in *Bits de Ciencia* about our research and development activities on wall-sized displays (A154), 2015.
- Movie "*Antenna Dance at ALMA*", in collaboration with Denis Barkats (ALMA), 2015.
  http://almaobservatory.org/en/press-room/announcements-events/790-antenna-dance-at-alma
- Interview for web documentary "*BD Interactive: 2101 Sciences et science-fiction*", Chromatiques, April 2015: Wendy Mackay **http://www.chroma-tv.com**
- Panel " *Les robots : substitution ou complément ?*", Journée d'étude robots/travail/intelligence, La Chaire des Bernadins — L'Humain au défi du numérique, FING, 8 October 2015 : Wendy Mackay (panel member)
- Interview for a film on the attractivity of research in France, Ministère de Recherche, "*65th Lindau Nobel Laureate Meeting*", June 2015: Wendy Mackay. **https://www.dailymotion.com/video/x2vvhz4**
- Panel "*New Instruments and Evolving Performance Practices*", Ableton Loop Summit, 1 November 2015: Joseph Malloch (panel member)
- Demonstration at Fête de la Science, "*The WILDER platform*", LRI, 9 October 2015: Olivier Gladin, Rémi Hellequin, Amani Kooli, Jonathan Thorpe

2016

- Meet-up with start-ups on new interfaces, BeyondLab, 10 February 2016: Sarah Fdili Alaoui, Michel Beaudouin-Lafon, Wendy Mackay, Theophanis Tsandilas

- Article "*Ultra-high-resolution walls for visualizing very large datasets*", SPIE Newsroom, May 2016: E. Pietriga, F. del Campo, A. Ibsen, R. Primet, C. Appert, O. Chapuis, M. Hempel, R. Muñoz, S. Eyheramendy Duerr, A. Jordan, H. Dole. **http://spie.org/newsroom/6505-ultra-high-resolution-walls-for-visualizing-very-large-datasets**
- One-day seminar, "*La fabrique des outils, concevoir et pratiquer les logiciels de design*", ENSCI, Paris, 15 April 2016: Nolwenn Maudet
- Demonstration at Inria Rencontres Industrielles 2016, "*Expressive Keyboards: Enriching Gesture-Typing on Mobile Devices*", 25 November 2016: Jessalyn Alvina, Wendy Mackay
- Demonstration at Inria Rencontres Industrielles 2016, "*StickyLines: Reifying Alignment and Distribution of Graphical Objects*", 25 November 2016: Michel Beaudouin-Lafon, Wendy Mackay
- Interactive installation "*La Grande Vitrine de Noël*", Fête de la Science, Saclay, October 2016; Evry shopping mall, Evry, December 2016; Curiositas festival, Gif-sur-Yvette, June 2017: Wendy Mackay, Michel Beaudouin-Lafon, Joe Malloch, Andrew Webb, John MacCallum, Shu-Yuan Hsueh

2017

- Fête de la Science, Université Paris-Sud, 13 October 2017: Caroline Appert
- Fête de la Science, *Science en Direct*, Cité des Science, Paris, October 2017: María-Jesús Lobo
- Presentation to high-school students visiting Telecom ParisTech, "*Qu'est-ce qu'un chercheur en IHM ?*", 2017: Bruno Fruchard
- Interviews on France Culture, LCI, TV5 Monde on the standardization of the AZERTY and BEPO keyboards, June-July 2017: Michel Beaudouin-Lafon
- Interview on France Culture, "*Machines au croisement du design et du numérique*", 22 Février 2017: Nolwenn Maudet
- Demonstration at CEA Digital Days: Data Intelligence, "*StickyLines*", CEA List, March 2017: Marianela Ciolfi Felice, Wendy Mackay
- Demonstration at CEA Digital Days: Data Intelligence, "*Expressive Keyboard*", CEA List, March 2017: Jessalyn Alvina, Wendy Mackay
- Colloque L'Université Paris-Saclay fête les 10 ans de l'ERC, "*ONE - Unified Principles of Interaction*", Saclay, 9 June 2017: Michel Beaudouin-Lafon (presentation), Philip Tchernavskij (poster)
- Dance creation, "*Radical Choreographic Object*", Théatre de Villeneuve Tolosane, April 2017; Centre de développement Choregraphique, September 2017; Centre Bellegarde, October 2017; Le 104, Paris, November 2017; Centre Bellegarde, December 2017: Sarah Fdili Alaoui
- Dance creation, "*SKIN*", La friche de la belle, April 2017; festival Curiositas, Gif-sur-Yvette, May 2017; Attention Travaux, Culture en Essonnes, November 2017: Sarah Fdili Alaoui
- Workshop at Inria Silicon Valley, "*Scaling up for the Internet of Things*", Berkeley, CA, USA: Wendy Mackay and Theophanis Tsandilas (speakers)
- Workshop "*Intersections in Music, Movement, and Technology*", UC Berkeley, 17–19 August 2017: John MacCallum (co-facilitator).
- Workshop "*Relational Listening*", CLOUD/Danslab, The Hague, Netherlands, 26 February 2017; Montreal, Canada, 1–30 April 2017; Conference of Dance and Somatic Practices, Conventry, UK, 8 July 2017; Lake Studios, Berlin, 22 July 2018: John MacCallum (co-facilitator).

2018

- Panel at "*La Fabrique de la Danse*", Centre 104, Paris, 5 Avril 2018: Baptiste Caramiaux (panel member)
- Interview for the radio show *Les P'tits Bateaux*, France Inter, June 2018: Michel Beaudouin-Lafon

Contracts and grants

Public contracts and grants (jan 2013 - jun 2018)						
Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*		*Amount*
ERC Avanced	Mackay	ERC CREATIV	Inria	O6.2013	72	2 450
ERC Avanced	Beaudouin-Lafon	ERC ONE	Paris-Sud	10.2016	60	2 450
FP7 M. Curie	Mackay	SocialPrivacy	Inria	09.2012	36	268
H2020 M. Curie	Caramiaux	MIM	Paris-Sud	01.2018	12	70
EIT	Bezerianos Beaudouin-Lafon	EIT Digital	Paris-Sud	01.2015	60	556
LSST Subvention	Pietriga	LSST / AURA	Inria	07.2017	24	100
KISTI Subvention	Pietriga	Air Quality Monitoring	Inria	01.2017	12	72
ANR	Pietriga	MapMuxing	Inria	04.2013	42	208
ANR JCJC	Appert	MDGEST	Paris-Sud	10.2011	36	88
ANR JCJC	Tsandilas	DRAO	Inria	10.2012	36	153
EquipEx	Beaudouin-Lafon	DIGISCOPE	Paris-Sud, Inria	02.2011	115	6 800
Subvention	Pietriga	BnF's data portal	Inria		12	60
CNRS PEPS S2IH	Caramiaux	INTACT	Paris-Sud	02.2018	11	13
CNRS PEPS S2IH	Appert	VIZGEST	Paris-Sud	02.2018	11	17
SESAME Ile-de-France	Huot	DigiPods	Inria	01.2012	36	219
Digicosme Ph.D.	Beaudouin-Lafon	MoveIT	Telecom	10.2015	36	109
Digiteo Ph.D.	Chapuis	MemSpace	Telecom	10.2015	36	109
Digicosme Ph.D.	Fleury	SensoMotorCVE	Paris-Sud	11.2014	36	109
Digicosme Ph.D.	Beaudouin-Lafon	MultiVis	Telecom	11.2014	36	109
Digicosme Ph.D.	Appert	ScaleGest	Inria	11.2014	36	109
Digicosme Ph.D.	Chapuis	DigiZoom	Inria	11.2012	36	100
Digiteo Post-doc	Huot	DigiCarts	Inria	10.2013	18	77
Diagonale Paris-Saclay	Beaudouin-Lafon Mackay	Vitrine de Noël	Paris-Sud	05.2015	24	15
Diagonale Paris-Saclay	Fdili Alaoui	SKIN	Paris-Sud	04.2017	14	4.5
Diagonale Paris-Saclay	Fdili Alaoui	RCO	Paris-Sud	04.2017	14	15
Learning Center	Beaudouin-Lafon	Recherches Infinies	Paris-Sud	06.2017	12	30
Equipment	Tsandilas	ARSCPMD	Inria	01.2012	12	8
INRA Funding	Pietriga	CorTextViz.	Inria	01.2015	12	47
Subvention Paris-Sud	Appert	HCI PLATFORM	Paris-Sud	09.2012	24	78.8
Subvention Paris-Sud	Fleury	VR PLATFORM	Paris-Sud	09.2014	48	60
Subvention Paris-Sud	Fdili Alaoui	AAP ATTRACTIVITE	Paris-Sud	01.2016	12	2
Subvention Paris-Sud	Fleury	AAP ATTRACTIVITE	Paris-Sud	01.2015	12	7

European funding

ERC CREATIV

Type: ERC Avanced Grant
Amount: 2 450 k€
Duration: 72 months
Scientific director for LRI: W. Mackay

See **https://ex-situ.lri.fr/contracts/erc-creativ**

CREATIV explores how the concept of co-adaptation can revolutionize the design and use of interactive software. Co-adaptation is the parallel phenomenon in which users both adapt their behavior to the system's constraints, learning its power and idiosyncrasies, and appropriate the system for their own needs, often using it in ways unintended by the system designer.

ERC ONE

Type: ERC Avanced Grant
Amount: 2 450 k€
Duration: 60 months
Scientific director for LRI: M. Beaudouin-Lafon

See **http://erc.one**

The goal of ONE is to fundamentally re-think the basic principles and conceptual model of interactive systems to empower users by letting them appropriate their digital environment. The project addresses this challenge through three interleaved strands: empirical studies to better understand interaction in both the physical and digital worlds, theoretical work to create a conceptual model of interaction and interactive systems, and prototype development to test these principles and concepts in the lab and in the field. Drawing inspiration from physics, biology and psychology, the conceptual model combines *substrates* to manage digital information at various levels of abstraction and representation, *instruments* to manipulate substrates, and *environments* to organize substrates and instruments into digital workspaces.

SocialPrivacy

Type: FP7 Marie Curie grant
Amount: 268 k€
Duration: 36 months
Scientific director for LRI: W. Mackay

Partners: Inria, Massachusets Institute of Technology (USA)

Today's users lack informed consent: they must make all-or-nothing decisions about on-line privacy regardless of context. The Social Privacy project first diagnosed the problem at the individual, enterprise and society levels, and then generated effective solutions, from providing users with technical safeguards and informed consent, to establishing corporate guidelines for protecting privacy, to developing and testing recommendations for public policy.

MIM

Type: H2020 Marie Curie grant
Amount: 70 k€
Duration: 12 months
Scientific director for LRI: B. Caramiaux

Partners: CNRS, McGill University, IRCAM

MIM – Enhancing Motion Interaction through Music Performance: This project develops computational models of motor control and expressive variations built from music performance data collected during psychophysical studies. Then it creates and assesses a new type of Digital Musical Instrument (DMI) based on sensorimotor learning mechanisms. Therefore the project contributes a fundamental understanding of sensorimotor learning processes, and an original application of computational modelling of expressive gestures to interactive systems.

EIT Digital

Type: European Institute of Technology
Amount: 556 k€
Duration: 60 months
Scientific director for LRI: A. Bezerianos, M. Beaudouin-Lafon

Partners: European Institute of Innovation and Technology

EIT Digital is a Knowledge and Innovation Community of the European Institute of Technology. We participate in the European Master School of EIT Digital by running the HCID (Human-Computer Interaction and Design) major at Université Paris-Sud. HCID is a two-year Master program with a minor in innovation and entrepreneurship and attracts students from around the world. A significant number of students intern in our group, and some continue as Ph.D. students.

Other international funding

Large Synoptic Survey Telescope - Operations Monitoring and Control User Interfaces

Type: LSST / AURA
Amount: 100 k€
Duration: 24 months
Scientific director for LRI: E. Pietriga

Partners: LSST / AURA

See **https://www.lsst.org**

Collaborative project between NOAO in Arizona, Inria Chile and ILDA on the design and development of user interfaces for operations monitoring and control of the Large Synoptic Survey Telescope, currently under construction in Chile. The goal of the LSST project is to conduct a 10-year survey of the sky that will deliver a 200 petabyte set of images and data products that will address some of the most pressing questions about the structure and evolution of the universe and the objects in it.

Air Quality Monitoring in Korean Metropolises on Ultra-high-resolution Wall Displays

Type: Funded by KISTI
Amount: 70 k€
Duration: 12 months
Scientific director for LRI: E. Pietriga

Partners: Korea Institute of Science and Technology Information

We investigated the potential of ultra-high-resolution wall-sized displays for the visualization of stream IOT data in the field of air quality monitoring in large and dense urban areas in Korea. The goal of the project was to design and implement an interactive multi-scale visualization of streamed data collected from vehicles (taxis) equipped with a battery of sensors and geolocation devices. The project focused on how to design effective visualizations that take advantage of the specific characteristics of large surfaces featuring a very high pixel density ; and on how to handle streams of IOT data, in this case the sensor data from all taxis, including both live data streams and historical data retrieved from a database.

National funding

MapMuxing

Type: ANR
Amount: 208 k€
Duration: 42 months
Scientific director for LRI: E. Pietriga

Partners: COGIT de l'IGN, UMR GRED CNRS – Université de Montpellier

See **http://mapmuxing.ign.fr/**

Thanks to applications such as Google Maps, OpenStreetMap or the French geoportail, citizens can now easily access to a large amount of geographic data. Operations related to the combination of such data, and of their visualisations, as well as more basic operations related to navigation, remain tough for users. MapMuxing gathers HCI and GI science researchers, in order to propose new ways to combine different cartographical representations and efficiently navigate through these representations. The new methods combine techniques from automated cartography such as map generalisation or cartographical stylisation, and innovative HCI techniques, such as the JellyLens, which allow the mix of cartographic representations. The main application of the project is the fluid navigation between cartographical representations during tasks related to tsunami hazard management.

MDGEST

Type: ANR JCJC
Amount: 88 k€
Duration: 36 months
Scientific director for LRI: C. Appert

Interacting with gestures is becoming increasingly more relevant since the introduction of touch-screen devices where the user can trace gestures directly on the screen, as opposed to using an indirect input device such as a mouse. Gestures, in existing solutions, are identified solely based on their geometrical shape. Unfortunately, this approach does not scale, leading to complex gesture vocabularies that are hard to learn and hard to execute. MDGest focuses on the use of new gesture characteristics such as (dynamics, drawing direction and orientation, or distinctive drawing patterns, to discriminate different gestures and to propose a large vocabulary of gestures having a simple shape to be usable from both motor and cognitive perspectives.

DRAO

Type: ANR JCJC
Amount: 153 k€
Duration: 36 months
Scientific director for LRI: T. Tsandilas

Partners: Inria Sophia-Antipolis (Adrien Bousseau)

See **https://www-sop.inria.fr/members/Adrien.Bousseau/drao/**

Drawing is a powerful support for creation and communication but requires significant artistic and technical skills to achieve convincing results. The goal of the DRAO (*Dessin Réaliste Assisté par Ordinateur*) project is to facilitate and accelerate drawing for amateurs as well as for expert designers and illustrators, with a particular emphasis on drawing plausible material and lighting effects. The project explored the following research directions: (1) understanding how professionals draw, (2) automating parts of the drawing process, and (3) teaching people to draw.

DIGISCOPE

Type: Équipement d'Excellence
Amount: 6 800 k€
Duration: 115 months
Scientific director for LRI: M. Beaudouin-Lafon

Partners: Université Paris-Saclay, Digiteo, Univ. Paris-Sud, CNRS, CEA, Inria, Intitut Télécom, CentralSupélec, Université Versailles Saint-Quentin, ENS Paris-Saclay, Maison de la Simulation, Investissements d'Avenir, ANR

See **http://digiscope.fr**

Digiscope is a network of high-performance platforms for interactive visualization of large datasets and complex computation. Distributed throughout the Paris-Saclay campus, Digiscope's ten rooms feature extremely large displays and advanced interaction devices, including two CAVE immersive environments, four PowerWalls with 3D display capabilities, and four HyperWalls with ultra-high resolution wall-sized displays. HCC hosts two of these platforms: the WILD and WILDER hyperwalls. The platforms are interconnected via a telepresence network that supports remote collaboration over high-speed audio/video/data links. Applications include scientific research, computer-aided design, decision support systems, and education. The project also features a FabLab used by the project partners and accessible to the general public.

Visual Exploration of Linked Data on BnF's data portal

Type: Accord Inria – Ministère de la Culture
Amount: 60 k€
Duration: 12 months
Scientific director for LRI: E. Pietriga

Partners: Bibliothèque nationale de France

The project explores novel ways of visually navigating the data exposed by the Bibliothèque Nationale de France as linked data on **http://data.bnf.fr**.

INTACT

Type: CNRS PEPS S2IH
Amount: 13 k€
Duration: 11 months
Scientific director for LRI: B. Caramiaux

Partners: HCC group

Current research in artificial intelligence (AI) put forward a vision of digital tools that can surpass human skills in certain tasks (e.g. Go game). However, an alternative vision exists where digital tools embedding AI techniques can help people, and become partners in more complex and less well-defined tasks. This project examines the use of current AI technologies by artists through an empirical, field-based approach to study their interaction. The issue is both scientific for the fields of HCI and AI, and societal.

VIZGEST

Type: CNRS PEPS S2IH
Amount: 17 k€
Duration: 11 months
Scientific director for LRI: C. Appert

Partners: LIMSI – CNRS

A promising way of interacting with multi-display environments consists of using mid-air gestures that do not require any proximity between users and displays. However, mid-air gestures have discoverability and learnability issues as they are not *visible*. VizGest aims at giving some visibility to mid-air gestures by means of annotations put in the physical environment thanks to augmented reality glasses.

Regional funding

DigiPods

Type: SESAME
Ile-de-France
Amount: 219 k€
Duration: 36 months
Scientific director for LRI:
S. Huot

Partners: Digiteo/FCS Campus Paris-Saclay, Univ. Paris-Sud, Inria, CNRS, CEA, Telecom ParisTech

The goal of DIGIPODS was to design new interactive equipments and devices for collaborative interaction in immersive and interconnected, high-resolution visualization platforms such as those of DIGISCOPE. It developed new devices to facilitate co-located or remote interaction and collaboration: telepresence robots and the Digicarts, a new kind of interaction devices specifically designed for these needs.

DigiCarts

Type: Digiteo Post-doc
Amount: 77 k€
Duration: 18 months
Scientific director for LRI:
S. Huot

Partners: Univ. Paris-Sud, Inria, CNRS, CEA, Telecom ParisTech

Complements the DigiPods project with funding for an 18 months post-doctoral position focused on the design, implementation and evaluation of the Digicart devices.

MoveIT

Type: Digicosme Ph.D.
Amount: 109 k€
Duration: 36 months
Scientific director for LRI:
M. Beaudouin-Lafon

Partners: LTCI – Telecom ParisTech (O. Rioul)

MoveIT – Modeling the Speed/Accuracy Trade-Off of Human Aimed Movement with the Tools of Information Theory: The goal of this project is to conduct fundamental studies of aimed and pointing movements based on information theory. The project studies the interaction phenomena involved in pointing, in order to discover novel, more effective pointing techniques. This project funds Wanyu Liu, a joint Ph.D. student with the COMELEC and VIA groups at Institut Mines Telecom.

SensoMotorCVE

Type: Digicosme Ph.D.
Amount: 109 k€
Duration: 36 months
Scientific director for LRI:
C. Fleury

Partners: LIMSI-CNRS (P. Bourdot)

SensoMotorCVE – Sensor-motor Interface for Collaborative Virtual Environments with Heterogeneous Devices: Application to Industrial Design: In the context of collaborative virtual environments, the goal of this project is to develop a sensorimotor interface model for CAD data manipulation that supports heterogeneous interactive systems such as wall-sized displays or virtual reality rooms. This project funds Yujiro Okuya, a joint Ph.D. student with the VENISE group at LIMSI.

MemSpace

Type: Digiteo Ph.D.
Amount: 109 k€
Duration: 36 months
Scientific director for LRI:
O. Chapuis

Partners: LTCI – Telecom ParisTech (E. Lecolinet)

MemSpace – Interaction Techniques Exploiting Memory to Faciliate Command Activation: This project explored a new category of interactive techniques based on methods that augment human memory to allow, through gestural interaction, easy and fast access to a large set of commands or data items. The goal was to improve our understanding of phenomena involved in learning gestures and memorizing commands, and to propose new gestural interaction techniques helping memorization using mnemonic methods. This project funded Bruno Fruchard, a joint Ph.D. student with the VIA group at Institut Mines Telecom.

MultiVis

Type: Digicosme Ph.D.
Amount: 109 k€
Duration: 36 months
Scientific director for LRI: M. Beaudouin-Lafon

Partners: LTCI – Telecom ParisTech (J. Eagan)

MultiVis – Novel Interaction Models for Multi-surface Visualization: The goal of this project was to design, evaluate, and implement novel interaction models that help users appropriate multiple computational surfaces in the sense-making process. Our initial approach is to operationalize and extend the instrumental interaction model to specifically accommodate the specific needs of the sense-making process for information visualization. This project funded Marc-Emmanuel Perrin, a joint PhD student with the VIA group at Institut Mines-Telecom.

ScaleGest

Type: Digiteo Ph.D.
Amount: 109 k€
Duration: 36 months
Scientific director for LRI: C. Appert

Partners: LTCI – Telecom ParisTech (G. Bailly)

This project investigated the design of gesture-based interaction for expert users who navigate and manipulate large datasets. In the context of advanced graphical applications, the number of gestures should be large-enough to cover the set of controls (commands and parameter settings) but remain simple enough to avoid exceeding human abilities. The project characterized the space of application controls and the space of surface gestures in order to establish guidelines for appropriate control-gesture mappings, and defined an evaluation methodology to assess these mappings This project funded Rafael Morales, a joint PhD student with the VIA group at Institut Mines-Telecom.

DigiZoom

Type: Digicosme Ph.D.
Amount: 100 k€
Duration: 36 months
Scientific director for LRI: O. Chapuis

Partners: LTCI – Telecom ParisTech (E. Lecolinet)

This project studied multiscale navigation techniques adapted to the type of input and output device and the context of use: individual, collaborative in co-located setting, collaborative in a remote setting. The project made extensive use of the DIGISCOPE platforms WILD and WILDER. This project funded Can Liu, a joint PhD student with the VIA group at Institut Mines-Telecom.

Local funding

La Grande Vitrine de Noël

Type: Diagonale Paris-Saclay
Amount: 15 k€
Duration: 24 months
Scientific director for LRI: M. Beaudouin-Lafon, W. Mackay

Partners: Theater group $n+1$

This art-science project created, in collaboration with the theather group "n+1", an interactive store front in the form of an advent calendar, where users must discover which gestures to perform in order to make an animated character open the next window. This installation raises the question of who is controlling whom: Participants think that their gestures directly control the character, but the system actually uses shaping techniques from experimental psychology that encourage users to make successive approximations to the correct gesture. The installation was shown in several public events.

SKIN

Type: Diagonale Paris-Saclay
Amount: 4.5 k€
Duration: 14 months
Scientific director for LRI: S. Fdili Alaoui

SKIN is an Art and Science performance that integrates dance, video, sound and interactive technologies. The dancers generate digital images and sound through their movement: the images that are projected and the sound reflect their inner movements and their finest sensations in real time. The interaction is based on the proximity, the heartbeat as well as the muscular activity of the dancers. Through SKIN we are exploring the role of interactive technology as a dramaturgie of the body.

RCO

Type: Diagonale Paris-Saclay
Amount: 15 k€
Duration: 14 months
Scientific director for LRI: S. Fdili Alaoui

Radical Choreographic Object: RCO is a participatory and interactive performance in which the audience activates rules by reacting to both invitations of the performers and instructions sent on their mobile phones. We designed an interactive system based on sending text instructions or invitations to act through the sensors of the mobile phones (accelerometers, gyroscopes, proximity sensors native to smartphones) in order to trigger behaviors among the performers and to make a collective and participative dynamic emerge. With RCO we aim at developing a social ecology where we favour risks of unpredictability, emergence of the unexpected, appropriation and creativity.

Le Plateau des Recherches Infinies

Type: Learning Center, Univ. Paris-Saclay
Amount: 30 k€
Duration: 12 months
Scientific director for LRI: M. Beaudouin-Lafon

Partners: Univ. Paris-Sud, Learning Center Paris-Saclay

The goal of this project is to create an interactive installation presenting the portraits of a hundred researchers from Université Paris-Saclay. It is a collaboration with portrait photographer Didier Goupy. The installation is designed to be exhibited in various sites of Université Paris-Saclay until it is permanently installed in its Learning Center.

ARSCPMD

Type: Equipment
Amount: 8 k€
Duration: 12 months
Scientific director for LRI: T. Tsandilas

Partners: Univ. Paris-Sud, Inria, Dept STIC Paris-Saclay

ARSCPMD – Augmented Reality System for Collaborative Phusical Modeling and Desing: The goal of this project is to develop an augmented-reality system to support collaboration over 3D models and enhance digital-fabrication approaches. It is a collaboration with the AVIZ group and provides funding (8k) for equipment.

CorTextViz.

Type: INRA Funding
Amount: 47 k€
Duration: 12 months
Scientific director for LRI: E. Pietriga

Partners: INRA, Aviz at INRIA Saclay

This project developed interactive visualizations of medium-scale multilevel dynamic networks, supporting data storytelling on wall-sized displays.

HCI PLATFORM

Type: Univ. Paris-Sud
Amount: 79 k€
Duration: 24 months
Scientific director for LRI: C. Appert

This project created a pedagogical platform for teaching Human-Computer Interaction (HCI) at the L1, M1 and M2 levels so that students can develop innovative projects. The platform consists of about twenty Apple workstations and mobile devices (tablets and smartphones), and supports HCI practical classes that are up to date with current trends

VIRTUAL REALITY PLATFORM

Type: Univ. Paris-Sud
Amount: 60 k€
Duration: 48 months
Scientific director for LRI: C. Fleury

This project created a pedagogical platform for teaching virtual reality to students of the Polytech Paris-Sud engineering school and of the University's HCI program (M1, M2). This platform includes a small CAVE-like system and AR and VR head-mounted displays. It enables students to experience immersion in VR and to acquire technical skills through projects.

AAP ATTRACTIVITE

Type: Univ. Paris-Sud
Amount: 2 k€
Duration: 12 months
Scientific director for LRI: S. Fdili Alaoui

The goal of this project was to explore a methodology on research creation and tools for supporting choreography as well as dance documentation and annotation.

AAP ATTRACTIVITE

Type: Univ. Paris-Sud
Amount: 7 k€
Duration: 12 months
Scientific director for LRI: C. Fleury

The goal of this project was to build telepresence systems suitable for large wall-sized displays, where multiple users can move in the space in front of the display. The project developed camera arrays installed on wall-sized displays and expored the use of telepresence robots.

Private contracts and grants (jan 2013 - jun 2018)						
Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*		*Amount*
Donation	Beaudouin-Lafon	Microsoft	U. Paris-Sud	01.2016	12.2018	45k€

MULTIHUB

Type: Microsoft donation
Amount: 45 k€
Duration: 24 months
Scientific director for LRI: M. Beaudouin-Lafon

HCC was one of the ten academic groups worldwide awarded a hardware and monetary grant by Microsoft Research as part of its request for proposal to expand the potential applications of the Surface Hub across all aspects of society (**http://research.microsoft.com/en-us/projects/surface-hub/**). The goal of the MultiHub project is to enable interaction in the large, where groups of experts can interact with rich content and complex data while collaborating both locally and remotely in interactive, multi-surface environments. HCC was awarded two 55" Surface Hubs and $19,000 in cash.

Training and Education

Management of Teaching Programs

- Interaction Masters (Research Master in Computer Science, Interaction Specialty), M2, Univ. Paris-Sud & Univ. Paris-Saclay: Anastasia Bezerianos (2013-) & Michel Beaudouin-Lafon (2013-2016), Chairs; Caroline Appert (2013), Wendy Mackay (2013), Cédric Fleury (2013-), Internships organization
- HCID Masters (EIT ICT Labs European Master in Human-Computer Interaction and Design), M1 & M2, Univ. Paris-Sud & Univ. Paris-Saclay: Michel Beaudouin-Lafon (2013-2016) & Anastasia Bezerianos (2013-), Chairs; Sarah Fdili Alaoui, Innovation & entrepreneurship (2016-)
- 3rd year of engineering school in Computer Science (Bac+3), apprenticeship training, Polytech Paris-Sud: Cédric Fleury (2017-), Chair.

Master Internships

HCC hosted 63 Master internships. 18 of them continued as Ph.D. students in the group.

2013:

- Master (M1): Maria Jesus Lobo, *Graphical interaction techniques for undo and redo*, January - March 2013, Advisors: Olivier Chapuis, Caroline Appert. **Continued as HCC PhD student**
- Master (M2): Jessalyn Alvina (Univ. Paris-Sud), *RouteLens: efficient route following for map applications*, April - September 2013. Advisors: Olivier Chapuis, Caroline Appert. **Continued as HCC PhD student**
- Master (M2): Stephan Delarue (Univ. Paris-Sud), *Performance gestuelle et anatomie*, April 2013 - August 2013, Advisors: Caroline Appert, Halla Olafsdottir
- Master (M2): Evanthia Dimara (Univ. Paris-Sud), *Linking AI and HCI through Co-Adaptive Instruments*, April - September 2013, Advisor: Wendy Mackay. **Continued as HCC PhD student**
- Master (M2): Magdalini Grammatikou (Univ. Paris-Sud), *BricoSketch: Replicating and reusing electronic and physical material in professional illustrations*, April - September 2013, Advisors: Stéphane Huot, Theophanis Tsandilas
- Master (M2): Thibaut Jacob (Univ. Paris-Sud), *Sketching Interactions for Data Exploration*, April - September 2013, Anastasia Bezerianos, Theophanis Tsandilas
- Master (M2): Ghita Jalal (Supelec), *Co-Adaptive Instruments*, May - September 2013, Advisor: Wendy Mackay. **Continued as HCC PhD student**
- Master: Antoine Ponsard (Ecole Polytechnique), *Interactive Visualisation with Temporal Data*, April - June 2013, Advisor: Michel Beaudouin-Lafon
- Master (M2): Julia Vlasenko, *Interactive Visualization of Ubiquitous Data*, May - November 2013, Advisor: Wendy Mackay

2014:

- Master (M2): Athanasios Taousakos (Univ. Paris-Sud), *Detecting and Simplifying Users' Routines on Mobile Devices*, March 2014 - August 2014, Advisors: Anastasia Bezerianos, Caroline Appert

- Master (M2): Nolwenn Maudet (UTC Compiegne), *Substrates and Co-Adaptive Instruments*, 2014, Advisor: Wendy Mackay. **Continued as HCC PhD student**
- Master (M2): Ignacio Avellino (RWTH Aachen), *Audio-Video support for Remote Collaboration*, 2014, Advisor: Cédric Fleury. **Continued as HCC PhD student**
- Master (M2): Guilherme Soares (Univ. Paris-Sud), *Instrumental Interaction for Neuroanatomy Imaging*, 2014, Advisor: Michel Beaudouin-Lafon
- Master: Niyati Chowdhury (Univ. Trento), *Interactive Brain Visualization*, 2014, Advisor: Michel Beaudouin-Lafon, Wendy Mackay
- Master (M2): Olutosin Oduwole (Univ. Paris-Sud), *Distributed Video Editing on a Wall-Size Display*, 2014, Advisors: Wendy Mackay, Can Liu
- Master (M2): Paola Pastor (Univ. Paris-Sud), *Making non-interactive surfaces interactive*, 2014, Advisors: Wendy Mackay, Daniel Strazzulla
- Master (M2): Chen Wang (Univ. Paris-Sud), *BFF Band: Rethinking Personal Communication*, 2014, Advisors: Wendy Mackay, Daniel Strazzulla
- Master: Lucien Bobo (ENS Cachan), *Comm Apps for Remote Communication*, 2014, Advisors: Wendy Mackay, Daniel Strazzulla
- Master: Louis Faucon (Ecole Polytechnique), *Interactive Communication Bands*, 2014, Advisors: Wendy Mackay, Daniel Strazzulla
- Master: Jianqiao Li (Ecole Polytechnique), *Dynachord - Combining chord and gesture recognition*, 2014, Advisor: Wendy Mackay
- Master (M1): Miguel Rodriguez & Gabriella Villalobos (Univ. Paris-Sud), *Video Clipper - Structured Capture of Video Data*, 2014, Advisor: Wendy Mackay
- Master (M1): Bruno Fruchard (Univ. Paris-Sud), *Development of flexible mobile interfaces on Android*, 2014, Advisors: Olivier Chapuis, Anastasia Bezerianos. **Continued as HCC PhD student**

2015:

- Master (M2): Bruno Fruchard (Univ. Paris-Sud), *Virtual Navigation on Wall-Displays*, April - September 2015, Advisors: Olivier Chapuis, Emmanuel Pietriga. **Continued as HCC PhD student**
- Master (M2): Jean-Baptiste Louvet (Insa Rouen), *Touch-based Interaction Technique for 3D Manipulation on Wall-sized Displays*, 2015, Advisor: Cédric Fleury
- Master (M2): Niyati Roy Chowdhury (Univ. Paris-Sud), *Brain on the wall: An observational study with a novel brain image analysis tool (BrainTwister)*, 2015, Advisors: Wendy Mackay, Michel Beaudouin-Lafon
- Master (M2): Xu Yuebai (Univ. Paris-Sud), *Interactive Brain Visualization*, 2015, Advisors: Michel Beaudouin-Lafon, Wendy Mackay
- Master (M2): Panagiota Tziova (Univ. Paris-Sud), *Bad Hacks and Good tricks: How professional designers appropriate creativity tools*, 2015, Advisor: Wendy Mackay
- Master (M1): Hae Jin Song (MIT), *Interactive Visualization of Training Sets for Gesture-based Interfaces*, May 2015 - July 2015, Advisors: Caroline Appert, Emmanuel Pietriga
- M.Eng. student (Universidad de Chile), *Visualization of FITS images and Virtual Observatory data on ultra-high-resolution wall displays*, April - December 2015, Advisors: Emmanuel Pietriga

2016:

- Master (M1): Dylan Lebout (Univ. Paris-Sud), *Indirect vs Direct surface gestures for wall-sized displays*, May - August 2016, Advisors: Caroline Appert, Olivier Chapuis
- Master: Brennan Jones (University of Calgary), *Physical and virtual avatars for telepresence and remote collaboration*, 2016, Advisors: Ignacio Avellino, Cédric Fleury, Michel Beaudouin-Lafon
- Master (M2): Francesco Vitale (Univ. Paris-Sud), *Field study of operating systems upgrades*, 2016, Advisors: Joanna McGrenere, Wendy Mackay
- Master (M2): Dimitri Belopopsky (Univ. Paris-Sud), *La Grande Vitrine des Choses*, 2016, Advisors: Michel Beaudouin-Lafon, Wendy Mackay, Joseph Malloch
- Master (M2): Sruthi Coimbatore Viswanathan (Univ. Paris-Sud), *Touch Keyboard with Haptic Feedback*, 2016, Advisor: Michel Beaudouin-Lafon
- Master (M2): Iva Karabatic (Univ. Paris-Sud), *Chord input on a digital whiteboard*, 2016, Advisors: Wendy Mackay, Michel Beaudouin-Lafon
- Master (M2): Diana Lipcanu & Isha Van Baar (Univ. Paris-Sud), *The Inteaction Musuem*, 2016, Advisors: Wendy Mackay, Michel Beaudouin-Lafon
- Master (M2): Nam Giang (Univ. Paris-Sud), *Interactive Video Preview Playlist*, Advisors: Wendy Mackay, Carla Griggio
- Master (M2): Midas Nouwens (Univ. Paris-Sud), *Communication Appliances to Support Communication for Distributed Families*, 2016, Advisor: Wendy Mackay, Carla Griggio
- Master (M2): Pierre Mahe (IRCAM), *EMBRACe Expressive Movement Body fRAmework and Computing*, 2016, Advisor: Sarah Fdili Alaoui
- Master (M2): Niels Mourette (IRCAM), *The augmented body from within*, 2016, Advisor: Sarah Fdili Alaoui
- Master (M2): Shu-Yuan Hsueh (IRCAM & ENSCII), *Dynamic Guides for Embodied Interaction*, Advisors: Wendy Mackay,

Sarah Fdili Alaoui. **Continued as HCC PhD student**
- Master (M2): Philip Tchernavskij (University of Aarhus), *Information Substrates for Asymmetrical Collaboration*, Advisors: Wendy Mackay, Michel Beaudouin-Lafon. **Continued as HCC PhD student**

2017:

- Master (M2): Dylan Lebout (Univ. Paris-Sud), *Visualization of geolocated and temporal data on the Web*, May - September 2017, Advisors: Caroline Appert, Emmanuel Pietriga
- Master (M2): Reyhaneh Raissi(Univ. Paris-Sud), *Multi-user Multi-selection on Tabletop*, Mars - September 2017, Advisors: Anastasia Bezerianos, Olivier Chapuis
- Master (M1): Eleonore Bartenlian (Univ. Paris-Sud), *Tools for customizing tangible interfaces*, May - July 2017, Advisors: Caroline Appert
- Master (M2): Jiali Liu (Telecom ParisTech), *Cross-Surface Interaction*, 2017, Advisors: Michel Beaudouin-Lafon, Philip Tchernavskij
- Master (M2): Linghua Lai (Univ. Paris-Sud), *VideoBoard: Video for Interaction Design*, 2017, Advisors: Wendy Mackay, Germán Leiva
- Master (M2): Chengcheng Qu (Univ. Paris-Sud), *Animated Emojis: Creating Dynamic Expressions with Expressive Keyboards*, 2017, Advisors: Wendy Mackay, Jessalyn Alvina
- Master (M2): Jean-Philippe Rivière (Univ. Toulouse), *MoveOn: Understanding and Supporting Dance Skill Acquisition through Multimodal Interactive Technology*, 2017, Advisors: Wendy Mackay, Sarah Fdili Alaoui. **Continued as HCC PhD student**

2018:

- Master (M2): Raphaël James (Univ. Paris-Sud), *Studying collaboration using augmented reality and high-resolution Wall displays*, April - September 2018, Advisors: Anastasia, Bezerianos Olivier Chapuis, Tim Dwyer.
- Master (M2): Eugénie Brasier (Univ. Paris-Sud), *Techniques pour apprendre à contrôler un monde virtuel via des interactions*, April – September 2018, Advisor: Caroline Appert. **Continued as HCC PhD student**
- Master (M1): Sebastien Sauvard (Univ. Paris-Sud), *Interaction tangible collaborative avec les TouchTokens*, May 2018 - July 2018, Advisors: Caroline Appert, Olivier Chapuis
- Master (M1): Robin Duraz (Univ. Paris-Sud), *Navigation multi-échelle sur mur d'écrans avec tablette*. May - Juillet 2018, Advisors: Anastasia, Bezerianos Olivier Chapuis.
- Master (M2): Krishnan Chandran (University of Hamburg), *Designing Interaction for AR-Enhanced Collaborative Modeling*, June - August 2018, Advisors: Cédric Fleury and Theophanis Tsandilas
- Master (M2): Miguel Renom (M2 Interaction, Univ. Paris-Saclay), *Transfer of tool-based skills from physical to digital tools*, March - August, 2018, Advisor: Michel Beaudouin-Lafon. **Continued as HCC PhD student**
- Master (M2): Tong Xue (M2 Interaction, Univ. Paris-Saclay), *Analysis of information substrates and digital instruments in existing software*, March - August, 2018, Advisor: Michel Beaudouin-Lafon. **Continued as HCC PhD student**
- Master (M2): Dimitrios Christaras-Papageorgiou (M2 Interaction, Univ. Paris-Saclay), *Prototyping of an environment based on information substrates and digital instruments*, March - August, 2018, Advisor: Michel Beaudouin-Lafon. **Continued as HCC PhD student**
- Master (M1): Johannes Maas (RWTH Aachen), *Adapting the Digiscape telepresence middleware to touch displays*, May - July, 2018, Advisors: Olivier Gladin and Michel Beaudouin-Lafon
- Master (M2): Alexander Eiselmeyer (University of Zurich), *Touchstone II*, January-February, April, 2018, Advisors: Michel Beaudouin-Lafon and Wendy Mackay
- Master (M2): Wuji Geng (KTH & HCID M2), *Interaction Museum for designers*, March - August, 2018, Advisor: Wendy Mackay
- Master (M2): Viktor Gustafsson (KTH & HCID M2), *Applying instrumental interaction to Game Development*, March - August, 2018, Advisor: Wendy Mackay. **Continued as HCC PhD student**
- Master (M2): Yi Zhang (U. Twente & HCID M2), *Interaction Museum for researchers*, March - August, 2018, Advisor: Wendy Mackay. **Continued as HCC PhD student**
- Master (M2): Téo Sanchez (Sorbonne Université), *Active Learning for Supporting Movement-based Creative Interaction*, February - July 2018, Advisor: Baptiste Caramiaux. **Continued as HCC PhD student**

Graduate Courses

Interaction Masters and HCID (Human-Computer Interaction & Design) Masters, Univ. Paris-Sud & Univ. Paris-Saclay:

- *Fundamentals of Human-Computer Interaction*, M1/M2: Michel Beaudouin-Lafon (2013-)
- *Programming of Interactive Systems*, M1/M2: Anastasia Bezerianos (2013, 2014, 2016-), Cédric Fleury (2013, 2014), Theophanis Tsandilas (2014, 2015), Sarah Fdili Alaoui (2015), Caroline Appert (2015)
- *Design and Evaluation of Interactive Systems*, M1/M2: Wendy Mackay (2013-)
- *Advanced Design of Interactive Systems*, M1/M2: Wendy Mackay (2016-)
- *Evaluation of interactive systems*, M1: Caroline Appert (2013-)

- *Digital Fabrication*, M1/M2: Joseph Malloch & Romain Di Vozzo(2015-2016), Sarah Fdili Alaoui (2017)
- *Creative Design*, M1/M2: Sarah Fdili Alaoui (2015-)
- *Gesture and Mobile Interaction*, M1/M2: Sarah Fdili Alaoui (2015, 2016)
- *Mixed Reality and Tangible Interaction*, M2: Anastasia Bezerianos (2013-)
- *Groupware and Collaborative Interaction*, M2: Michel Beaudouin-Lafon & Cédric Fleury (2013-)
- *Design Project & HCI Project*, M1/M2: Sarah Fdili Alaoui (2015, 2016, 2017), Caroline Appert (2015), Anastasia Bezerianos (2016, 2017)
- *Career Seminar* M1/M2: Wendy Mackay (2016, 2017), Anastasia Bezerianos (2016, 2017)
- *Introduction to Java*, M1/M2: Anastasia Bezerianos (2016, 2017)

HCID (Human-Computer Interaction & Design) Masters, Univ. Paris-Sud & Univ. Paris-Saclay:

- *Fundamentals of Situated Interaction*, M1/M2: Michel Beaudouin-Lafon (2016-), Wendy Mackay (2016-)
- *Business Design Labs*, M1: Wendy Mackay (2013, 2015, 2016), Sarah Fdili Alaoui (2017)
- *Innovation & Entrepreneurship thesis*, M2: Sarah Fdili Alaoui (2017)
- *Human-Computer Interaction project*, M1: Anastasia Bezerianos (2013, 2014), Wendy Mackay (2013, 2014), Michel Beaudouin-Lafon (2013, 2014)

Polytech engineering school, Univ. Paris-Sud:

- *Interaction Homme-Machine*, 3rd year: Anastasia Bezerianos (2013, 2014), Olivier Chapuis (2014), Cédric Fleury (2015, 2016, 2017)
- *Projet Java-Graphique-IHM*, 3rd year: Cédric Fleury (2014, 2015, 2016, 2017)
- *Réalité Virtuelle et Interaction*, 5th year: Cédric Fleury (2014, 2015, 2016, 2017)
- *Mise en situtation: Réalité Virtuelle*, 5th year apprenticeship training: Cédric Fleury (2017)
- *Informatique Graphique et visualisation*, 5th year: Sarah Fdili Alaoui (2015, 2016, 2017)

Other teaching:

- *Formation à la Recherche*, Research Masters in Computer Science, M2, Univ. Paris-Sud: Wendy Mackay (2013, 2014, 2015) & Anastasia Bezerianos (2013, 2014)
- *Design and Evaluation of Interactive Systems*, Master 2 Professional, M2Pro, Univ. Paris-Sud: Anastasia Bezerianos (2013, 2014)
- *Probabilities and Statistics*, International Masters, M1, Univ. Paris-Saclay: Theophanis Tsandilas (2017)
- *Data Visualization*, Informatique Décisionelle, M2, Univ. Paris-Dauphine: Emmanuel Pietriga (2015, 2016, 2017)

Schools

- Rencontres Jeunes Chercheurs en Interaction Homme-Machine, RJC-IHM'17. Ethics and Experimental Protocols. Wendy Mackay (July 2017).
- Rencontres Jeunes Chercheurs en Interaction Homme-Machine, RJC-IHM'13. Animation of "reviewing process" workshop. Caroline Appert (June 2013).
- Rencontres Jeunes Chercheurs en Interaction Homme-Machine, RJC-IHM'13. Les thèmes émergents de l'IHM. Olivier Chapuis (June 2013).

Honors

Students of our HCID Master Program won the first prize of a European competition for young entrepreneurs. Another group won second prize the following year. A third group won a prize in an international competition to design solutions for mobility.

A pair of students from the HCID program returned to China and created a start-up in the education area that had 150 employees two years later.

Internships

- Engineer: Leo Colombaro (Télécom Saint-Etienne) Integrating a camera array with a telepresence middleware, February - July, 2018, Advisor : Cédric Fleury, Olivier Gladin and Michel Beaudouin-Lafon

Habilitations

Habilitations à Diriger des Recherches	
Name	*Defense*
Stéphane Huot	07.05.2013
Caroline APPERT	26.06.2017

Stéphane Huot was recruited as Research Director at Inria-Lille in October 2014.

Caroline Appert was promoted to Research Director at CNRS in June 2018.

Theses

Defended theses				
Name	*Start*	*Defense*	*Funding*	*Advisor*
Jessalyn ALVINA	01.10.2014	13.12.2017	ERC CREATIV	Mackay
Ignacio AVELLINO MARTINEZ	01.09.2014	12.12.2017	Inria CORDI	Beaudouin-Lafon, Fleury
Evanthia DIMARA	02.10.2013	30.11.2017	DigiCosme	Dragicevic, Bezerianos
Jérémie GARCIA	01.09.2010	10.06.2014	EDIPS Paris-Sud	Tsandilas, Mackay
Ghita JALAL	01.01.2012	16.12.2016	ERC CREATIV	Mackay
Can LIU	01.10.2012	17.12.2015	Digicosme	Chapuis, Lecolinet, Beaudouin-Lafon
Maria LOBO	01.10.2014	05.12.2017	ANR	Pietriga, Appert
Nolwenn MAUDET	01.10.2014	11.12.2017	EDSTIC Paris-Saclay	Beaudouin-Lafon, Mackay
Rafael MORALES GONZALEZ	01.11.2014	09.10.2017	Digicosme	Appert, Pietriga, Bailly
Cyprien PINDAT	01.09.2010	20.12.2013	EDIPS Paris-Sud	Pietriga, Puech, Chapuis
Arnaud PROUZEAU	01.10.2014	15.12.2017	EDSTIC Paris-Saclay	Bezerianos, Chapuis
Oleksandr ZINENKO	16.09.2013	25.11.2016	Inria CORDI	Huot, Bastoul

Position after the thesis	
Name	*Position*
Jessalyn ALVINA	Post-doc, Univ. British Columbia, Canada
Ignacio AVELLINO MARTINEZ	Post-doc, ISIR, Sorbonne-Université, Paris
Evanthia DIMARA	Post-doc, ISIR, Sorbonne-Université, Paris
Jérémie GARCIA	Assistant Professor, ENAC, Toulouse
Ghita JALAL	Post-doc, LIRIS, Lyon
Can LIU	Assistant Professor, City University, Hong-Kong, China
Maria LOBO	Post-doc, ENAC, Toulouse
Nolwenn MAUDET	Post-doc, Tokyo Design Lab, University of Tokyo, Japan
Rafael MORALES GONZALEZ	Post-doc, University of Sussex, UK
Cyprien PINDAT	Software Engineer, Grist Labs, New York, US
Arnaud PROUZEAU	Research Fellow, Monash University, Australia
Oleksandr ZINENKO	Research Engineer, Inria & ENS Ulm, Paris

Theses in progress			
Name	*Start*	*Funding*	*Advisor*
Marianela CIOLFI FELICE	01/02/2015	EDSTIC Paris-Saclay	Mackay
Marie DESTANDAU	01/10/2017	Inria CORDI	Pietriga, Appert
Bruno FRUCHARD	01/10/2015	DigiCosme	Lecolinet, Chapuis
Anna GOGOLOU	01/10/2016	Inria CORDI	Bezerianos,
Carla GRIGGIO	01/10/2015	ERC CREATIV	Mackay
Shu-Yuan HSUEH	01/10/2016	EDSTIC Paris-Saclay	Mackay
German LEIVA	01/10/2015	Inria CORDI	Beaudouin-Lafon
Wanyu LIU	07/12/2015	DigiCosme	Beaudouin-Lafon, Rioul
Yujiro OKUYA	01/10/2015	DigiCosme	Fleury
Jean-Philippe RIVIERE	15/10/2017	EDSTIC Paris-Saclay	Mackay
Hugo ROMAT	30/05/2016	CIFRE	Pietriga, Appert
Michaël WESSELY	01/11/2015	ERC CREATIV	Tsandilas, Mackay

Software Licensing and Distribution

Touchstone - Software platform for designing and running controlled experiments
http://code.google.com/p/touchstone-platforms/
Contact: Caroline APPERT

Touchstone is an open-source platform designed to help establish a solid research foundation for HCI in the area of novel interaction techniques. Touchstone includes a design platform for exploring alternative designs of controlled laboratory experiments and a run platform for running subjects. Designed for HCI researchers and their students, Touchstone facilitates the process of creating new experiments, as well as replicating and extending experiments in the research literature.

FlowStates Toolkit - Programming Interactive Applications with Data Flow and State Machines
http://www.lri.fr/~appert/FlowStates/
Contact: Caroline APPERT

FlowStates is a user interface toolkit compatible with Java Swing that combines two models for managing events: dataflow and state machines. The dataflow model makes it easy to support non-standard input devices and to reconfigure interactions according to the available devices, while state machines support the programming of complex interactions. This hybrid approach provides power and expressivity. It also provides flexibility by explicitly not setting strict limits between the roles of each model.

Substance - Programming framework and middleware for developing distributed interactive application
http://substance-env.sourceforge.net/
Contact: Michel BEAUDOUIN-LAFON

Substance is a middleware for developing flexible interactive multi-surface applications, based on a data-oriented framework that decouples functionality from data. Shared Substance is a middleware implemented in Substance that provides powerful sharing abstractions to develop distributed applications.

Scotty - User Interface Programming at Run Time
http://insitu.lri.fr/Projects/Scotty
Contact: Michel BEAUDOUIN-LAFON

The goal of Scotty is to support "malleability", i.e. interfaces that can be modified at run-time in ways not anticipated by the designers. Scotty is a toolkit that allows a programmer to extend an existing Mac OS X application without access to its source code. Scotty provides the following abstractions: hooks to alter the appearance of windows and widgets, event funnels to alter their behavior, glass sheets to overlay graphics and add new interaction methods, dynamic code loading and object proxies to redefine and extend existing objects. Scotty also provides a higher-level interface based on instrumental interaction.

Metisse - Windowing System to explore inovative window management techniques
http://insitu.lri.fr/metisse/
Contact: Olivier CHAPUIS

Metisse is an X-based window system that makes it easy for HCI researchers to design and implement innovative window management techniques. It conforms to existing standards and is robust and efficient enough to be used on a daily basis, making it a suitable platform for the evaluation of the proposed techniques. Metisse is not focused on a particular kind of interaction (e.g. 3D) and should not be seen as a new desktop environment. It is rather a tool for creating new types of desktop environments.

jBricks - Java toolkit for interactive visualization platforms
Contact: Stéphane HUOT

jBricks is a Java toolkit that integrates a high-quality 2D graphics rendering engine and a versatile input configuration module into a coherent framework, enabling the exploratory prototyping of interaction techniques and rapid development of post-WIMP applications running on cluster-driven interactive visualization platforms. It is based on our ZVTM and WILD Input Server toolkits.

GlideCursor - Inertial cursor
Contact: Michel BEAUDOUIN-LAFON

GlideCursor is a Mac OS X application that implements an inertial cursor, i.e. a cursor that can be "thrown" when moving it with a trackpad, thereby saving time when moving the cursor across large distances. The application lets users configure gliding, and can also log cursor activity for later analyses.

SwingStates - An extension to the Java Swing toolkit based on state machines
http://swingstates.sourceforge.net/
Contact: Caroline APPERT

SwingStates is an extension to the Java Swing user interface toolkit that facilitates the creation of interactive applications by providing state machines to specify interactions. SwingStates also provides a powerful Canvas to create new widgets and a flexible input system to use non-standard input devices. State machines are specified directly in Java by taking advantage of the syntax of inner classes. The explosion of the number of states is controlled by allowing multiple state machines to run in parallel.

ZVTM - Zoomable Visual Transformation Machine
http://zvtm.sourceforge.net/index.html
Contact: Emmanuel PIETRIGA

The ZVTM is a Zoomable User Interface (ZUI) toolkit implemented in Java, designed to ease the task of creating complex visual editors with large amounts of objects or with complex geometrical shapes that need to be animated. It is based on the metaphor of universes that can be observed through smart movable/zoomable cameras, and offers features such as perceptual continuity in object animations and camera movements, which should make the end-user's overall experience more pleasing.

ZGRViewer - A GraphViz/DOT Viewer
http://zvtm.sourceforge.net/zgrviewer.html
Contact: Emmanuel PIETRIGA

ZGRViewer is a 2.5D graph visualizer implemented in Java and based upon the Zoomable Visual Transformation Machine (ZVTM). It is specifically designed to display graphs expressed using the DOT language from AT&T GraphViz and processed by programs such as *dot*, *neato* or *twopi*.

UnityCluster - Distributed Unity3D application middleware
Contact: Cédric FLEURY

Unity Cluster provides an easy solution for running existing Unity 3D applications on a tiled display that uses a rendering cluster. Unity Cluster manages data distribution and synchronization among the computers to obtain a consistent image on the entire wall-sized display surface. It can also deform the displayed images according to the user's position, resulting in a better sense of depth on a 2D screen.

WildOS - Middleware for interactive rooms
Contact: Michel BEAUDOUIN-LAFON

WildOS is a web-based middleware to support applications running in an interactive room featuring various interaction resources, such as the WILD and WILDER rooms of the DIGISCOPE project: a tiled wall display, a motion tracking system, tablets and smartphones, etc.

DIGISCAPE - Telepresence middleware
Contact: Olivier GLADIN

Digiscape is an application and a framework that facilitates the development of remote collaboration applications running across heterogeneous platforms such as those of the DIGISCOPE project. Through the Digiscape application, users can connect to a remote workspace and share files, video and audio streams with other users. Applications running on complex visualization platforms can be easily launched and synchronized using the Digiscape framework.

Smarties - The Smarties Input System

http://smarties.lri.fr/
Contact: Olivier CHAPUIS

The Smarties system provides an easy way to add interactive support on mobile devices to collaborative applications for wall-sized displays. It consists of (i) an interface that runs on mobile devices for input, (ii) a communication protocol between the mobile devices and the wall application, and (iii) libraries that implement the protocol and handle synchronization, locking and input conflicts. Each mobile device features a set of cursor controllers ("pucks") associated with keyboards, widgets and clipboards. The pucks control cursors on the wall application, or specific content, and can be shared among users. Developers can customize the mobile interface from the application code.

MapMosaic - Dynamic Layer Compositing for Interactive Geovisualization

http://ilda.saclay.inria.fr/mapmuxing/mapmosaic/index.html
Contact: Emmanuel PIETRIGA

MapMosaic is a novel approach to combine geographical layers based on dynamic visual compositing that enables users to interactively create and manipulate local composites of multiple vector and raster map layers. It takes into account the semantics and attribute values of objects and fields in the compositing process. MapMosaic aims at better supporting GIS users in their tasks such as correlating data from multiple layers and gaining insight from the resulting visualizations.

Baia - Advanced animated transitions between before-and-after satellite images

http://ilda.saclay.inria.fr/mapmuxing/baia/index.html
Contact: Emmanuel PIETRIGA

Baia is a framework to create advanced animated transitions, called animation plans, between before-and-after satellite images. Baia relies on a pixel-based transition model that gives authors a high expressive power. The animation editor enables authors to easily represent common types of changes thanks to predefined animation primitives and to sequence different changes across time.

LODAtlas - Browsing Linked Data Catalogs with LODAtlas

http://lodatlas.lri.fr/
Contact: Emmanuel PIETRIGA

LODAtlas is a portal that enables users to find datasets of interest in the Web of Data. Users can make different types of queries about both the datasets' metadata and contents, aggregated from multiple sources. They can then quickly evaluate the matching datasets' relevance, thanks to LODAtlas' summary visualizations of their general metadata, connections and contents.

TouchTokens - Low-cost Solution for Tangible Interfaces

https://www.lri.fr/~appert/touchtokens/index.html
Contact: Caroline APPERT

TouchTokens make it possible to easily build interfaces that combine tangible and gestural input using passive tokens and a regular multi-touch surface. The tokens constrain users' grasp, and thus, the relative spatial configuration of fingers on the surface, theoretically making it possible to design algorithms that can recognize the resulting touch patterns.

WILD Input Server - Multi-device input configuration

Contact: Stéphane HUOT

The WILD Input Server (WIS) helps prototype, develop, test and debug interactive applications on cluster-based visualization platforms such as WILD and WILDER. WIS is a multi-device environment that lets users gather input from a heterogeneous resources, including standard input devices, multi-touch devices such as tablets, motion trackers and standard communication protocols (OSC, TUIO, VRPN). WIS uses the ICon data-flow visual editor to create and edit input configurations that connect input devices and interaction techniques to applications at runtime. An extension API and a dynamic plugin architecture also allows to extend WIS functionalities at runtime.

Patents

CommandBoard - Computer system with improved touch-based interface

Contact: Wendy MACKAY

CommandBoard allows users to generate the full set of available commands within an app or an application by typing the word on a soft gesture-typing keyboard followed by an ‘execute‘ gesture, or by directly drawing the gesture to execute the command.

HCC team publications (20 %)

Journal articles

Major international journals

(1) B. Caramiaux, F. Bevilacqua, M. M. Wanderley, and C. Palmer. Dissociable effects of practice variability on learning motor and timing skills. *PLoS ONE*, 13(3), Mar. 2018.

(2) E. Dimara, A. Bezerianos, and P. Dragicevic. Conceptual and Methodological Issues in Evaluating Multidimensional Visualizations for Decision Support. *IEEE Transactions on Visualization and Computer Graphics*, 24, 2018.

(3) M.-J. Lobo, C. Appert, and E. Pietriga. Animation Plans for Before-and-After Satellite Images. *IEEE Transactions on Visualization and Computer Graphics*, 24:1 – 1, Jan. 2018.

(4) M. Nancel, E. Pietriga, O. Chapuis, and M. Beaudouin-Lafon. Mid-air Pointing on Ultra-Walls. *ACM Transactions on Computer-Human Interaction*, 22(5):21:1–21:62, Aug. 2015.

(5) A. Prouzeau, A. Bezerianos, and O. Chapuis. Evaluating Multi-User Selection for Exploring Graph Topology on Wall-Displays. *IEEE Transactions on Visualization and Computer Graphics*, 23(8):1936–1951, Aug. 2017.

Conference articles

Major international conferences and workshops

(6) J. Alvina, C. G. F, X. Bi, and W. E. Mackay. CommandBoard: Creating a General-Purpose Command Gesture Input Space for Soft Keyboards. In *UIST '17 Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology*, pages 17–28, Quebec City, Canada, Oct. 2017.

(7) I. Avellino, C. Fleury, W. Mackay, and M. Beaudouin-Lafon. CamRay: Camera Arrays Support Remote Collaboration on Wall-Sized Displays. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, CHI '17, pages 6718 – 6729, Denver, United States, May 2017. ACM.

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(10) S. Fdili Alaoui, J. Françoise, T. Schiphorst, K. Studd, and F. Bevilacqua. Seeing, Sensing and Recognizing Laban Movement Qualities. In *ACM Conference on Human Factors in Computing Systems (CHI)*, Denver, United States, May 2017.

(11) C. Fleury, T. Popa, T. J. Cham, and H. Fuchs. Merging Live and pre-Captured Data to support Full 3D Head Reconstruction for Telepresence. In *Proceedings of Eurographics conference*, EG'18, Strasbourg, France, Apr. 2014.

(12) B. Fruchard, E. Lecolinet, and O. Chapuis. MarkPad: Augmenting Touchpads for Command Selection. In *Proceedings of the 35th international conference on Human factors in computing systems*, CHI '17, Denver, United States, May 2017. ACM.

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(14) G. Jalal, N. Maudet, and W. E. Mackay. Color Portraits: From Color Picking to Interacting with Color. In *Proceedings of the ACM International Conference on Human Factors in Computing Systems, 2015*, Seoul, South Korea, May 2015.

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(30) C. Appert. *From Direct manipulation to Gestures*. Habilitation à diriger des recherches, Paris-Sud XI, June 2017.

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(37) M. J. Lobo. *Interactive Transitions for Map Applications*. Theses, Université Paris-Saclay, Dec. 2017.

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(39) R. Morales Gonzalez. *Rich multi-touch input with passive tokens*. Theses, Université Paris-Saclay, Oct. 2017.

(40) C. Pindat. *A Content-Aware Design Approach to Multiscale Navigation*. Theses, Université Paris Sud - Paris XI, Dec. 2013.

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(A5) N. Boukhelifa, W. G. Cancino Ticona, A. Bezerianos, and E. Lutton. Evolutionary Visual Exploration: Evaluation With Expert Users. *Computer Graphics Forum*, 32(3):31–40, June 2013.

(A6) B. Caramiaux, F. Bevilacqua, M. M. Wanderley, and C. Palmer. Dissociable effects of practice variability on learning motor and timing skills. *PLoS ONE*, 13(3), Mar. 2018.

(A7) A.-S. Dadzie and E. Pietriga. Visualisation of Linked Data - Reprise. *Open Journal Of Semantic Web*, 8(1):1 – 21, 2017.

(A8) E. Dimara, A. Bezerianos, and P. Dragicevic. The Attraction Effect in Information Visualization. *IEEE Transactions on Visualization and Computer Graphics*, 23(1), 2017.

(A9) E. Dimara, A. Bezerianos, and P. Dragicevic. Conceptual and Methodological Issues in Evaluating Multidimensional Visualizations for Decision Support. *IEEE Transactions on Visualization and Computer Graphics*, 24, 2018.

(A10) T. Duval, T. T. H. Nguyen, C. Fleury, A. Chauffaut, G. Dumont, and V. Gouranton. Improving Awareness for 3D Virtual Collaboration by Embedding the Features of Users' Physical Environments and by Augmenting Interaction Tools with Cognitive Feedback Cues. *Journal on Multimodal User Interfaces*, 8(2):187–197, June 2014.

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(A13) P. Isenberg, P. Dragicevic, W. Willett, A. Bezerianos, and J.-D. Fekete. Hybrid-Image Visualization for Large Viewing Environments. *IEEE Transactions on Visualization and Computer Graphics*, 19(12):2346–2355, 2013.

(A14) M.-J. Lobo, C. Appert, and E. Pietriga. MapMosaic: Dynamic Layer Compositing for Interactive Geovisualization. *International Journal of Geographical Information Science*, 31(9):1818 – 1845, May 2017.

(A15) M.-J. Lobo, C. Appert, and E. Pietriga. Animation Plans for Before-and-After Satellite Images. *IEEE Transactions on Visualization and Computer Graphics*, 24:1 – 1, Jan. 2018.

(A16) M. Nancel, E. Pietriga, O. Chapuis, and M. Beaudouin-Lafon. Mid-air Pointing on Ultra-Walls. *ACM Transactions on Computer-Human Interaction*, 22(5):21:1–21:62, Aug. 2015.

(A17) A. Prouzeau, A. Bezerianos, and O. Chapuis. Evaluating Multi-User Selection for Exploring Graph Topology on Wall-Displays. *IEEE Transactions on Visualization and Computer Graphics*, 23(8):1936–1951, Aug. 2017.

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(A22) J. Li, M. Wessely, S. Follmer, and S. Mueller. Summer School for Computational Fabrication and Smart Matter. *IEEE Pervasive Computing*, 16(4):50–53, Oct. 2017.

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(A25) J. Alvina, C. G. F, X. Bi, and W. E. Mackay. CommandBoard: Creating a General-Purpose Command Gesture Input Space for Soft Keyboards. In *UIST '17 Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology*, pages 17–28, Quebec City, Canada, Oct. 2017.

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(A27) C. Appert, E. Pietriga, E. Bartenlian, and R. Morales Gonzalez. Custom-made Tangible Interfaces with TouchTokens. In *Proceedings of the International Working Conference on Advanced Visual Interfaces*, AVI '18, Grosseto, Italy, May 2018. ACM.

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(A44) C. G. F, N. Giang, G. L. F, and W. Mackay. The UIST Video Browser. In *UIST 2016 - 29th ACM Symposium on User Interface Software and Technology*, pages 59 – 60, Tokyo, Japan, Oct. 2016. ACM. Demonstration.

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(A158) C. Appert. *From Direct manipulation to Gestures*. Habilitation à diriger des recherches, Paris-Sud XI, June 2017.

(A159) I. Avellino. *Supporting collaborative practices across wall-sized displays with video-mediated communication*. Theses, Université Paris-Saclay, Dec. 2017.

(A160) J. Garcia. *Supporting music composition with interactive paper*. Theses, Université Paris Sud - Paris XI, June 2014.

(A161) S. Huot. *'Designeering Interaction': A Missing Link in the Evolution of Human-Computer Interaction*. Habilitation à diriger des recherches, Université Paris Sud - Paris XI, May 2013.

(A162) G. Jalal. *Reification of visual properties for composition tasks*. Theses, Université Paris-Saclay, Dec. 2016.

(A163) C. Liu. *Embodied Interaction for Data Manipulation Tasks on Wall-sized Displays*. Theses, Université Paris-Saclay, Dec. 2015.

(A164) M. J. Lobo. *Interactive Transitions for Map Applications*. Theses, Université Paris-Saclay, Dec. 2017.

(A165) R. Morales Gonzalez. *Rich multi-touch input with passive tokens*. Theses, Université Paris-Saclay, Oct. 2017.

(A166) C. Pindat. *A Content-Aware Design Approach to Multiscale Navigation*. Theses, Université Paris Sud - Paris XI, Dec. 2013.

(A167) A. Prouzeau. *Utilisation collaborative d'un mur d'écran en contexte critique*. Theses, Université Paris-Saclay, Dec. 2017.

(A168) O. Zinenko. *Interactive Program Restructuring*. Theses, Université Paris-Saclay, Nov. 2016.

6/ LaHDAK

Large-scale Heterogeneous Data and Knowledge

équipe
LaHDAK

Responsable: Nathalie Pernelle, Nicole Bidoit-Tollu

L'objectif de l'équipe LaHDAK est de relever les défis qui découlent de la disponibilité croissante des données et des connaissances et de proposer des solutions permettant de gérer des données complexes, sémantiquement hétérogènes, incertaines, incomplètes et évolutives, provenant de sources variées, telles que le Web social, le Linked Open Data ou les données scientifiques. L'équipe LaHDAK développe des solutions visant à résoudre les problèmes d'efficacité, de pertinence sémantique et de robustesse.

L'équipe LaHDAK rassemble des expertises complémentaires en bases de données et en intelligence artificielle. Ses travaux de recherche sont organisés autour de trois axes : la gestion des données du Web, l'intégration de données et de connaissances et, le raisonnement automatique.

Dans l'axe gestion des données du Web, nos contributions portent sur la définition de modèles formels pour des données complexes (structurées, semi-structurées, RDF, XML, graphes, annotées, probabilistes), le requêtage approximatif (graph patterns, requête skyline, recherches top-k), et l'optimisation de requêtes ou de transformations de données complexes.

Dans l'axe intégration de données et de connaissances, nos contributions portent sur la gestion et l'enrichissement de bases de connaissances (données sémantiques) volumineuses, évolutives, et hétérogénes. Ces travaux portent sur les requêtes basées sur les ontologies, l'annotation sémantique, l'intégration de données et de connaissances (liage de données et alignement d'ontologies).

Dans l'axe raisonnement automatique, nos contributions portent sur le raisonnement en présence de données inconsistantes, la découverte de connaissances à partir des données (découvertes de concepts complexes ou de règles), la diagnosticabilité ou encore la prévisibilité.



Large-scale Heterogeneous DAta and Knowledge

Head: Nathalie Pernelle, Nicole Bidoit-Tollu

The aim of LaHDAK group is to address the massive data and knowledge challenges. The main objective is to offer solutions to process complex-structured, semantically heterogeneous, uncertain, missing and evolving data, coming from any sources including social web data, linked open data, or scientific data. Semantic relevancy, efficiency, scalability and robustness are the main issues that are focussed on.

The LaHDAK team brings together two complementary expertizes, data management and artificial intelligence. Its research activities are organized in three themes: Web data management, Data and knowledge integration and, Automated reasoning.

Wrt Web data management, our contributions focus on formal models for complex data (structured, semistructured, XML, RDF, graph, annotated, probabilistic data), approximate query answering (graph-pattern queries, skyline queries, top-k queries) and data management optimization for queries and complex transformations.

Wrt Data and knowledge integration, our contributions focus on ontology-based query answering, semantic annotation, data and knowledge integration (data linkage and ontology alignment).

Wrt Automated reasoning, we focus on reasoning (how to reason with inconsistent data) and knowledge discovery (rules and complex description logic based classes), diagnosability and predictability.

Synthetic presentation

Heads of the LaHDAK team : **Nathalie PERNELLE - Nicole BIDOIT**

Staff
In January, 2013, the team had 15 faculty members (3 PR, 10 MCF) and 2 researchers (1 CR CNRS, 1 DR INRIA).
Since January 1st, 2018, the team has 12 faculty members (4 PR, 8 MCF).

Permanent members who left the group
François Goasdoue is now Professor at University of Rennes 1.
Dario Colazzo is Professor at University Paris Dauphine.
Laurent Simon is professor at University of Bordeaux.
Melanie Hershel is Professor at Stuttgart University, Germany (IPVS), since 2014/09/01.
Meghyn Bienvenu joined the Graphik team at LIRMM (Montpellier) on 2015/09/01.
Ioana Manolescu left the group for the creation of the new CEDAR INRIA project on 01/01/2016.
Véronique Ventos moved to the A&O team of the LRI in 2015.

Permanent members who joined the group
1 PR and 3 MCF have joined the team during that period :
Bogdan Cautis (PR) in September 2013 (Assistant processor at Telecom ParisTech)
Benoit Groz (MCF) in September 2014 (Postdoc researcher at University of Tel Aviv, Israel)
Yue Ma (MCF) in September 2014 (Postdoc researcher at TU Dresden, Germany)
Silviu Maniu (MCF) in September 2015 (Postdoc researcher at Huawei Noah's Ark Lab, Hong Kong).

Highlights of the scientific activity

1. LaHDAK is recognized at the highest international level with many publications in major journals and conferences dedicated to databases, semantic web, data mining and artificial intelligence.
2. We have explored new approaches to tackle the problem of querying voluminous, uncertain and incomplete data. We have defined algorithms (1) that allow fast retrieval of distance queries in probabilistic graphs, (2) that compute answers to Why-not questions to help users to understand why some expected answers are missing. We have shown the practicality of these algorithm both in terms of efficiency and accuracy, compared to existing algorithms.
3. Querying and reasoning on (inconsistent) knowledge bases is a long-standing challenge in the AI communauty. We have (1) provided new results on the complexity of ontology based data access, (2) defined inconsistency measures that can be computed on large propositionnal knowledge bases (3) designed ontology-based query approaches that are more robust to data errors by using inconsistency tolerant semantics and (4) defined algorithms that compute all the minimal ontology modules and all best excerpts to ensure access to the most relevant knowledge.
4. When the knowledge bases evolve, the ontology mappings and the semantic annotations have to evolve. We have proposed methods that can be used to detect changes, adapt mappings without recomputing them from scratch and supports semi-automatic annotations maintenance. Experiments conducted on real knowledge bases of the biomedical domain have shown that the results are promising.
5. Influence is a crucial ingredient for successful recommandation campaign in social media. To discover influent users without any assumption on the underlying diffusion model, we have proposed an original approach that leads to high quality spreads on both simulated and real datasets, while being orders of magnitude faster that state of the art Influence Maximization methods.

Number of publications

- Articles in major international journals : 21 – Other journals : 23
- Articles in major international conferences: 71 – Other conferences : 103
- Édited books : 1
- Books and chapters: 12

Five major publications

- Paul Lagree, Olivier Cappe, Bogdan Cautis, Silviu Maniu: Effective Large-Scale Online Influence Maximization. IEEE International Conference on Data Mining (ICDM), pp 937-942, 2017.
- Said Jabbour, Yue Ma, Badran Raddaoui, Lakhdar Sais, Yakoub Salhi: A MIS Partition Based Framework for Measuring Inconsistency. Proceedings of the International Conference on Principles of Knowledge Representation and Reasoning (KR), pp 84-93, 2016.

- Nicole Bidoit, Melanie Herschel, Aikaterinia Zompanaki: Efficient Computation of Polynomial Explanations of Why-Not Questions. ACM International Conference on Information and Knowledge Management (CIKM), pp 713-722, 2015.
- Duy Dinh, Julio Cesar dos Reis, Cédric Pruski, Marcos Da Silveira, Chantal Reynaud-Delaître: Identifying relevant concept attributes to support mapping maintenance under ontology evolution. Journal of Web Semantics, 29: 53-66, 2014.
- Nathalie Pernelle, Fatiha Saïs, Danai Symeonidou: An automatic key discovery approach for data linking. Journal of Web Semantics, 23:16-30, 2013.

5 softwares

- The sameAs.cc resource that has been developed in collaboration with VU University Amsterdam is the biggest set of identity links ever collected on the Linked Open Data (500 millions of sameAs links) the transitive closure of which has been computed. Data and web services allowing to query those links have been made available to the community (**http://sameAs.cc**).
- Two tools that automatically discover OWL2 almost-keys and conditional keys in large knowledge graphs (SAKEY and VICKEY) have been developed and made available.
- CQAPRI is a prototype system for query answering under AR, IAR and brave semantics over DL-LiteR inconsistant knowledge bases. The CQAPri benchmark are also available and consists in 30 inconsistent databases of growing size and ratio of conflicts.
- Nautilus analyser is an eclipse plugin designed to help developers in understanding and debugging their declaratively specified data transformations. It allows to analyze SQL queries with the help of why and why-not provenance algorithms.

Main facts illustrating the scientific visibility

- Members of the team participated to the steering committee of several major conferences (ACM SIGMOD, EDBT Association, IEEE TCDE Awards Committee) and to program committee of major conferences in our domain (IJCAI, ECML PKDD, SIGMOD, EDBT, WISE, ECAI, ...).
- We have obtained two Jean d'Alembert grants (Idex, Paris Saclay), for welcoming foreign researchers from Univ. of Trento and UC San Diego.
- Three tutorials have been presented in major conferences : *Entity resolution in the web of data* (CIKM 2013, WWW 2014) and *Knowledge Graph Completion* (WWW 2018).
- Members of the team are regularly involved in the executive committee of the national conferences BDA and IC and are also involved in the management of national research structures (GDR MaDICS) as well as in the animation of a working group (Data and Knowledge at Paris-Saclay).

Main facts illustrating the interactions with the socio-economic and cultural environment

- Member of the Conseil d'Administration of Paris-Sud University (Nathalie Pernelle, since 2016), Member of the Conseil de l'IUT d'Orsay (Fatiha Saïs, 2014–2018), Member of the Conseil de l'IUT de Sceaux (Nathalie Pernelle, 2012–2016).
- Member of the Board of IMT Télécom Sud (Nicole Bidoit, 2012–).
- Member of the CNECA, section 3 (Commission Nationale des Enseignant Chercheurs relevant du Ministre chargé de l'Agriculture) and of the CEI (Comité national pour l'Evaluation des Ingénieurs de l'INRA) (Nathalie Pernelle, 2013–2017).
- Corresponding member for the LRI at DATAIA Institute (Institut convergence), dedicated to Data Sciences, Artificial Intelligence and Society (Bogdan Cautis, 2018–) .
- Co-organization of La Fête de la Science at LRI (Meghyn Bienvenu, 2013).

Main contributions to teaching and training

- Director of the EDIPS Doctoral School of Paris-SUD (Nicole Bidoit, 2013-2015). Responsible for the creation and direction of the STIC Doctoral School of Paris-Saclay University (Nicole Bidoit, 2013-2015).
- Representative of Paris-Sud University in the EIT Digital Doctoral Program (Nicole Bidoit).
- Member of the Computer Science Departement of the Faculté des Sciences (Nicole Bidoit, permanent invited member and Fatiha Saïs, 2017–2020).
- Member of the Commission Formations of the Labex Digicosme (Nicole Bidoit).
- Head of the Computer Science Department of IUT d'Orsay(Chantal Reynaud, 2015–).
- Management of teaching (Licence & Masters) : 8 participations as leading manager.

- Computer Science département representative for International Relationships at the Faculté des Sciences (Emmanuel Waller).
- Coordinator of a MOOC (FunMooc) in english on Ethics and Scientific Integrity (Nicole Bidoit, 2016-2017) developed by Th. Baudel and Ch. Froidevaux.
- Scientific co-leader of the thematic school *Masses de données distribuées*, Oléron, (Nicole Bidoit, 2014).

Research Group Members and evolution since 2013

The tables below give all the members of the LaHDAK group during the period. The names of the present members are in bold.

Permanent Members				
Name	*First name*	*Position*	*Institution*	*Remarks*
BIDOIT	**Nicole**	PRCE	PARIS SUD	
BIENVENU	Meghyn	CR2	CNRS	until 31th Aug. 2015
CAUTIS	**Bogdan**	PR2	PARIS SUD	since 1st Sept. 2013
COLAZZO	Dario	MCF	PARIS SUD	until 31th Aug 2013
CHATALIC	**Philippe**	MCFHC	PARIS SUD	
DAGUE	**Philippe**	PRCE	PARIS SUD	
GOASDOUE	François	MCF	PARIS SUD	until 31th Aug 2013
GROZ	**Benoit**	MCF	PARIS SUD	since 1st Sept. 2014
HERSCHEL	Mélanie	MCF	PARIS SUD	until 31th Aug. 2014
MA	**Yue**	MCF	PARIS SUD	since 1st Sept. 2014
MANIU	**Silviu**	MCF	PARIS SUD	since 1st Sept. 2015
MANOLESCU	Ioana	DR2	INRIA	until 31 Dec. 2015
PERNELLE	**Nathalie**	MCFHC	PARIS SUD	
REYNAUD	**Chantal**	PRCE	PARIS SUD	
SAFAR	**Brigitte**	MCFHC	PARIS SUD	
SAIS	**Fatiha**	MCF	PARIS SUD	
SIMON	Laurent	MCF	PARIS SUD	until 31th Aug 2013
VENTOS	Véronique	MCF	PARIS SUD	until Aug. 2015
WALLER	**Emmanuel**	MCF	PARIS SUD	

PhD students				
Name	*First name*	*Funding*	*Institution*	*Remarks*
ALEC	Céline	Alloc. Ministère	PARIS SUD	01/10/13-26/09/16
BAHRI	**Maroua**	Digicosme		1/05/17-
BONAQUE	Raphael	DIGICOSME	INRIA	1/10/13-30/09/16
BOURGAUX	Camille	Alloc. Ministère	PARIS SUD	1/10/13-29/09/16
CAMACHO RODRIGUEZ	Jesus	Alloc. Ministère	PARIS SUD	08/09/11-25/09/14
CARDOSO	**Silvio**	FNR Luxembourg	PARIS SUD	18/11/15-
CHEN	**Jieying**	CSC	PARIS SUD	1/10/2015-
DOS REIS	Julio Cesar	FNR Luxembourg	PARIS SUD	01/10/11-24/10/14
IBRAHIM	Hassan	Alloc. Ministère	PARIS SUD	7/01/13-16/12/16
ILEANA	Ioana	FP7 Arcomem	Paris Sud	1/01/2011-24/10/14
LAGREE	Paul	ANR ALICIA	Paris Sud	1/10/2014-12/10/17
LEBLAY	Julien	Alloc. Ministère	PARIS SUD	1/01/10-27/09/13
PALACIOS	**Luis**	CIFRE	PARIS SUD	1/06/16-
RAAD	**Joe**	LIONES-CDS Paris Saclay	AgroParisTech	01/10/15-
ROATIS	Alexandra	CDD sur contrat UPS	INRIA	01/09/11-22/09/14
KATSIFODIMOS	Asterios	Contrat INRIA	INRIA	01/09/09-5/07/13
KHEFIFI	Rania	ANR PIMI	PARIS SUD	01/10/10-26/09/14
MORTEROL	Martin	Alloc. Ministère	PARIS SUD	01/10/13-13/12/16
RAMACHANDRA RAO	**Sanjay**	ANR GOASQ	PARIS SUD	01/10/16-
SYMEONIDOU	Danai	Alloc. Ministère	PARIS SUD	5/10/11-9/10/14
TZOMPANAKI	Aikaterini	Alloc. Ministère	PARIS SUD	01/10/12-14/12/15
ZAATITI	**Hadi**	CEA	PARIS SUD	01/10/15 -
ZHANG	**Zheng**	CSC	PARIS SUD	01/10/16 -
ZAMPETAKIS	Stamatis	Contrat INRIA	INRIA	08/09/11-24/09/14

Temporary personnel				
Name	*First name*	*Position*	*Institution*	*Remarks*
DECHAUX	**Eva**	Engineer	Paris Sud	01/09/17-31/08/18
DJAHANDIDEH	Benjamin	Engineer	INRIA	01/10/13-30/09/15
DUMONT	Cyril	Engineer	DIGITEO	01/10/20-31/12/14
GHOSH	Tushar	Engineer	INRIA	05/12/11-04/12/13
GONZALES MALAVERRI	**Joana**	Post-doc	PARIS SUD	15/05/18-14/05/19
MUNOZ NARANJO	Juan Alvaro	Engineer	INRIA	01/03/14-31/12/14
KAOUDI	Zoi	Post-doc	INRIA	01/09/11-31/10/13
LU	**Kevin**	Engineer	Paris Sud	01/02/18-31/01/19
MENDOZA RIVERA	Oscar	Engineer	INRIA	02/11/15-31/12/15
PAPALEO	Laura	Post-doc	PARIS SUD	01/01/14-30/06/15
ROY CHOWDHURY	Soudip	Post-doc	INRIA	01/09/13-30/06/15

Group evolution

The group has been leaded from september 2013 to june 2016 by Chantal Reynaud and by Nicole Bidoit (as co-director). Since June 2016, LahDAK is now leaded by Nathalie Pernelle and Nicole Bidoit. During this period, the number of permanent members has remained rather stable despite the arrival and departure of several members: Bogdan Cautis (PR) has been hired in 2013, Benoît Groz (MCF) and Yue Ma (MCF) in 2014, Silviu Maniu (MCF) in 2015. Dario Colazzo (MCF) has been hired as professor at the University of Paris Dauphine in 2013. Laurent Simon (MCF) has been hired as professor at the University of Bordeaux in 2013. Melanie Hershel (MCF) has been hired as full professor at the University of Stuttgart in 2014. Meghyn Bienvenue (CR) has joined the Graphik team of the University of Montpellier in 2015. Ioana Manolescu (DR INRIA) was leading the joint project OAK (2012-2015) between Inria Saclay and University Paris Sud (LaHDAK team). In december 2015, she created a new joint INRIA project with LIX (Ecole Polytechnique) called Cedar.

Bogdan Cautis was on extended leave from 2015 to 2017. He was a senior researcher at the Huawei Noah's Ark Lab, Hong Kong during this period. Fatiha Sais got a one year CNRS delegation and then 6 months INRA delegation to collaborate with INRA-AgroParisTech, from Sept. 2016 to Feb 2018. Philippe Dague had a 6 months leave at Biosys INRA Jouy from Sept. 2015 to Feb. 2016 and 18 months at Lifeware INRIA Saclay from Jan. 2018 to June 2019.

The team was pleased to host : Liliana Ibanescu (MCF, AGroParisTech–INRA) for 6 months, Yannis Velegrakis (Univ. of Trento) for 9 months, Alin Deutsch (Univ. South California) for 8 months.

Nathalie Pernelle has defended her HDR in 2016.

The team has supervised 24 PhD students, of which 16 have defended their thesis. It also has welcomed 15 master students (M2 and M1) and supervised 7 internships of L3 students interested in our research topics.

Research Description

The research activities of the LaHDAK team are organized in three themes : Web data management, Data and knowledge integration and, Automated reasoning. The main contributions of each theme are introduced below.

Web Data Management

Scientific coordinator: B. Cautis; Permanent members: N. Bidoit, B. Groz, M. Hershel, S. Maniu, I. Manolescu, F. Saïs, E. Waller.
PhD theses: R. Bonaque, J. Camacho Rodrigues, I. Ileana, R. Khefifi, P. Lagree, J. Leblay, A. Roatis, A. Tzompanaki, S. Zampetakis. In progess: Maroua Bahri.
Key words: Uncertain data, information extraction, semi-structured data, crowdsourcing, social networking, query optimization, materialized views, top-k, personalisation, updates and dynamic constraints

In this axis, our recent research activities cover a large spectrum in data management and data mining, from foundational results to systems solutions. In particular, we focus on several key areas, at the intersection of databases and data management systems, Web mining, the Semantic Web and knowledge management.

Validating Semi-structured Documents Schemas. XML Schema (and DTDs) are among the most popular schema languages for web data. To simplify the task of validating documents against the schema, these schema languages rely on deterministic regular expressions, a specific subclass of regular expressions. We introduce (9) the first optimal algorithms for checking if a given regular expression (possibly with counters) is deterministic, and introduce mostly optimal algorithms for the evaluation of such expressions.

In collaboration with: Universität Bremen.

Optimization of relational queries using views. We revisit in (45) the Chase&Backchase (C&B) algorithm for query reformulation under constraints, which provides a uniform solution to problems such as view-based rewriting under constraints, semantic query optimization, or physical access path selection. For an important class of queries and constraints, C&B has been shown to be complete, i.e. guaranteed to find all (join-)minimal reformulations under constraints. While the conventional wisdom has held that completeness is a concept of mainly theoretical interest, we show that it can be preserved at practically relevant cost by introducing a novel reformulation algorithm, which allows to directly "read off" the minimal reformulations from the result of a single chase of a universal plan, thus saving exponentially many chase steps. We exhibit natural scenarios yielding speedups of over two orders of magnitude between the execution of the best view-based rewriting found by a commercial query optimizer and that of the best rewriting found by our algorithm.

In collaboration with: University of California San Diego.

Why-not Provenance. Today, in many domains (sciences and others), massive amounts of data are being generated and then processed to answer various types of questions (analytical, statistical, scientific, etc). In the output of a query, it is essential to be able to understand why certain data are obtained. It is equally important to be able to understand why some expected data are missing from a query result with the purpose to debug the query. In this context, we formalize *Why-Not* questions and their answer (query based explanations), we propose an efficient algorithm (Ted++) (19)(18) in order to compute answers of Why-Not questions and finally, we tackle fixing conjunctive queries (FixTed) (A155) based on these explanations. Evaluation and comparative studies are available (A54). This work is integrated in the Nautilus Analyzer.

Rich Queries on Real-World Graphs. We consider dealing with search tasks over rich graph content, which may have a social or/and semantic dimension. Social contents such as blogs, tweets, news etc. are examples of such rich sources of interconnected information. In (A65), we identify a set of requirements for the meaningful exploitation of such rich contents, and provide a new data model S3, the first to fulfil these requirements. This model captures social relationships between users, and between users and contents, but also the structure present in rich social content, as well as its semantics. We designed top-k keyword search algorithms taking into account the social, structured, and semantic dimensions, and provide for them formal and empirical analysis.

In the same context although assuming data is uncertain or probabilistic (e.g., speed distribution or probability of a relationship existing), we study (A18) algorithms to allow fast retrieval of distance queries in probabilistic graphs, based on tree decompositions of graphs, a concept closely related to that of the well-known graph treewidth measure, by designing ProbTree, an indexing framework on graphs. We currently extend the tree-decomposition approaches to cases where the edges are labeled, and the queries are more complex than just distance queries (e.g., asking for the expected arrival time on a route which only uses buses). We currently work on generic approaches using provenance annotations on the graph edges, an extension of the provenance semirings in relational databases.

In collaboration with: Université Rennes 1, École Normale Supérieure, Inria, Téécom ParisTech.

Social-aware and context-aware top-k query answering. For a specific model of graph social data, we focus on social-aware as-you-type keyword search. This raises new challenges for effectiveness and efficiency in online search, and we describe a memory-efficient and incremental prefix-based retrieval algorithm. In (11, 50), in collaboration with industry partners (Yahoo Research), we evaluate our approach through extensive experiments for several applications and search scenarios, in microblogging (Yahoo's Tumblr, Twitter) or for business (Yelp) and movie (Amazon) reviewing. They show that our solution is effective in answering real-time as-you-type searches over social media.

In collaboration with: Yahoo Research Barcelona.

Knowledge Base enabled query recommendation in Web search. In an application environment of mining graph data for information needs, we revisit in (A90) query recommendation algorithms, which are designed to provide related queries for search engine users. Most of the existing solutions, which perform extensive analysis of the users search history (or query logs), are largely insufficient for long-tail queries that rarely appear in query logs. To handle such queries, we study a new solution, which makes use of

knowledge graphs (or knowledge bases – KB), such as YAGO and Freebase. A KB is a rich information source that describes how real-world entities are connected. We extract entities from a query in order to explore new ones in the KB. Those discovered entities are then used to suggest new queries to the user. As shown by our experiments, our approach provides better recommendation results for long-tail queries than existing solutions.

In collaboration with: University of Hong Kong.

Querying specific knowledge on the web: beyond the power of keyword search. Although a relevant part of Human Knowledge is on the web, getting at it and into its structure so as to make the best of it is not easy. We address that issue by focusing on a restricted and well structured area: graph theory theorems on the web. Answering with Google bibliography queries such as "What is the minimal degree for a claw-free graph to be hamiltonian?" may be very difficult, and for some queries we conjecture impossible. We propose a query language taking advantage of the implicit structure of the theorems to answer such queries. We try simultaneously to prove formally or/and experimentally that Google cannot express such queries, and that our language can.

In collaboration with: LRI Galac team.

CrowdSourcing. We develop methods for evaluating queries over uncertain data with the crowd while considering two types of queries : boolean properties and order queries (skylines). A typical use case for boolean queries could be: using web users to decide which images in a large set contain a car. For order queries, we would ask users to order hotels according to multiple criteria (price, distance...) in view of discarding the irrelevant ones. The main objective here is to obtain highly accurate classification with a minimal amount of work from web users. We finalized our work about optimizing the crowd for filtering objects satisfying a boolean property (42), and also designed algorithms to compute skylines (=Pareto optima) from noisy comparisons (A88, A38).

In collaboration with: Tel-Aviv University.

Influence maximization in social media. Word-of-mouth effects and influence are nowadays crucial ingredients for successful recommendation campaigns in social networks. We study the influence maximization (IM) problem, for finding influent users (nodes in a graph) so as to maximize the spread of information. We study a version of IM in which we maximize influence campaigns by adaptively selecting spread seeds from a set of candidates, a small subset of the node population. Influencer marketing is one straightforward application of this kind. According to our main motivation, we make the hypothesis that, in a given campaign, previously activated nodes remain persistently active throughout, and thus, do not yield further rewards. We make no assumptions on the underlying diffusion model and we work in a setting where neither a diffusion network nor historical activation data are available. This problem, called online influence maximization with persistence (OIMP) is addressed in (49) using an original approach based on multi-armed bandit techniques for adaptive learning and show that it leads to high-quality spreads on both simulated and real datasets, while being orders of magnitude faster than state-of-the-art IM methods.

In collaboration with: University of Hong Kong, Télécom ParisTech.

Context-aware Personal information Management. In the setting of Personal Information Systems (PIMS), we explore the problem of modelling, querying and composition of personal information. We consider that the use and the access to personal information is context dependent (e.g., social, geographical). In the one hand, we propose an approach which represents heterogeneous personal information through multiple point-of-view ontologies. In the other hand, we develope a context-aware service composition method (48) that allows the automatic realization of on-line procedures and the automatic filling of online forms through a context-aware querying of the personal information system.

In collaboration with: Université Paris Nanterre.

Cloud computing and organisational design. Due to the generative nature of digital technology, new business models and therefore new ways of organising are continuously emerging, inducing a continuous

change in the competitive landscape. When considering more specifically cloud adoption practices by organisations, the issue of identifying and combining the key factors to suggest a relevant adoption is crucial (A28). In (A174), technical and economic factors governing the cloud adoption are analysed and a set of dimensions for positioning firms are provided. The rule-based model proposed has been validated against a representative set of companies.

In collaboration with: RITM, Faculté Droit - Economie - Gestion, U. Paris-Sud and Télécom ParisTech.

Integration of Data and Knowledge

Scientific coordinator: F. Saïs; Permanent members: N. Pernelle, C. Reynaud, B. Safar, F. Saïs.
PhD theses: C. Alec, J. Dos Reis, D.Symeonidou. In progess: S. Cardoso, J. Raad.
Key words: Identity Management, Knowledge Discovery, Ontology and Data Evolution, Semantic Annotation, Ontology Enrichment

This axis of research contributes to the problem of identity management in the Web of data through the development of several methods handling the problems of identity link invalidation, contextual identity link detection and key discovery. We have also studied and contributed to the problem of data and ontology evolution. In particular, we focus on ontology mapping maintenance in the biomedical domain and more recently on automatic maintenance of biomedical document annotations when ontologies and mappings evolve. We also propose an approach that aims to enrich knowledge bases by learning new concepts definitions from annotated documents. Furthermore, we develope an approach which predicts missing values in a knowledge base from a set of existing expert rules.

Data Linking and Identity management. Most of Semantic Web (SW) applications currently rely on the use of *owl:sameAs* predicate for linking objects. Indeed, exploiting identity links over RDF objects allows applications to efficiently integrate data. However, several studies have identified multiple misuses of identity link. These misuses, mainly caused by the lack of other less-strict and context-aware linking alternatives, can lead to erroneous statements or inconsistencies. We first propose an approach (A208) that automatically detects erroneous *owl:sameAs* links by exploiting ontology axioms through logical reasoning. We also collected the identity links that are available on the Linked Open Data and propose web services that aim to query those links (500 millions of links) after the application of the transitive closure (sameAs.cc) (A50). We also developed DECIDE (A107) that is dedicated to the discovery of contextual identity link. It provides for every pair of objects the more specific semantic contexts in which they are identical. The evaluation on INRA scientific knowledge bases describing transformation processes shows the relevance of the contextual identity links and their usefulness for generating prediction rules.

Many data linking approaches are based on keys which are rarely available. KD2R (13), proposes a method that efficiently discovers keys from large knowledge bases (KBs) under the unique name assumption. It discovers first the maximal non-keys and then derives minimal keys. We develop SAKey, an approach (58) for discovering $n-$almost-keys (keys with n exceptions) in KBs where redundancies and errors may occur. Finally, we designed VICKEY (57), the first approach to discover minimal conditional keys, i.e., keys that are valid only for a subset of class instances fulfilling specific conditions on the property values. The evaluation of the three approaches on real large KBs (e.g. Yago and DBPedia) demonstrates the relevance of the keys, the almost-keys and the conditional keys for identity link discovery: significant improvements of the recall while keeping good precision. They also show good efficiency results by scaling up to KBs of millions of triples. We also compare theoritically and experimentally our approaches with other key discovery approaches with different semantics (A243) and we show that specific preprocessing and specific quality measures can be defined for numerical data (i.e. wine chemical components obtained from the Pilotype project) (A214).

In collaboration with: LIG-Grenoble, LIRMM, INRA Montpellier, INRA AgroParisTech, Télécom ParisTech, Aalborg University, and VU University Amsterdam.

Ontology : evolution and maintenance Knowledge Organization Systems (KOS) are used for mapping heterogeneous datasets. Such mappings must be updated when the underlying knowledge sources evolve. One central question is how to find, as automatically as possible, updates of mappings between changing KOS, in an incremental manner (without recomputing the mappings from scratch) (35). This question is studied for biomedical information systems in (64). We started by analysing real organization systems to understand the impact of changes over mappings. Then, we propose a method to perform

fine-grained analysis of the changes on attributed concepts, plus methods used to detect changes in order to adapt the KOS mappings. These methods have been implemented and evaluated with promising results.

We are also interested in the semi-automatic maintenance of semantic annotations. In (A170), based on bio-medical data, we highlight the correlation between changes in the ontologies and changes in the annotations. New features are included in the existing annotation formalisms in order to support semi-automatic annotations maintenance and a four level approach is introduced, combining different methods to process to the annotation adaptation. Finally, we build a semantic network able to keeping the modified annotations searchable without to change them when they cannot be. This solution proves to be a valuable solution even in the case where changes on annotations can be performed.

In collaboration with: LIST at Luxembourg.

Ontology enrichment and population from texts and data from LOD: Application to automatic annotation of documents. This work (15) deals with an ontology-driven approach for semantic annotation of documents from a corpus where each document describes an entity of a same domain. The goal is to annotate each document with concepts that are too specific to be explicitly mentioned in texts. The only thing known about the concepts is their labels, i.e., we have no semantic information. Moreover, their characteristics in the texts are incomplete. Our approach aims at performing the annotation process by combining several approaches. It relies (1) on a domain ontology relative to the field under study, which has a pivotal role, (2) on property assertions population coming from documents and external resources, and (3) on enrichment with formal specific concept definitions. Experiments carried out in two application domains, show the benefit of the approach compared to well-known classifiers.

In collaboration with: start-up Wepingo.

Prediction of missing values. Incompleteness of knowledge bases (KB) is one of the crucial problems when one attempts at making decisions from available knowledge. For decision support issues, we propose an approach which enriches an existing KB by constructing new predictions. More precisely, it relies on knowledge expressed by numerous existing causal rules that are extracted from various scientific publications in a specific domain. Our predictive approach (A21) is in two steps: a reconciliation step which identifies groups of similar rules expressing a common experimental tendency, and a prediction step which generates new rules, using both descriptions coming from experimental conditions and similar rules obtained in the reconciliation step. The method has been evaluated over a case study related to food science and has been compared to a decision trees. It provides better results in terms of accuracy, completeness and error rate which showed the relevance of such a data reconciliation-based approach.

In collaboration with: INRA Montpellier.

Automated Reasoning

Scientific coordinator: Y. Ma; Permanent members: M. Bienvenu, P. Dague, P. Chatalic, Y. Ma, C. Reynaud.
PhD theses: C. Bourgaux, H. Ibrahim, M. Morterol. In progress: J. Chen, L. Palacios, S. Ramachandra Rao, H. Zaatiti, Z. Zhang. *Key words*: Reasoning in description logic, reasoning in propositional logic, model-based reasoning, diagnosis, diagnosability, distributed reasoning

In this axis, we work on automated reasoning problems for different formal systems, including logic based knowledge bases, ontology based data access, discrete event systems, and metabolic networks.

Ontology based data access We study the problem of answering queries in the presence of ontologies from several aspects: complexity, algorithm, expressivity. In particular, we have contributed to: (1) extend the query class to be used in the context of considering different query types based on regular paths (23); (2) better understand the possibilities and the limits of the query rewriting techniques by studying the size and the existence of a rewriting; (3) establish the correspondences with other formalisms (datalog, constraint satisfaction problems) to be able to exploit the techniques and results from other research domains (2).

In collaboration with: Sapienza Universitàdi Roma in Italy, Universität Bremen in Germany, University of

Liverpool in UK, Free Univ. of Bozen-Bolzano of Italy, Vienna Univ. of Technology of Austria.

Handling inconsistency/uncertainty Reasoning about inconsistent knowledge bases (KBs) has been a long-standing challenge in the AI community. In recent years, measuring inconsistency has proved useful in diverse scenarios. We focus on reasoning and querying with inconsistency/uncertainty, as well as measuring inconsistency of logic-based knowledge bases, with the goal to tolerate imperfect semantic data. We propose a general framework, for defining a family of fine-grained inconsistency measures for propositional knowledge bases (46, 47). A set of MinCostSAT-based encodings is provided, which enables the use of efficient SAT solvers for the computation of the proposed measures. We implemented these algorithms and tested them on real-world datasets. The preliminary experimental results for a variety of inputs show that our framework gives a wide range of possibilities for evaluating large knowledge bases.

In the context of ontolgy based data access (see above), we also develop different approaches in order to increase robustness to data errors by using inconsistency tolerant semantics and we propose techniques to help users clean their data (25, 22, 21, 20).

In collaboration with: CRIL, IRISA, Telecom SudParis, Griffith University in Australia, Tianjin University of China.

Ontology excerpts and minimal modules extraction: Ensuring access to the most relevant knowledge contained in large ontologies has been identified as an important challenge. In this context, we use techniques such as justification, SAT, description logics, reasoners. We introduce the notion of subsumption justification as an extension of justification (a minimal set of axioms needed to preserve a logical consequence) to capture the subsumption knowledge between a term and all other terms of the vocabulary (31). We show how subsumption justifications can be used to obtain minimal modules and to compute best excerpts by additionally employing a partial Max-SAT solver. This yields two state-of-the-art methods for computing all minimal modules and all best excerpts, which we evaluate over large biomedical ontologies.

In collaboration with: INRIA ILDA project, Fraunhofer IVI Germany.

Ontology complex concept learning The aim of this work is to learn interesting patterns from (even few) data in the form of complex Description logic based concepts. In contrast to prediction approaches, the benefit of our method is two-fold: returning a human-readable explanation of the results and discovering implicit but meaningful situations that are not explicitly through manual labels. The approach has been integrated into a Thales Research Technology platform for assisting avionics experts to repair equipments.

In collaboration with: Thales TRT, Palaiseau.

Diagnosability Here, we focuse on diagnosability and predictability analysis of discrete event systems, in particular for distributed systems (7, 59) and for probabilistic systems (A202, A61). One direction studied is the use of incremental SAT for diagnosability analysis (A189, A188) and diagnosability planning for controllable systems (A50, 15). The new concept of fault manifestability was introduced and its verification studied (A92, A175). Extension of diagnosability analysis to real-time systems modeled by timed automata and its verification by SMT solvers was studied (A49). Extension to hybrid systems by using timed automata abstractions and refinement process guided by counterexample is ongoing (A70, A76).

In collaboration with: LRI ModHel team, CEA LIST and LSIS.

Metabolic pathway analysis The aim of this work is the analysis of metabolic networks, in particular computation of elementary flux modes (efms), which are the minimal pathways at steady state. We investigate the use of SAT and SMT for computing efms in presence of Boolean regulation constraints (A200). Characterization of efms in presence of thermodynamic (A19, A209, A42) or kinetic constraints has been theoretically studied and their computation using the double description method in convex geometry is ongoing. A qualitative energetic model for nutrition is used as an application domain.

In collaboration with: LRI Bioinfo and Galac teams, Lifeware Inria-Saclay project.

Team Organisation

Team Organisation

The LaHDAK team, permanent researchers, PhD students, post-doctorants, engineers and master research, meets two times per year. The first part of these meetings is devoted to present new members, to let each member briefly introduce their current research topics. The second part is devoted to organizational issues : general news, new projects, project submissions, or budget. Some responsibilities are hold by specific members: Brigitte Safar is in charge for the allocation of offices, Emmanuel Waller is in charge of computers, Benoit Groz is in charge of HAL and Philippe Chatalic is in charge of the web site. The permanent members meet fourth times per year and team members hold regular meetings for each research activity. In addition, during the period, we conducted a series of seminars with a frequency of one seminar every three weeks (73 talks): 30 seminars were given by french or foreign researchers and the remaining seminars were given by Lahdak members/PhDs. Trainees are invited to these seminars and a particular seminar is organized in july devoted to the work of the master students. All these seminars allow the members to present their research, to talk about new projects but also to express particular needs. Thanks to our grants and the budget allocated by the laboratory, we were able to cover all our needs (mission, internships, material) during this period aimed at permanent or non permanent members or the trainees.

Self Assessment

Strengths: During the last period, the team has succeeded in merging the activities of the Database and IASI teams. These complementary expertizes are particulary relevant to cover the massive complex data and knowledge challenges (Making Sense of Data). It allows us to provide contributions (formal models, algorithms, applications) over the whole data and knowledge spectrum, from data management to reasonning and knowledge discovery.
Another strength of our contributions is the validation of most of our research results on real data (biomedical data, wine chemical components, biological transformation processes, DBPedia, Yago, Tweeter, ...). In terms of partnership, the team has long term collaboration with UCSD (San Diego), the LIST (Luxembourg), INRA Montpellier and Agro ParisTech, LTCI at Telecom ParisTech and the Valda INRIA project at ENS Ulm. The team has also developed collaboration with Bioinfo and Modhel LRI teams and with Iles LIMSI team. During these period, the team has attracted colleagues from outside the lab: Bogdan Cautis from LTCI - Telecom ParisTech, Benoît Groz from Tel Aviv Univ., Silviu Maniu from Huawei Noah'sArk Lab, Yue Ma from TU Dresden. We also hosted long term international visitors: Yannis Velegrakis from Trento Univ. and Alin Deutsch from UCSD.

Weaknesses: The stability of the team workforce is hiding a somewhat high turnover. During this period, although four colleagues were hired, the team has lost seven other members out of which one DR INRIA (I. Malolescu) and one CR CNRS (M. Bienvenu). At this point of time, there is no full researcher in the team which is unfortunate and penalizes our research efforts and project investigation. This has to be added to the very strong investment in administrative tasks: head/creation of Paris Saclay STIC doctoral school (N. Bidoit), head of IUT Computer Science Department (Ch. Reynaud), head of the LRI (P. Dague until 2014). The team is also strongly involved in teaching management (8 master or licence year managements).

Opportunities: The emergence of projects, institutes (for instance DataIA, Center for Data Science) in the Paris Saclay area is a real opportunity for the team to strengthen existing collaborations (for instance, RITM at Jean Monet University, INRA Agro ParisTech, LIMSI) and develop new ones. Furthermore, in the context of Paris Saclay lab restructuration, our team is involved in starting a collaboration with researchers of the ROCS LRI team working on the Internet of Things.

Threats: During the next period, five permanent members (4 PR and 1 MCF) may retire meaning that the team will have to build on its attractivity to anticipate the outgoing flow and also to strenghen its effort to recrute full researcher.

Strategy and five-year project

In the very next future (Sept. 2018), the members of the Data and Knowledge Management group of the LRI Modhel team will join LaHDAK. These researchers are specialist of data integration, semantic annotation, recommendation systems, user profiling and social network analysis. Joining these two groups of researchers will strengthen even further the team advanced expertises and open new opportunities towards meeting the big data and knowledge challenges ("Making sense of Data") requiring to combine techniques coming from both databases and artificial intelligence areas. Join projects have already been run by members of both teams. For instance, a technological maturation project on data integration, user profiling and data anonymisation has recently been accepted through the SATT of Paris Saclay..

Scientific Programme

We are experiencing an unprecedented production of resources and for many modern data-rich and data-driven applications (medicine, astronomy, social data, data sourcing, physics, economics, etc), data is often heterogeneous, complex-structured, may have errors and missing information. These applications are leading to the creation of data/knowledge graphs that may contain billions of Resource Description Framework (RDF) triples, such as DBpedia, YAGO and Wikidata on the academic side, and the Google Knowledge Graph or Microsoft Satori graph on the commercial side.

The Linked Open Data (LOD) resources describing real world entities are linked one to each other, mostly through *owl:sameAs* links. However, several studies showed that many of them are erroneous. Hence, there is a real need to spend efforts for developing **link invalidation methods** that combines different kinds of information such as identity graph topology, resource description and provenance information (collaborations with VU Amsterdam and NII Tokyo). We are also interested in defining new strategies for ontology-based **identity link detection** approaches. We aim at developing approaches that can efficiently learn key graphs from voluminous RDF datasets and to define new strategies that can combine data linking approaches that exploit approximate but efficient keys with refined invalidation approaches. We will also spend more efforts on defining new **logic based approaches for concepts discovery** ie for learning interesting patterns from (even few) data in the form of complex Description logic based concepts. In contrast to prediction approaches, the benefit will be a human-readable explanation of the results.

Handling imperfect data in a knowledge base is an important task for knowledge engineering and management. We will handle this problem wrt (1) defining **nonstandard entailment semantics** and its reasoning techniques, and (2) the rational of **knowledge measuring**, (3) handling **fact validation and veracity assessment**.
Wrt (1), we are interested in examining argumentation based approaches which offer advantageously precise evidences of reasoning results. Wrt (2), we will study new measures, for instance using ontology modules, justifications, and excerpts to define an ontology measure able to compare the information richness of different ontologies. Wrt (3), we will develop new approaches able to consider the whole knowledge graph, as well as ontology axioms while assessing the veracity degree of the facts. These research directions will be investigated in collaboration with CRIL (University of Artois), Telecom SudParis, Fraunhofer IVI Germany and INRA AgroParisTech.

Semi-structured data and graph data are currently experiencing a comeback, either in native (dedicated) systems or as part of hybrid data models and systems (such as the so called polystores). They cut across many data-centric applications and are fuelled by the recent trends of NoSQL, BigData, and mining over large and heterogenous volumes of data. In this context, classic database problems such as query optimisation, query answering, or data updates must be revisited, from formal foundations to highly efficient solutions, in order to deal with the well-known "Vs" characteristic of data management in modern applications. Regarding *volume* and *variety*, one important perspective of research is the one on **polystore systems**, based on the "one size does not fit all" philosophy, integrating seamlessly dedicated stores, data structures, algorithms, for various models (relational, RDF, JSON, key-value, array, etc). Regarding *veracity*, we will continue to study **uncertain graph data models**, as well as problems such as **data provenance** and data attribution in social / diffusion graphs. Regarding *velocity*, we intend to focus in particular on querying and mining solutions over highly dynamic / streaming data scenarios, such as in micro-blogging and mobile applications.

Automatically or semi-automatically question answering raises challenges that have been targeted separately over the last years by different communities, including Query Answering in Semantic Web based on structured semantic data and Question Answering in Natural Language Processing based on unstructured textual data. While the former is powerful in representing complex questions and exploring background knowledge (e.g., large biomedical ontologies), it is often difficult to master and cannot be used without a specialized user interface. In contrast, the latter can formulate constraints that cannot be handled by query answering approaches. But then it is not obvious how to take into account the background and common sense knowledge to get precise answers over unstructured data. The objective of this work is to study **hybrid question answering** techniques by taking advantage of question/query answering systems over structured or unstructured knowledge. This work will be done in collaboration with LIMSI CNRS and TU Dresden, Germany.

Most information is published in structured and evolving databases or documents and this information should be cited or annotated appropriately. We will pursue our work on **automatically update and enrich document annotations** in order to take into account the evolution of the underlying ontologies, in collaboration with LIST Luxembourg. We are also interested in defining new formal models for database annotations, and we will study how annotated databases can be efficiently queried and semantically enriched.

An important part of the Web content is created and exploited by social media or crowdsourcing applications. Effectively answering user needs in personalized search or in recommendation scenarios requires fine-grained user profiling, rich graph-based data models, capturing interconnections, semantics, or information diffusion patterns. At the same time, privacy, provenance, trustworthiness, recency, or geolocation may represent crucial ingredients when dealing with **data from social media**. Our work in this area will also have an interdisciplinary reach, pertaining to domains such as journalism and marketing to cite a few.

We also intend to focus on computational problems pertaining to **influence estimation and influence maximization in social media**. Word-of-mouth effects and influence are nowadays crucial ingredients for successful recommendation campaigns in social networks. Some of our most recent research deals with understanding influence patterns and using them when running spread campaigns in social networks, using network inference techniques and sequential learning (multi-armed bandits) for online learning settings. We will continue in this direction and we intend to focus on more realistic scenarios than those usually covered by the state-of-the-art, making no (or very few) assumptions on the underlying diffusion models and diffusion medium. In this way, we hope to obtain more generic methods with broader practical applicability.

Important questions that we envision to explore are related to **data anonymisation, reproductibility**. A new project with the start-up DataForYou has been selected by the SATT Paris Saclay in which new data anonymisation approaches will be defined to anonymise data based on the (conditional) keys. Furthermore, we aim at using our expertise in data provenance shared with and in collaboration with the BioInfo team in order to develop reproducibility enhancement technics for data intensive computation, not limiting ourselves to workflows but investigating other less structured data access. For example, one challenge is to provide researchers including computer scientists with tools to trace the development of scientific results.

Annex 4

Collaborations

Participation to national and international collaborative research projects

International projects

- NII (National Institute of Informatics in Tokyo) collaborative Research Project Fun2GPCR: Process-centric functional grammar for generating and proving cooking recipes (2017-2018). Coordinator: Frédéric Andrès. Scientific co-leaders: Fatiha Saïs and Emmanuel Waller.
- KEYSTONE: Semantic keyword-based search on structured data sources (EU COST – 2013-2017). Coordinator and WG co-chair: Bogdan Cautis. Participants: Ioana Manolescu. Partners from approx. 25 countries.

- CCIPX "Curating and Crowdsourcing Information using Probabilistic XML" (STIC Asie 2013 – 2014). Collaboration France – Asia, with National University of Singapore et Hanoi University of Science and Technology. Participant: Bogdan Cautis.
- Oaksad "Expressive and efficient tools for complex Web data processing". Associated team project between INRIA and UC San Diego. Participants: Ioana Manolescu, Bogdan Cautis.
- LIST-Luxembourg Institute of Science and technology: Agreement for the Co-Supervision of a Doctoral Thesis on Evolution of Semantic Annotations. (2015-2018). LRI co-supervisor: Chantal Reynaud. LIST co-supervisor: Cédric Pruski.
- ANR International project GOASQ: Generating and Answering Ontological Queries (2016-2019) among LRI, LIMSI, and TU Dresden (Germany). Coordinator: Yue Ma. Participants: Philippe Chatalic, Philippe Dague, Chantal Reynaud.

National projects

- Qualinca: Quality and Interoperability of Large Bibliographical Knowledge Bases, ANR grant (2012-2016). Coordinator for LRI : Fatiha Saïs. Partners: Agence Bibliographique de l'Enseignement Supérieur (ABES), Institut National de l'Audiovisuel (INA), Laboratoire d'Informatique de Grenoble (LIG), Laboratoire d'Informatique de Robotique et de Microélectronique de Montpellier (LIRMM)
- ANR project PIMI: Personal Information Management through Internet (2010-2013). Coordinator: Pascal Poizat. LaHDAK members: Fatiha Saïs. Partners: Paris Sud University, Paul Sabatier University, Paris-Dauphine University and GeniGraph company.
- RD2C CNRS PEPS project: Découverte de Règles pour améliorer la Complètude et la Cohérence des bases de connaissances scientifiques. (2016-2017). Coordinator: Fatiha Saïs. LaHDAK members: Nathalie Pernelle. Partners: AgroParisTech, University Paris-Descartes, CIRAD/Irstea (Montpellier), Heudiasyc/CNRS and LIST (Luxembourg).
- ANR project ALICIA: Adaptive learning for intelligent crowdsourcing and information access. ANR CONTINT project (Feb. 2013 – Jul. 2018). ALICIA scientific coordinator: Bogdan Cautis. LaHDAK members: Silviu Maniu. Partners: XEROX Research (XRCE), Naver Research France, AlephD, Vodkaster, Telecom ParisTech, Université de Grenoble (LIG), Université Paul Sabatier Toulouse.
- Industrial PORASO project: Ontology enrichment by reasonings on semantic annotations using ontologies. (2014-2017). Coordinator: Chantal Reynaud. LaHDAK members: Brigitte Safar. Partner: Wepingo Company (France).
- Industrial Thales Research and Technology project: Ontology-based Situation Model Extraction for Information Fusion. (2016-2019). LRI Coordinators: Chantal Reynaud, Yue Ma. Thales Research and Technology Partners Coordinators: Gaëlle Lortal, Claure Laudy. Partner: Thales Research and Technology Company (France).
- ERABle PEPS project: Evaluation de Requêtes d'Agrégation sur Bases de données probabiListEs. Coordinator: B. Groz. LaHDAK members: S.Maniu.
- ANR Project CBOD: Cloud-based organizational design (2013-2017). Partners : Laboratoire de recherches en économie et gestion (Pesor-ADIS) Université Paris Sud, EPI OAK INRIA Université Paris sud. LaHDAK members: Ioana Manolescu, Emmanuel Waller. Coordinator: A. Bounfour (Pesor-ADIS, UPSud).
- ANR project Pagoda (JCJC): Practical algorithms for ontology-based data access (2013-2017). LahDak members: Meghyn Bienvenue (until 2015). Partners: LIRMM (Montpellier), LIX (Paris Saclay), LIG et LADAF (Grenoble), IRISA. Coordinator: M. Bienvenue
- BizModel4Cloud PEPS interdisciplinary project: a common conceptual framework for the analysis and specification of business models based on the cloud. Partners : Laboratoire de recherches en économie et gestion (Pesor-ADIS) Université Paris Sud, EPI OAK INRIA Université Paris sud, Telecom Paris Tech. LaHDAK members: Ioana Manolescu, Emmanuel Waller. Coordinator: A. Bounfour (Pesor-ADIS, UPSud).
- Investissement d'Avenir Datalyse (Cloud & Big Data national program): building scalable and expressive tools for Big Data analytics (2013-2016). Partners: LIG Grenoble, U. Lille 1, U. Montpellier, and Inria Rhône-Alpes . Coordinator: Eolas Grenoble company
- Digiteo DIM project DW4RDF: Data Warehousing for RDF (DW4RDF) (2011-2013). Partners: Inria, Univ. Paris-Sud .
- Project funded by the Direction Générale de l'Armement ODIN: building a complete framework for analytics on Web data (2014-2018), Partners: SemSoft company, IRISA Rennes and Inria Saclay (EPI Oak). LaHDAK members: Ioana Manolescu.
- IoTA: Internet of Things Analytics (2016–2019). Project funded by Digicosme Emergence, between LTCI (Télécom ParisTech) and LRI. LaHDAK members: Silviu Maniu.

Local projects

- LIONES: Semantic links between multi-scales objects, CDS-Paris Saclay grant (2015-2018). Coordinator: Juliette Dibie-Barthelemy (AgroParistech&INRA). LaHDAK members: Nathalie Pernelle, Fatiha Saïs. Partners: AgroParisTech & INRA MIA JRU (LINK team), AgroParisTech & INRA GMPA JRU (BioMiP team).
- VASTE: Veracity Assessment in Spatio-TEmporal heterogeneous data, an application on Web animal epidemiological surveillance, Digiscome Paris Saclay grant (2018-2019). Coordinator: Fatiha Saïs. Partners: AgroParisTech, University of Versailles Saint Quentin, CIRAD/Irstea (Montpellier) and Telecom ParisTech.
- DEVIEW: Determining and Explaining Veracity in the Web (2018-2019). Internal LRI Project supporting the collaboration between LaHDAK and Modhel teams. Scientific leaders: Gianluca Quercini (Modhel) and Fatiha Saïs (LaHDAK).
- Analysis of metabolic networks (2016 and 2017). Internal LRI Project supporting the collaboration between LaHDAK

and Bioinfo teams. Scientific leaders: Sabine Peres (Bioinfo) and Philippe Dague (LaHDAK). Digicosme labex funding of one year (2017-2018) research engineeer (Eva Dechaux).

- WEBSTORE: storage and extraction of social data (2016-2017). Internal LRI Project supporting the collaboration between LaHDAK and MODHEL teams. LAHDAK members: B. Groz, S. Maniu; MODHEL: F. Bugiotti, N. Bennacer.

Collaborations with other laboratories leading to joint publications

International collaborations

- Emmanuel Waller, Tom J. Ameloot and Jan Van den Bussche (University of Hasselt): On the expressive power of update primitives (A146)
- Fatiha Saïs, Cédric Pruski and Marcos Da Silveira (Luxembourg Institute of Technology-LIST): Inference of Ontology Axiom Evolution (A108)
- Nathalie Pernelle, Fatiha Saïs, Wouter Beek and Frank van Harmelen (VU University Amsterdam, NL): Identity Management on the Web. (A50)
- Nathalie Pernelle, Fatiha Saïs, Luis Galarraga (Aalborg University, Denmark): Conditional Key Discovery (57)
- Bogdan Cautis: UC San Diego, Yahoo Research, Hong Kong University, Chinese University of Hong Kong, Northeastern University, University of Helsinki.
- Chantal Reynaud, Cédric Pruski and Marcos Da Silveira (Luxembourg Institute of Technology-LIST), Erhard Rahm, Anita Gross and Yin-Chin Li (Univ. of Leipzig, Germany): Evolution of Semantic Annotations (30), (A102), (A169)
- Silviu Maniu: Reynold Cheng (University of Hong Kong), Probabilistic graphs (12)
- Chantal Reynaud, Cédric Pruski and Marcos Da Silveira (Luxembourg Institute of Technology-LIST): Mappings Maintenance under Ontology Evolution (33), (A34), (5), (A179), (A35), (A181), (6), (A180), (A37), (A182)
- Philippe Dague and Antoine Deza (McMaster University, Hamilton, Canada): Double description method for efms computation.
- Benoît Groz, Ezra Levin, Tova Milo (Tel-Aviv University, Israël) and Sudeepa Roy (Duke University, USA) : Filtering with the Crowd, Order queries with the Crowd (42) (43)
- Benoît Groz and Sebastian Maneth (Universität Bremen, Allemagne): Deterministic regular expressions (9)
- Meghyn Bienvenu and Riccardo Rosati(DIAG, Sapienza Universitàdi Roma, Italy): Tractable Approximations of Consistent Query Answering for Robust Ontology-based Data Access (25).
- Meghyn Bienvenu and Carsten Lutz (Universität Bremen, Germany) and Frank Wolter (University of Liverpool, UK): First-Order Rewritability of Atomic Queries in Horn Description Logics (A59).
- Meghyn Bienvenu and Ten Cate(Santa Cruz, CA, USA) and Carsten Lutz (Universität Bremen, Germany) and Frank Wolter (University of Liverpool, UK): Ontology-Based Data Access: A Study through Disjunctive Datalog (A63, 2).
- Meghyn Bienvenu and Stanislav Kikot (Institute for Information Transmission Problems & MIPT, Moscow, Russia) and Vladimir Podolskii (Steklov Mathematical Institute, Moscow, Russia): Succinctness of Query Rewriting in OWL 2 QL: The Case of Tree-like Queries (A159).
- Meghyn Bienvenu and Diego Calvanese (Free Univ. of Bozen-Bolzano, Italy) and Magdalena Ortiz (Vienna Univ. of Technology, Austria) and Mantas Simkus (Vienna Univ. of Technology, Austria): Nested Regular Path Queries in Description Logics (23, A60).
- Meghyn Bienvenu and Xiao, Guohui (Free Univ. of Bozen-Bolzano, Italy): Tractable Queries for Lightweight Description Logics (A61).
- Yue Ma and Xiaowang Zhang (Tianjin University, China) and Kewen Wang (Griffith University, Australia) and Zhe Wang (Griffith University, Australia) and Guilin Qi (Southeast University, China): A Distance-Based Paraconsistent Semantics for DL-Lite (A222).
- Jieying Chen, Yue Ma, and Dirk Walter (Fraunhofer IVI, Dresden, Germany): Extracting minimal modules of ontologies (31, A176, A175).

National Collaborations

- Fatiha Saïs, Maguelonne Teisseire (Irstea Montpellier): Discovery of Partially Ordered Gradual Patterns from RDF Data
- Nathalie Pernelle, Fatiha Saïs, Fabian Suchaneck (Telecom ParisTech), Danai Symeonidou (INRA, Montpellier): Conditional Key Discovery (A111)
- Fatiha Saïs, Rallou Thomopoulos (INRA Montpellier): Data fusion and missing value prediction (A136, A135, A21)
- Nathalie Pernelle, Fatiha Saïs, Danai Symeonidou (INRA Montpellier), Madalina Croitoru (University of Montpellier), Pascal Neveu (INRA Montpellier), Patrice Buche (INRA Montpellier): Key Discovery in Scientific Numerical Data. (A214)
- Nathalie Pernelle, Fatiha Saïs, Manuel Atencia (Université Grenoble Alpes), Michel Chein (University of Montpellier), Madalina Croitoru (University of Montpellier), Jérome David (Université Grenoble Alpes), Michel Leclere (University of Montpellier): Definition of Key Semantics for RDF Datasets (A150)
- Fatiha Saïs, Pascal Poizat (Paris Nanterre-la-Défense University): Context-aware personal information management (A98)
- Bogdan Cautis: IRISA – Université de Rennes 1, Telecom ParisTech, Ecole Polytechnique
- Chantal Reynaud, Gaëlle Lortal and Claire Laudy (Thales Research and Technology Company): Data Driven Concept Refinement to support Avionics Maintenance (A205), (A206)

- Chantal Reynaud, Brigitte Safar, Zied Sellami and Uriel Berdugo (Wepingo Company): Automatic Ontology Population from Product Catalogs (A117), (A144), (A23)
- Silviu Maniu and Pierre Senellart (ENS), Probabilistic graphs (12)
- N. Bidoit and Dario Colazzo (Lamsade): Queries and Updates on Big XML Documents (A26)
- Yue Ma and Said Jabbour, Raddaoui Badran, Lakhdar Sais and Yakoub Salhi: Inconsistency measures and computations (A192, 46, 47, A162, A40)

Paris-Saclay Collaborations

- Emmanuel Waller, Ahmed Bounfour (RITM, UFR Droit-Economie-Gestion, U. Paris-Sud), Valérie Fernandez (Télécom ParisTech): Cloud computing and organisational design (A28)
- Fatiha Saïs, Anne Goelzer (INRA), Vincent Fromion (INRA), Juliette Dibie (AgroParisTech), Elodie Marchadier (GQE-Le Moulon, INRA, AgroParisTech): Modelling of Biological interlocked Processes in metabolism
- Nathalie Pernelle, Fatiha Saïs, Juliette Dibie (AgroParisTech), Liliana Ibanescu (AgroParisTech): Knowledge Modelling and Contextual Identity Link Detection in Transformation Processes Data
- Silviu Maniu, Albert Bifet (Télécom ParisTech): Data stream mining
- Philippe Dague, in leave 9 months at Biosys INRA Jouy (Vincent Fromion) and 18 months at Lifeware Inria-Saclay (François Fages).

Visiting professors and students (more than one week)

- Stefano Ceri (Politecnico di Milano, Italy) in Sept 2013,
- Alin Deutsch (UC San Diego) in july 2013, and sept 2014 and then from May to October 2018 under a Jean d'Alembert Idex grant from Univ. Paris Saclay.
- Liliana Ibanescu (MCF, AGroParisTech–INRA) from January to June 2016.
- Yannis Velegrakis (head of the Data Management Group, Department of Information Engineering and Computer Science, Univ. of Trento) has obtained a Jean d'Alembert grant (idex, Univ. Paris Saclay) to visit us during 9 months (jan 2017–oct 2017).
- Stratis Ioannidis (Northeastern Univ. Boston) in June-July 2018.

Other Collaborations

- Emmanuel Waller: Evelyne Flandrin (GALAC, LRI).
- Nicole Bidoit: Dario Colazzo (Lamsade) and Amine Baazizi (LIP6).

Group seminar

During the period we conducted a series of seminars with a frequency of a seminar every three weeks: there were about 73 talks. The speakers were both members of the group as well as invited speakers from outside the group: around 30 seminars were given by researchers from outside the group.

Participation to national and international networks

- KEYSTONE: Semantic keyword-based search on structured data sources (EU COST – 2013-2017). Coordinator and WG co-chair: Bogdan Cautis. Participants: Ioana Manolescu. Partners from approx. 25 countries.
- ERVEN (Extraction, Représentation et Visualisation de connaissance pour l'Enseignement Numérique) working group of Labex Digicosme, Paris-Saclay (2017-2018), involving LIMSI, LRI, SAMOVAR/Telecom SudParis, Centrale Supélec. LaHDAK members: Brigitte Safar and Fatiha Saïs.
- D2K (De la Donnée à la Connaissance) working group of Labex Digicosme, Paris-Saclay (2015-2018), involving LRI, INRA, AgroParisTech, LIMSI, SAMOVAR/Telecom SudParis, Centrale Supélec. Chantal Reynaud is one of the coordinators. LaHDAK members: Nathalie Pernelle, Brigitte Safar and Fatiha Saïs.
- TheoBioR working group of Labex Digicosme. LaHDAK member: Philippe Dague.
- Bioss (systemic symbolic Biology) working group of GDR IM and GDR BiM. LaHDAK member: Philippe Dague.
- RAP (Representations and Algorithms in Practice) working group of GDR IA. LaHDAK member: Philippe Dague.

Volunteer Professional Service

Management Positions in Scientific Organisations

National or external organisations

- Member of the steering committee of the association of "Extraction et Gestion des Connaissances": Chantal Reynaud since 2014.
- Member of the steering committee of BDA: Nicole Bidoit.
- Member of the STIC scientific department of Paris Saclay: Nicole Bidoit.

Paris-Saclay University

- Director of the EDIPS Doctoral School of Paris-SUD (Nicole Bidoit, 2013–2015). Responsible for the creation and direction of the STIC Doctoral School of Paris-Saclay University (Nicole Bidoit, 2015–2018).
- Member of the Commission Formations of the Labex Digicosme (Nicole Bidoit).
- Representative of Paris-Sud University in the EIT Digital Doctoral Program (Nicole Bidoit).
- Representative of LRI at DATAIA Institute (Institut convergence), dedicated to Data Sciences, Artificial Intelligence and Society: Bogdan Cautis, 2017–).
- Member of the *Commission formation* of IMT Télécom Sud.

Paris-Sud University

- Director of the LRI: Philippe Dague (2009–2014).
- Representative of Paris-Sud University in the EIT Digital Doctoral Program: Nicole Bidoit.
- Head of the Computer Science Department of IUT d'Orsay: Chantal Reynaud (2015–).
- Member of the Board of Governors (*Conseil d'administration*) of Paris-Sud University: Nathalie Pernelle, since 2016; Member of the *Conseil de l'IUT d'Orsay* (Fatiha Saïs, 2014–2018), Member of the *Conseil de l'IUT de Sceaux* (Nathalie Pernelle, 2012–2016).
- Computer Science Department of the Faculté des Sciences: member Fatiha Saïs 2017–2020; permanent invited member Nicole Bidoit ; representative for International Relationships Emmanuel Waller.
- CCSU 27th section (*Commission Consultative de Spécialistes de l'Université*): Nathalie Pernelle, member (2013–) and member B of the bureau (2017–); Nicole Bidoit, Chantal Reynaud members since 2013.

Organisation of Conferences and Scientific Events

- International conference on Data, Digital, Business models, cloud computing and organizational design, 2014, Sceaux, France. Emmanuel Waller, co-chair and organizer.
- JDSE, Paris-Saclay Junior Conference on Data Science and Engineering, Orsay, 2018. Fatiha Saïs, general chair and organisation committee co-chair.
- EGC, Conférence Francophone sur l'Extraction et la Gestion de Connaissances, Paris, 2018. Fatiha Saïs, organisation committee member.
- e-EGC, EGC-Winter school on Social Networks, Paris, 2018. Fatiha Saïs, scientific co-chair and organisation committee member.
- The first and the second workshop "From Open Sources to Web of Data" (SoWeDo) co-located with the french conference IC (Ingénierie des Connaissances) 2014 and 2016. Nathalie Pernelle and Fatiha Saïs, co-chairs.
- The second workshop "From Open Sources to Web of Data" (SOS-DLWD) co-located with the french conference IC 2013. Nathalie Pernelle and Fatiha Saïs, co-chair.
- Summer school MDD (Masses de données distribuées), Oléron, juin 2014. Nicole Bidoit, Scientific Co-chair.
- The Medical Informatics day, LIST-Luxembourg, Esch-sur-Alzette, Luxembourg, March 2014. Chantal Reynaud, organisation co-chair.
- The First International Workshop on Hybrid Question Answering with Structured and Unstructured Knowledge (HQA'18), part of WWW'18. April 2018, Yue Ma, co-chair.
- The 26th International Workshop on Principles of Diagnosis, Paris, August-September 2015. Philippe Dague, organisation co-chair.
- The 28th International Workshop on Principles of Diagnosis, Brescia, Italy, September 2017. Philippe Dague, PhD panel chair.
- BIOSS-IA Days, Logical models for formal representation of living systems, Gif-sur-Yvette, June 2017, funded by preGDR IA, GDR BiM, BIOSS working group and TheoBioR working group from Digicosme labex. Philippe Dague, organisation co-chair.
- Workshop Computational Systems Biology for Cancer, Paris, January 2018, in the framework of the PSay-CompBio project, funded by ICST and Life Sciences departments of Univ. Paris-Saclay. Philippe Dague, organisation co-chair.

Honors

Awards

- Prix de thèse EGC 2016 (J. Dos Reis)
- Best Resource Paper Award, at the International ESWC conference 2018 (Joe Raad)
- Best Paper Award, at the International conference ICBO 2017 (V. Henry, F. Saïs, E. Marchadier, J. Dibie, A. Goelzer, V. Fromion).
- Best Paper Award, at the national conference IC 2017 (J. Raad, N. Pernelle, F. Saïs)
- Best paper award at the 23rd International World Wide Web Conference 2014 (D. Colazzo, F. Goasdoué, I. Manolescu, A. Roatis).
- Best paper award in "The International Journal on Very Large Databases", June 2014 (Z. Kaoudi, I. Manolescu).
- Lifetime Achievement Award DX 2017 (P. Dague)

Keynote Addresses and invited talks

International

- Fatiha Saïs: invited talk at Luxembourg Institute of Science and Technology (LIST), Luxembourg, March 2017.
- Yue Ma: invited talk at Jilin University, China, April 2016.
- Yue Ma: invited talk at Tianjin University, China, January 2018.
- I. Manolescu. Database Optimization Techniques for Semantic Queries, in "Sistemi Evolutivi di Basi di Dati (SEBD)", Gaeta, Italy, June 2015.
- S. Cebiric, F. Goasdoué, I. Manolescu. Query-oriented Summarization of RDF Graphs, in "Data Engineering Meets Semantic Web Workshop (DESWeb)", Seoul, South Korea, April 2015.

France

- Fatiha Saïs: invited talk at First day of Action Arquads of GdR CNRS-MADICS, Marseille, France, June 2018.
- Fatiha Saïs: invited talk at Métaséminaire du Département CEPIA@INRA, Massy, France, March 2018.
- Fatiha Saïs: invited tutorial at BDA Conference – Data management: Principles, Technologies and Applications, Nancy, France October 2017.
- Nathalie Pernelle: invited talk at the workshop QLOD joint with the EGC Conference, January 2017.
- Nathalie Pernelle: invited talk at UMR MISTEA, INRA Montpellier seminar, March 2015.
- Nathalie Pernelle and Fatiha Saïs: invited tutorial at EGC Conference (Knowledge Extraction and Management) in collaboration with Fayçal Hamdi (CNAM), Rennes, January 2014.
- Fatiha Saïs: invited talk at the day for alternative methods to reduce the use of animals in experiments, organized by INRA, Clermont Ferrand, November 2013.
- Fatiha Saïs: invited talk at the Workshop QetR (Qualité et Robustesse dans le Web de Données), in conjunction of the EGC conference, Lille, January 2013.
- Yue Ma: invited talk at the day for Artificial Intelligence and Information Retrieval (la Journée commune IA et RI), Paris, December 2015.
- Philippe Dague: invited talks about analysis of metabolic networks at BIOSS working group meeting in Lille, at BioSys INRA seminar and at Lifeware Inria seminar.
- Brigitte Safar: invited talk at the day Works-Web on Ontology, Reasoning, Knowledge and Semantic Web, seminar organized by University Paris 8, Montreuil, June 2016

Evaluation of Research

Editorial Boards

- Ioana Manolescu : Editor in Chief of the ACM SIGMOD Record until June 2014; associate editor of the ACM Transaction on Internet Technology, member of the review board of PVLDB 2014.
- Fatiha Saïs: co-editor of the special issue of the French journal ISI (Ingénierie des Systèmes d'Informations): Web of Data: publishing, linking and capitalisation, Hermann Editions 2016.
- Fatiha Saïs: co-editor of the special issue of the French journal RNTI (Revue des Nouvelles Technologies de l'Information): Des Sources Ouvertes au Web de Données, Hermann Editions 2014.
- Nathalie Pernelle: co-editor of the special issue of RIA-Revue d'Intelligence Artificielle, IC best papers, 2018.
- Chantal Reynaud : member of the editorial board of RIA-Revue d'Intelligence Artificielle, 2014-2018.
- Chantal Reynaud : member of the editorial board of ISI-Ingénierie des Systèmes d'Information for a special issue on "Web des données : publication, liage et capitalisation, 2016.
- Chantal Reynaud : member of the editorial board of RNTI-Revue des Nouvelles technologies de l'Information for a special issue on "Open Data : bilan, avancées et nouveaux défis, 2017.

Program Committees

Chair

International

- Bogdan Cautis: co-chair of the Workshop "Surfacing the Deep and the Social Web (SDSW)" in collocation with the International Semantic Web Conference (ISWC), October 2014, Riva del Guarda, Trentino, Italie.
- Yue Ma: co-chair of the Workshop International Workshop on Hybrid Question Answering with Structured and Unstructured Knowledge (HQA) with The Web Conference (WWW'18), April 2018, Lyon, France.
- Ioana Manolescu: co-chair of the 2nd International Workshop on Benchmarking RDF Systems (BeRSyS), in conjunction with VLDB, 2014
- Nathalie Pernelle: co-chair of the International conference ICCS, 2018.

National

- Chantal Reynaud: general chair of "14èmes Journées Francophones Extraction et Gestion des Connaissances (EGC)", Rennes, France, 2014.
- Nathalie Pernelle: general chair of the national conference "Ingénierie des connaissances", Montpellier, France, 2016.

Member (international events)

- Bidoit Nicole: Program committee member for ADBIS 2013, WISE 2015, ProvenanceWeek 2016, FoIKS 2018
- Bogdan Cautis: Program committee member for EDBT 2014, SIGMOD 2014, 2017, ICDE 2014, 2017, CIKM 2014, 2016.
- Yue Ma: Program committee member for CSWS2014, EKAWpd 2014, AAAI-15, KESW 2014, 2015, WoDOOM 2015, DL 2016, ESWC 2015, 2016, JIST 2015, 2017, IJCAI 2016, 2018, AIMSA 2014, 2018.
- Silviu Maniu: Program committee member for AAAI 2018; IJCAI 2018, 2017; ECML PKDD 2018, 2017, 2016, 2015 (industrial track); SIGMOD 2016, 2015; SSDBM 2016; SUM 2018, 2016; DASFAA 2015
- Chantal Reynaud: Program committee member for ECAI 2014, ISWC-Int. Semantic Web Conference 2014, 2015, ESWC-European Semantic Web Conference 2014, 2015, 2016, 2017, EKAW-Int. Conference on Knowledge Engineering and Management 2014, 2016, 2018, FOIS-Int. Conference on Formal Ontology in Information Systems 2016, Web2Touch Track on Modeling the Collaborative Web Knowledge 2014, 2015.
- Fatiha Saïs: Program committee member for the international conferences ECAI 2016, ICCS 2014 and 2016, EKAW 2018, AICCSA 2017 and 2018, CARI 2014–2018, SIMBig 2016 and 2017.
- Nathalie Pernelle: Program committee member for the international conferences IJCAI 2016, ECAI 2016, AAAI 2015, ICCS 2014 2016 2018, EKAW 2018, SI&IA 2015, IMMM 2014–2018, workshop GKR of IJCAI 2015, .
- Philippe Dague: Program committee member for DX 2013-2018.
- Philippe Chatalic: Program committee member for ICTAI 2014,2015
- Mélanie Hershel : Program commitee member for ADBIS 2013, DATA 2013 and 2014, IEEE Big Data 2013 and 2014, EDBT 2013 and 2014, TAPP 2014 Business Technology and web (BTW 2013)
- I. Manolescu: Program committee member for ACM SIGMOD 2013 and 2014, EDBT 2013 (demonstration track) and 2014, ICDE 2014, International Workshop WebDB 2013, Workshop WOD 2013, and the Workshop DESWEB 2013, Data4U workshop
- Emmanuel Waller: Program committee member for ICDE 2018 Workshop Data Engineering meets Intelligent Food and COoking Recipe (DECOR 2018)

Member (national events)

- Emmanuel Waller: Program committee member for BDA 2013
- Bogdan Cautis: Program committee member for BDA 2014
- Silviu Maniu: Program committee member for BDA 2017
- Chantal Reynaud: Program committee member for RFIA-Congrès Francophone Reconnaissance des Formes et Intelligence Artificielle 2014, CNIA- Conférence Nationale en Intelligence Artificielle 2016, IC-Journées Francophones d'Ingénierie des Connaissances since 1998, EGC-Conférence Extraction et Gestion des Connaissances since 2007, JFO-Journées Francophones sur les Ontologies 2014.
- Fatiha Saïs: Program committee member for the national conferences EGC-Conférence Extraction et Gestion des Connaissances since 2011, IC-Journées Francophones d'Ingénierie des Connaissances since 2014.
- Nathalie Penrelle: Program committee member for the national conferences EGC-Conférence Extraction et Gestion des Connaissances since 2010, IC-Journées Francophones d'Ingénierie des Connaissances since 2012, CNRIA since 2013.
- Ioana Manolescu: Program committee member for BDA 2014

Evaluation Committees and Invited Expertise

- Nicole Bidoit : Expert for HCERES evaluation of LIMOS, December 2015
- Nicole Bidoit : Chair of the HCERES evaluation committee of 3 PhD schools of brittany : MathSTIC, SPI et 3M
- Nicole Bidoit : Member of the scientic committee of the INRIA SIF Center, 2012-2016.
- Silviu Maniu: Expert for Research Initiative in Industrial Data Science, Paris-Saclay, 2016
- Chantal Reynaud: Expert for ANR research, Big Data, Decision, Simulation, HPC 2014.
- Chantal Reynaud: Expert for phD Program (IDI), Paris-Saclay IDEX project, 2015.
- Fatiha Saïs: Expert for ANR CONTINT program in 2016 and for ANR (JCJC) Young Researchers Program in 2016.
- Fatiha Saïs: Expert for call for research projects "Chercheur(se)s d'avenir" of the region Languedoc-Roussillon (France) in 2013 and 2015.
- Nathalie Pernelle: Expert for ANR (JCJC) Young Researchers Program in 2014 and 2016.
- Nathalie Pernelle : expert for the call "Recherche - Enseignement Supérieur - Plateformes Mutualisées et ouvertes" de la Région Nouvelle-Aquitaine, 2018.

Other evaluation activities

Thesis commitees

During the period, the members were comittee members of 55 theses, including 11 PhD thesis as reviewers and 17 as chair of the comittee.

Interactions with the social, economic and cultural environment

Interaction with the economic environment

Dissemination

- We have contributed to *Panorama de l'intelligence Artificielle*, edited by P. Marquis, O. Papini, H. Prade, for Cepadues in 2014, in Vol 1 (Représentation des connaissances et formalisation des raisonnements en I.A.) and 3 (L'intelligence artificielle : frontières et applications):
  - in vol 1, *Ingénierie des Connaissances*, C. Reynaud with N. Aussenac-Gilles and J. Charlet,
  - in vol 1, *Diagnostic et supervision : approches à base de modeèles*, Ph. Dague with M.-O. Cordier, Y. Pencole and L. Travé–Massuyès,
  - in vol 1, *Argumentation et raisonnement en présence de contradictions*, Ph. Chatalic with L. Amgoud, Ph. Besnard, C. Cayrol, and M.-Ch. Lagasquie-Schiex,
  - in vol 3, *Bases de données et Intelligence Artificielle*, N. Bidoit with P. Bosc, L. Cholvy, O. Pivert, M.-Ch. Rousset.

Popularisation of Research Results

- I. Manolescu has given a conference "Big Data and the Internet" in January 2015 in the UniverCité Ouverte conference series organized by the city of Gif sur Yvette for the general public.
- R. Bonaque, D. Bursztyn, S. Cebiric and I. Manolescu have presented a game based on RDF graphs and social networks as part of "La Fête de la Science" in Inria Saclay, in 2015.
- I. Manolescu has presented a vision of data management techniques for journalistic fact-checking at the congress of the french Association of the Information Press Journalists (Association des Journalistes de la Presse d'Information) in October 2015. The same topic has lead to articles in the general press, in Ouest France (www.ouest-france.fr/-leditiondusoir/data/569/reader/reader.html#!preferred/1/package/569/pub/570/page/8), the canadian Le Devoir (www.ledevoir.com/politique/canada/450937/sur-la-piste-du-mensonge), Le Monde (data.blog.lemonde.fr/ 2015/10/23/le-fact-checking-peut-il-sautomatiser/), Rue89 (rue89.nouvelobs.com/2015/10/ 26/algorithmes-antimensonge-fin-bobards-politique-261827), as well as in the Journal du CNRS (lejournal.cnrs.fr/articles/un-logiciel-qui-decrypte-la-politique) and Inria's national Web site (www.inria.fr/centre/saclay/actualites/un-logiciel-de-fact-checking-pour-comprendre-le-monde-qui-nous-entoure).
- I. Manolescu has presented a database management vision for Data Science in the Big Data Business Convention in November, attended by 600 participants among which half were academics and half from the industry.
- M. Bienvenu has co-organized "La Fête de la Science" for the LRI in 2013.
- T. Ghosh, I. Manolescu, A. Tzompanaki, A. Roatis and S. Zampetakis have presented a graph-based game to the audience of "La Fête de la Science" in 2013.
- I. Manolescu has participated to a speed dating event between researchers and high-school students in Paris in the setting of "La Fête de la Science" in 2013.

Contracts and grants

Public contracts and grants (jan 2013 - jun 2018)							
Type	*Scientific director*	*Name*	*Managing Institution*		*Start*	*Duration*	*Amount*
ANR DFG	Yue Ma	GOASQ	Université Sud	Paris	12.2015	36	186.60
ANR FNR	Bogdan Cautis	ALICIA	Université Sud	Paris	02.2013	36	184.96
ANR FNR	Fatiha Sais	Qualinca	Université Sud	Paris	04.2012	48	99.58
ANR FNR (JCJC)	Meghyn Bienvenue	Pagoda	Université Sud	Paris	01.2013	36	260.31
ANR FNR	Pascal Poizat	PIMI	Université Sud	Paris	11.2010	36	180.57
ANR	Ioana Manolescu	CBOD	INRIA		02.2014	48	72.245
PEPS CNRS	Ioana Manolescu	BizModel4Cloud	CNRS		11.2013	12	7
PEPS CNRS	Fatiha Saïs	RD2C	CNRS		01.2016	12	10
PEPS CNRS	Fatiha Saïs	RD2C (v2)	CNRS		04.2017	8	5
PEPS CNRS	Benoit Groz	Erable	CNRS		01.2016	12	10.5
Digicosme	Fatiha Saïs	VASTE	Université Sud	Paris	06.2018	12	50
Digicosme Emergence	Silviu Maniu	IoTA	Université Sud	Paris	01.2017	36	49.8
Saclay (CDS)	N.Pernelle, F.Saïs	LIONES	INRA		09.2015	36	101
LRI grant	BioInfo-Lahdak grant	Analysis of Metabolic networks	CNRS		02.2015	24	5
LRI grant	LahDAK-Modhel grant	DEVIEW	CNRS		05.2018	24	10
LRI grant	LahDAK-Modhel grant	Webstore	CNRS		02.2016	24	10
KIC EIT Digital	Emmanuel Waller	Master School / I&E	Université Sud	Paris	10.2013	36	20

Some of the contracts are described below.

GOASQ: Generating and Answering Ontological Queries

Type: ANR-DFG
Amount: 186.6 k€
Duration: 36 months
Scientific director for LRI: Y. Ma

Partners: LIMSI, TU Dresden (Germany)

See **https://goasq.lri.fr/index.html**

Programme ANR DS0707; Project leader: Y. MA (LRI)

ALICIA: Adaptative learning for intelligent crowdsourcing and information access

Type: ANR FNR
Amount: 184.96 k€
Duration: 36 months
Scientific director for LRI: B. Cautis

Partners: XEROX Research, Naver Research France, IephD, Vodkaster, Telecom ParisTech, Univ. de Grenoble (LIG), Univ. Paul Sabatier de Toulouse

See **http://alicia.lri.fr**

Programme ANR Contint; Project leader: B. Cautis (LRI)

Qualinca: Quality and interoperability of large bibliographical knowledge bases

Type: ANR-FNR
Amount: 99.58 k€
Duration: 48 months
Scientific director for LRI: F. Saïs

Partners: ABIES, INA, Laboratoire d'informatique de Grenoble (LIG), Laboratoire d'Informatique de Robotique et de Microelectronique de Montpellier (LIRMM)

See **http://www.lirmm.fr/qualinca/index6a2d.html?q=en**

Programme ANR Contint; Project leader: M. Leclere (LIRMM)

Pagoda: Practical algorithms for ontology-based data access

Type: ANR-FNR
Amount: 260.31 k€
Duration: 36 months
Scientific director for LRI: M. Bienvenue

Partners: Laboratoire d'informatique de Grenoble (LIG), Laboratoire d'Informa-tique de Robotique et de Microelectronique de Montpellier (LIRMM), IRISA, LIX, LADAF

See **http://pagoda.lri.fr**

Programme ANR JCJC ; Project leader: M. Bienvenue (LRI puis LIRMM)

VASTE: Veracity Assesment in Spatio-TEmporal heterogeneous data

Type: Digicosme
Amount: 50 k€
Duration: 12 months
Scientific director for LRI: F. Saïs

Partners: AgroParisTech, Université de Versailles Saint Quentin, CIRAD/Irstea, Télecom ParisTech

See **https://www.lri.fr/~sais/vaste/**

Digicosme ; Project leader: F. Saïs (LRI)

Private contracts and grants (jan 2013 - jun 2018)

Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*		*Amount*
Industrial	C. Reynaud	Start-up Wepingo	Accord de collaboration (PORASO)	10.2014	36	30.00
Industrial	C. Reynaud	Thales Research and Technology	CIFRE	10.2016	36	15.00

Training and Education

Management of teaching programmes

- Head of the Computer Science Department of IUT d'Orsay (Chantal Reynaud, 2015–).
- co-head of Master D&K (Data and Knowledge) Paris Saclay (Bogdan Cautis , 2014-2015 and Silviu Maniu, 2015–)
- head of MIAGE 2 Informatique Décisionnelle (Brigitte Safar, 2009–)
- head of the 3rd year in computer science at Polytech engineering school (Yue Ma, 2016–)
- head of Licence Professionnelle PRISM at IUT d'Orsay (Bogdan Cautis, 2013–2015)
- head of the 1st year of DUT in computer science at IUT d'Orsay (Bogdan Cautis, 2017–)
- head of the 2nd year of DUT in computer science (apprenticeship training) at IUT d'Orsay (Chantal Reynaud, –2015)
- co-head of the DUT FC-AF (Fatiha Saïs, –2015) and of the Licence Professionnelle PRISM FC-AF, for Air France employees, at IUT d'Orsay (Fatiha Saïs, 2015-2016)
- creator and representative of Univ. Paris-Sud of the L3 Miage track at Université Française d'Egypte (UFE) au Caire (Emmanuel Waller, 2014-2016)

Master Internships

- Jiang You, Master (M2), internship (2017-2018): Fatiha Saïs, Juliette Dibie and Cristina Manfredotti (AgroParisTech)
- Anderson Carlos Ferreira Da Silva, Master (M2), internship (2017-2018): Emmanuel Waller, Fatiha Saïs, Fréderic Andrès

(NII, Tokyo)
- Yuhao Zhao, Master (M2), internship 2017: Silviu Maniu, Bogdan Cautis
- Sara Oulkfif, Master (M2), internship (2016-2017): Fatiha Saïs, Juliette Dibie (AgroParis Tech)
- Toufik Baktaoui (M2) internship (2013-2014) : Philippe Chatalic
- Hiba Hajri, Master (M2), internship (2013-2014): Fatiha Saïs, Liliana Ibanescu (AgroParisTech)
- Ioanna Giannopoulos, Master (M2), internship (2013-2014): Fatiha Saïs, Rallou Thomoupolos (INRA Montpellier)
- Fei Liang , Master (M1), internship (2017-2018): Nathalie Pernelle, Fatiha Saïs
- Viktor Frelikh, Master (M1), internship (2016-2017): Fatiha Saïs
- Thomas Perraut, Master (M1), internship (2016-2017): Fatiha Saïs
- Dimitrios Christaras Papageorgiou, Master (M1) Magistère, internship (2016-2017): Philippe Chatalic, Nathalie Pernelle, Fatiha Saïs
- Daniel Mercier, Master (M1) Magistère, internship (2016-2017): Nathalie Pernelle, Fatiha Saïs
- Sujeeban Thuraisamy, Master (M1), internship (2016-2017): Nathalie Pernelle, Fatiha Saïs
- Anderson Carlos Ferreira Da Silva, Master (M1), internship (2016-2017): Fatiha Saïs
- Xiyu Zhang, Master (M1), internship (2015-2016): Yue Ma

Other Internships

- Ning Guo, Licence (L3) , internship (2017-2018): Philippe Chatalic
- Sanketh Vysyaraju, Bachelor Ecole Centrale-Inde Mahindra, (2017-2018): Evelyne Flandrin, Emmanuel Waller
- Sai Garaga, Bachelor Ecole Centrale-Inde Mahindra, (2017-2018): Evelyne Flandrin, Emmanuel Waller
- Simon Ser, Licence (L3) Magistère, internship (2016-2017): Fatiha Saïs, Maguelonne Teisseire (Irstea, CIRAD Montpellier)
- Léo Hahn Lecler, Licence (L3) Magistère Maths, internship (2017-2018): Silviu Manu, Emmanuel Waller
- Simon Montero, Licence (L3) Maths-info, internship (2017-2018): Silviu Manu, Emmanuel Waller
- Xiyu Zhang, Master (Engineer 3), internship (2014-2015): Yue Ma

Graduate Courses

- Data and Knowledge Master 2 (D&K), Paris Saclay University, *Introduction to Research and Business*: Emmanuel Waller
- EIT Digital/Human Computer Interaction Master 2 (HCI), Paris Saclay University, *Innovation and Entrepreneurship thesis*: Emmanuel Waller
- Data and Knowledge Master 2 (D&K), Paris Saclay University, *Web Data Models*: Nicole Bidoit, Silviu Maniu
- Data and Knowledge Master 2 (D&K), Paris Saclay University, *Social and Uncertain Data Management*: Silviu Maniu
- Data and Knowledge Master 2 (D&K), Paris Saclay University, *Architectures for Massive Data Management*: Silviu Maniu, Ioana Manolescu
- Data and Knowledge Master 2 (D&K), Paris Saclay University, *Semantic Web*: Yue Ma
- Data and Knowledge Master 2 (D&K), Paris Saclay University, *Information Integration*: Nathalie Pernelle, Fatiha Saïs.
- Data and Knowledge Master 2 (D&K), Paris Saclay University, *Data Warehouses*: Benoît Groz.
- Data and Knowledge Master 2 (D&K), Paris Saclay University, *Complex Data and Knowledge*: Brigitte Safar
- Master Systèmes Intelligents (ISI), Paris Dauphine University, *Semantic Web*: Nathalie Pernelle, Fatiha Saïs.
- Master IAC, Université Paris-Sud, *Données et Connaissances pour le Web*: Brigitte Safar
- Master IAC, Université Paris-Sud : *Masses de données*: Ioana Manolescu, Bogdan Cautis (2014)
- Master 2 Miage (ID), Université Paris-Saclay, *Entrepôts de données*: Benoît Groz
- Master 2 Miage en apprentissage (ID), Université Paris-Saclay, *Entrepôts de données*: Benoît Groz

Schools

- N. Bidoit has been co-organiser of the summer school Ecole Thèmatique Bases de Données, June 2014, Oléron, whose focus was on Massive and Distributed Data Management.
- Meghyn Bienvenu (with M. Ortiz): Ontology-Mediated Query Answering with Data-Tractable Description Logics, Invited tutorial at the 11th Int. Reasoning Web Summer School.

Other

- At the International Conference on Database Systems for Advanced Applications (DASFAA 2014), B. Cautis gave a lecture for the local Indonesian students, on "Searching the Social Web".
- N. Pernelle gave two lectures on Information systems at the SHNU university (Shangai, Chine) for student that follow a Management and financial cursus, 2x 2 weeks in 2016 and 2017.

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Thesis

Habilitation à Diriger des Recherches	
Name	*Defense*
Nathalie PERNELLE	06.2016

Defended thesis				
Name	*Start*	*Defense*	*Funding*	*Advisor*
Paul LAGREE	01.10.2014	12.10.2017	ANR	B. Cautis & O. Cappé
Raphael BONAQUE	01.10.2013	30.09.2016	Digicosme	I. Manolescu & B. Cautis & F. Goasdoué
Hassan IBRAHIM	07.01.2013	16.12.2016	Alloc. Ministère	P. Dague & L. Simon
Céline ALEC	01.10.2013	26.09.2016	Alloc. Ministère	C. Reynaud & B. Safar
Camille BOURGAUX	01.10.2013	29.09.2016	Alloc. Ministère	F. Goasdoué & M. Bienvenu
Martin MORTEROL	01.10.2013	13.12.2016	Alloc. Ministère	P. Dague & L. Simon & S. Peres
Aikaterini TZOMPANAKI	01.10.2012	14.12.2015	Alloc. Ministère	N. Bidoit & M. Hershel
Rania KHEFIFI	01.10.2010	26.09.2014	ANR PIMI	P. Poizat & F. Sais
Julio DOS REIS	01.10.2011	24.10.2014	FNR Luxembourg	C. Reynaud & C. Pruski
Danai SYMEONIDOU	05.10.2011	09.10.2014	Alloc. Ministère	N. Pernelle & F. Sais
Jesus CAMACHO RODRIGUES	08.09.2011	25.09.2014	Alloc. Ministère	D. Colazzo & I. Manolescu
Stamatis ZAMPETAKIS	08.09.2011	24.09.2014	INRIA	F. Goasdoué & I. Manolescu
Alexandra ROATIS	01.09.2011	22.09.2014	INRIA	I. Manolescu & F. Goasdoué & D. Colazzo
Ioana ILEANA	01.01.2011	24.10.2014	TelecomParisTech	B. Cautis & P. Senellart
Julien LEBLAY	01.01.2010	27.09.2013	Alloc. Ministère	F. Goasdoué & I. Manolescu

Position after the thesis	
Name	*Position*
Paul LAGREE	Engineer R&D, PriceHubble
Raphael BONAQUE	Data Scientist, Made in Data
Hassan IBRAHIM	ATER, Université Paris Sud
Céline ALEC	MCF, Université de Caen
Camille BOURGAUX	post-doc, Télécom ParisTech
Martin MORTEROL	Engineer, Nokia France
Aikaterini TZOMPANAKI	MCF, Université de Cergy Pontoise
Rania KHEFIFI	Product manager, FANVOICE
Julio DOS REIS	Assistant Prof., University of Campinas, Brazil
Danai SYMEONIDOU	CR, INRA Montpellier
Jesus CAMACHO RODRIGUES	Engineer, Hortonworks USA
Stamatis ZAMPETAKIS	R&D Engineer, Orchestra Networks
Alexandra ROATIS	Blockchain Engineer, Nuco, Canada
Ioana ILEANA	MCF Université Paris Descartes
Julien LEBLAY	Research Scientist, AIST Japan

Thesis in progress			
Name	*Start*	*Funding*	*Advisor*
Maroua BAHRI	01.05.2017	Digicosme	A. Bifet & S. Maniu
Silvio CARDOSO	18.11.2015	FNR Luxembourg	C. Reynaud & C. Pruski
Jieying CHEN	01.10.2015	CSC	P. Dague & Y. Ma
Luis PALACIOS	01.06.2016	CIFRE	C. Reynaud &Y. Ma
Joe RAAD	01.10.2015	CDS-P-Saclay	J. Dibie & N.Pernelle & F. Sais
Sanjay RAMACHANDRA RAO	01.10.2016	ANR GOASQ	B. Grau & Y. Ma
Hadi ZAATITI	01.10.2015	CEA	P. Dague & J.-P. Gallois
Zheng ZHANG	01.10.2016	CSC	P. Zweigenbaum & Y. Ma

Software Licensing and Distribution

RDFViews - RDFViews

http://rdfvs.saclay.inria.fr
Contact: Ioana MANOLESCU-GOUJOT

RDFViewS is a system capable of choosing the most suitable views to materialize, in order to minimize the query response time for a speci?c SPARQL query workload, while taking into account the view maintenance cost and storage space constraints. It exploits the available semantic information (eg RDF Schema) to ensure the completeness of the query evaluation. Demonstrated in the ACM CIKM 2010 conference.

XRP - The XR platform

https://team.inria.fr/oak/projects/xr-an-xml-rdf-hybrid-model-for-annotated-documents/
Contact: François GOASDOUE

XRP (a.k.a. the XR platform) is a data management platform for RDF-annotated XML data, relying on the XR data model and the XRQ query language. The platform works as a data integrator on top of XML and RDF data management systems. It features components for query evaluation, optimization and composition, as well as modules for managing XML node URIs. The platform can be accessed from command-line or through a web-based interface in the spirit of SPARQL endpoints.

AMADA - AMADA

https://team.inria.fr/oak/projects/amada
Contact: Jesus CAMACHO RODRIGUEZ

AMADA is a platform for storing Web data (in particular, XML documents and RDF graphs) based on the Amazon Web Services (AWS) cloud infrastructure. AMADA operates in a Software as a Service (SaaS) approach, allowing users to upload, index, store, and query large volumes of Web data.

PAXQuery - massively parallel processing of XQuery queries

Contact: Jesus CAMACHO RODRIGUEZ

The PAXQuery engine seamlessly parallelizes the execution of XQuery queries. By applying on-the-fly translation and optimization procedures, PAXQuery runs user queries over massive collections of XML documents in a distributed fashion. PAXQuery runs on top of Apache Flink, previously known as Stratosphere, a parallel execution platform that relies on the PACT model.

FactMinder - A browser (Chrome) extension targeted at online fact checkers and data journalists

https://www.youtube.com/watch?v=7sHSj6S6nbM
Contact: François GOASDOUE

FactMinder is a browser (Chrome) extension targeted at online fact checkers and data journalists. It enables users to analyze web pages with entity extractors and create, in a separate panel, views to cross these annotations with background knowledge from trusted XML or RDF sources such as data sets from the Linked Open Data or governmental agencies.

Nautilus Analyzer - Nautilus

http://nautilus-system.org
Contact: Mélanie HERSCHEL

The Nautilus Analyzer is an Eclipse Plugin designed to help developers in understanding and debugging their declaratively specified data transformations. More specifically, our prototye allows to analyze SQL queries with the help of why- and why-not provenance algorithms.

SAKey - Scalable Tool For Almost Key Discovery in RDF Data

https://www.lri.fr/sakey/
Contact: Nathalie PERNELLE-MANSCOUR

A scalable tool that discovers keys (properties that uniquely identify an entity) in RDF data in an efficient way. To prune the search space, SAKey exploits characteristics of the data that are dynamically detected during the process. Furthermore, our approach can discover keys in datasets where erroneous data or duplicates exist (i.e., almost keys). The approach has been evaluated on different synthetic and real datasets. The results show both the relevance of almost keys and the efficiency of discovering them.

WaRG - Warehousing RDF Graphs

https://team.inria.fr/oak/projects/warg
Contact: Ioana-Alexandra ROATIS

WaRG allows performing warehouse-style analytics on RDF graphs using typical OLAP operations. This framework keeps the warehousing process purely in the RDF format and takes advantage of the heterogeneity and semantics inherent to this model.

CliqueSquare - CliqueSquare

https://team.inria.fr/oak/projects/cliquesquare
Contact: Stamatis ZAMPETAKIS

CliqueSquare is a system for storing and querying large RDF graphs relying on Hadoop's distributed file system (HDFS) and Hadoop's MapReduce open-source implementation. CliqueSquare is equipped with a unique optimization algorithm capable of generating highly parallelizable flat query plans relying on n-ary equality joins. In addition, it provides a novel partitioning and storage scheme that permits first-level joins to be evaluated locally using efficient map-only joins.

PigReuse - 2 platform for specifying and exploiting warehouses of RDF data

Contact: Jesus CAMACHO RODRIGUEZ

PigReuse is a novel optimization algorithm aiming at identifying and reusing repeated subexpressions in Pig Latin scripts. It identifies subexpression merging opportunities, selects the best ones to execute based on a cost function, and reuses their results as needed in order to compute exactly the same output as the original scripts.

VICKEY - Mining Conditional Keys on Knowledge Bases

https://github.com/lgalarra/vickey
Contact: Nathalie PERNELLE-MANSCOUR

A conditional key is a key constraint that is valid in only a part of the data. Vickey mines automatically such keys on large knowledge bases (Kbs).

CQAPri - Consistent Query Answering with Priorities

https://www.lri.fr/~bourgaux/CQAPri/CQAPri.php
Contact: Camille BOURGAUX

Consistent query answering over a DL-Lite knowledge box. Compute the answers which hold under AR or IAR semantics, for classical or priority-based repairs in the case where the data is partitioned into priority levels.

SAUPODOC - Semantic Annotation Using Population of Ontology and Definition of Classes

Contact: Brigitte SAFAR

The SAUPODOC tool allows for the enrichment of an ontology with new formal specific concept definitions, learnt using property assertions coming from a corpus of manually annotated documents and some external resources. It has been developed during the PORASO Project, a collaboration with the Wepingo company.

LaHDAK team publications (20 %)

Journal articles

Major international journals

(1) P. Alina, Y. Ma, T. George, K. Maria, D. Felix, F. Baader, and M. Schroeder. Formalizing biomedical concepts from textual definition. *Journal of Biomedical Semantics*, page 24, 2015.

(2) M. Bienvenu, B. Ten Cate, C. Lutz, and F. Wolter. Ontology-Based Data Access: A Study through Disjunctive Datalog, CSP, and MMSNP. *ACM Transactions on Database Systems*, 39(4):33, Dec. 2014.

(3) A. Bonifati, M. Goodfellow, I. Manolescu, and D. Sileo. Algebraic incremental maintenance of XML views. *ACM Transactions on Database Systems*, 38(3):1–45, Apr. 2013.

(4) J. Camacho-Rodríguez, D. Colazzo, and I. Manolescu. PAXQuery: Efficient Parallel Processing of Complex XQuery. *IEEE Transactions on Knowledge and Data Engineering*, 27(7):1977 – 1991, July 2015.

(5) J. Dos Reis, D. Duy, M. Da Silveira, C. Pruski, and C. Reynaud-Delaître. Recognizing Lexical and Semantic Change patterns in Evolving Life Science Ontologies to Inform Mapping Adaptation. *Artificial Intelligence in Medicine*, 63(3):153–170, 2015.

(6) J. Dos Reis, D. Duy, C. Pruski, M. Da Silveira, and C. Reynaud-Delaître. Identifying Relevant Concepts Attributes to Support Mapping Maintenance under Ontology Evolution. *Journal of Web Semantics*, 29(0):53–66, 2014.

(7) Y. Fang, R. Cheng, W. Tang, S. Maniu, and X. Yang. Scalable Algorithms for Nearest-Neighbor Joins on Big Trajectory Data. *IEEE Transactions on Knowledge and Data Engineering*, 28(3), 2016.

(8) F. Goasdoué, K. Karanasos, Y. Katsis, J. Leblay, I. Manolescu, and S. Zampetakis. Growing Triples on Trees: an XML-RDF Hybrid Model for Annotated Documents. *The VLDB Journal*, 22(5):589–613, 2013.

(9) B. Groz and S. Maneth. Efficient testing and matching of deterministic regular expressions. *Journal of Computer and System Sciences*, 89:372 – 399, Nov. 2017.

(10) K. Karanasos, A. Katsifodimos, and I. Manolescu. Delta: Scalable Data Dissemination under Capacity Constraints. *Proceedings of the VLDB Endowment (PVLDB)*, 7(4):217–228, Dec. 2013.

(11) P. Lagree, B. Cautis, and H. Vahabi. As-You-Type Social Aware Search. *ACM Transactions on Intelligent Systems and Technology*, 8(5):1 – 27, Sept. 2017.

(12) S. Maniu, R. Cheng, and P. Senellart. An Indexing Framework for Queries on Probabilistic Graphs. *ACM Trans. Datab. Syst*, 2017.

(13) N. Pernelle, F. Saïs, and D. Symeonidou. An automatic key discovery approach for data linking. *Journal of Web Semantics*, 23:16–30, 2013.

(14) L. Ye and P. Dague. An Optimized Algorithm of General Distributed Diagnosability Analysis for Modular Structures. *IEEE Transactions on Automatic Control*, 15(1086), May 2017.

Conference articles

Major international conferences and workshops

(15) C. Alec, C. Reynaud-Delaître, and B. Safar. An Ontology-Driven Approach for Semantic Annotation of Documents with Specific Concepts. In *The Semantic Web. Latest Advances and New Domains. 13th ESWC 2016*, pages 609–624, Heraklion, Greece, May 2016. Springer.

(16) J.-F. Baget, M. Bienvenu, M.-L. Mugnier, and S. Rocher. Combining Existential Rules and Transitivity: Next Steps. In *IJCAI: International Joint Conference on Artificial Intelligence*, Buenos Aires, Argentina, July 2015.

(17) N. Bidoit, D. Colazzo, N. Malla, F. Ulliana, M. Nolé, and C. Sartiani. Processing XML queries and updates on map/reduce clusters. In *International Conference on Extending Database Technology (EDBT)*, Genova, Italy, Mar. 2013.

(18) N. Bidoit, M. Herschel, and A. Tzompanaki. Efficient Computation of Polynomial Explanations of Why-Not Questions. In *24th ACM International Conference on Information and Knowledge Management - CIKM 2015*, Melbourne, Australia, Oct. 2015.

(19) N. Bidoit, M. Herschel, and K. Tzompanaki. Query-Based Why-Not Provenance with NedExplain. In *Extending Database Technology (EDBT)*, Athens, Greece, Mar. 2014.

(20) M. Bienvenu, C. Bourgaux, and F. Goasdoué. Explaining Inconsistency-Tolerant Query Answering over Description Logic Knowledge Bases. In *AAAI: Conference on Artificial Intelligence*, Phoenix, United States, Feb. 2016.

(21) M. Bienvenu, C. Bourgaux, and F. Goasdoué. Query-Driven Repairing of Inconsistent DL-Lite Knowledge Bases. In *IJCAI: International Joint Conference on Artificial Intelligence*, New York, United States, July 2016.

(22) M. Bienvenu, C. Bourgaux, and F. Goasdoué. Querying Inconsistent Description Logic Knowledge Bases under Preferred Repair Semantics. In *AAAI Conference on Artificial Intelligence (AAAI)*, Quebec city, Canada, July 2014.

(23) M. Bienvenu, D. Calvanese, M. Ortiz, and M. Simkus. Nested Regular Path Queries in Description Logics. In *Fourteenth International Conference on the Principles of Knowledge Representation and Reasoning (KR)*, Vienna, Austria, July 2014.

(24) M. Bienvenu, M. Ortiz, M. Simkus, and G. Xiao. Tractable Queries for Lightweight Description Logics. In *International Joint Conference on Artificial Intelligence (IJCAI)*, pages 768–774, China, Aug. 2013.

(25) M. Bienvenu and R. Rosati. Tractable Approximations of Consistent Query Answering for Robust Ontology-based Data Access. In *International Joint Conference on Artificial Intelligence (IJCAI)*, pages 775–782, China, Aug. 2013.

(26) M. Bienvenu, B. Ten Cate, C. Lutz, and F. Wolter. Ontology-based data access: A study through disjunctive datalog, CSP, and MMSNP. In *ACM SIGMOD-SIGACT-SIGART Symposium on Principles of Database Systems (PODS)*, page to appear, United States, June 2013.

(27) R. Bonaque, B. Cautis, F. Goasdoué, and I. Manolescu. Social, Structured and Semantic Search. In *International Conference on Extending Database Technology (EDBT)*, Bordeaux, France, Mar. 2016.

(28) D. Bursztyn, F. Goasdoué, and I. Manolescu. Optimizing Reformulation-based Query Answering in RDF. In *EDBT: 18th International Conference on Extending Database Technology*, Brussels, Belgium, Mar. 2015.

(29) J. Camacho-Rodríguez, D. Colazzo, I. Manolescu, and J. A. M. Naranjo. PAXQuery: Parallel Analytical XML Processing. In *ACM SIGMOD International Conference on Management of Data 2015*, pages 1117–1122, Melbourne, Victoria, Australia, May 2015.

(30) S. D. Cardoso, C. Reynaud-Delaître, M. Da Silveira, and C. Pruski. Combining rules, background knowledge and change patterns to maintain semantic annotations. In *AMIA 2017*, Washington, D.C., United States, 2017.

(31) J. Chen, M. Ludwig, Y. Ma, and D. Walther. Zooming in on Ontologies: Minimal Modules and Best Excerpts. . In *In Proceedings of the 16th International Semantic Web Conference (ISWC'17)*, Vienna, Austria, Oct. 2017.

(32) D. Colazzo, F. Goasdoué, I. Manolescu, and A. Roatis. RDF Analytics: Lenses over Semantic Graphs. In *23rd International World Wide Web Conference*, Seoul, South Korea, Apr. 2014.

(33) D. Dinh, J. C. Dos Reis, C. Pruski, M. Da Silveira, and C. Reynaud-Delaître. Identifying change patterns of concept attributes in ontology evolution. In *11th Extended Semantic Web Conference (ESWC) 2014*, Anissaras/Heronissou, Greece, May 2014.

(34) J. C. Dos Reis. Maintaining Mappings Valid between Dynamic KOS. In *Extendend Semantic Web Conference*, volume 7882 of *Lecture Notes in Computer Science (LNCS)*, pages 650–655, Montpellier, France, May 2013. Springer.

(35) J. C. Dos Reis, D. Duy, C. Pruski, M. Da Silveira, and C. Reynaud-Delaître. Mapping Adaptation Actions for the Automatic Reconciliation of Dynamic Ontologies. In *CIKM 2013*, SanFrancisco, CA, United States, Oct. 2013.

(36) J. C. Dos Reis, C. Pruski, M. Da Silveira, and C. Reynaud-Delaître. Characterizing Semantic Mappings Adaptation via Biomedical KOS Evolution: A Case study Investigating SNOMED CT and ICD. In *AMIA 2013 Annual Symposium*, Washington DC, United States, Nov. 2013.

(37) Y. Fang, R. Cheng, W. Tang, S. Maniu, and X. Yang. Scalable Algorithms for Nearest-Neighbor Joins on Big Trajectory Data (Extended abstract). In IEEE, editor, *International Conference on Data Engineering (ICDE)*, pages 1528–1529, Helsinki, Finland, May 2016.

(38) C. Giatsidis, B. Cautis, S. Maniu, M. Vazirgiannis, and D. M. M. Thilikos. Quantifying trust dynamics in signed graphs, the S-Cores approach. In *SDM: SIAM Data Mining*, pages 668–676, Philadelphia, United States, Aug. 2014. Siam.

(39) F. Goasdoué, Z. Kaoudi, I. Manolescu, J.-A. Quiané-Ruiz, and S. Zampetakis. CliqueSquare: Flat Plans for Massively Parallel RDF Queries. In *International Conference on Data Engineering*, Seoul, South Korea, Apr. 2015.

(40) F. Goasdoué, K. Karanasos, Y. Katsis, J. Leblay, I. Manolescu, and S. Zampetakis. Fact Checking and Analyzing the Web. In *SIGMOD - ACM International Conference on Management of Data*, New York, United States, June 2013.

(41) F. Goasdoué, I. Manolescu, and A. Roatis. Efficient Query Answering against Dynamic RDF Databases. In *EDBT - 16th International Conference on Extending Database Technology*, Genoa, Italy, Mar. 2013.

(42) B. Groz, E. Levin, I. Meilijson, and T. Milo. Filtering with the Crowd: CrowdScreen revisited (technical report). In W. Martens and T. Zeume, editors, *19th International Conference on Database Theory (ICDT 2016)*, volume 48 of *19th International Conference on Database Theory, ICDT 2016, Bordeaux, France, March 15-18, 2016*, pages 12:1–12:18, Bordeaux, France, Mar. 2016. Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik.

(43) B. Groz and T. Milo. Skyline Queries with Noisy Comparisons. In *ACM SIGMOD/PODS*, Melbourne, Australia, May 2015.

(44) H. Ibrahim, P. Dague, A. Grastien, L. Ye, and L. Simon. Diagnosability Planning for Controllable Discrete Event Systems. In *31st National Conference on Artificial Intelligence AAAI-17*, San Francisco, United States, Feb. 2017.

(45) I. Ileana, B. Cautis, A. Deutsch, and Y. Katsis. Complete Yet Practical Search for Minimal Query Reformulations Under Constraints. In *SIGMOD Conference 2014*, Snowbird, Utah, United States, June 2014.

(46) S. Jabbour, Y. Ma, R. Badran, L. Sais, and Y. Salhi. On Structure-Based Inconsistency Measures and Their Computations via Closed Set Packing. In *Proceedings of the Autonomous Agents and Multiagent Systems (AAMAS'15)*, Istanbul, Turkey, May 2015.

(47) S. Jabbour, Y. Ma, R. Badran, L. Sais, and Y. Salhi. A MIS Partition Based Framework for Measuring Inconsistency. In *15th International Conference on Principles of Knowledge Representation and Reasoning (KR'16)*, Cape Town, South Africa, Apr. 2016.

(48) R. Khefifi, P. Poizat, and F. Saïs. Automatic Composition of Form-Based Services in a Context-Aware Personal Information Space. In *11th International Conference on Service Oriented Computing, ICSOC 2013*, volume 8274 of *Lecture Notes in Computer Science*, pages 575–583, Berlin, Germany, Dec. 2013. Springer.

(49) P. Lagree, O. Cappé, B. Cautis, and S. Maniu. Effective Large-Scale Online Influence Maximization. In *ICDM 2017 - IEEE International Conference on Data Mining*, New Orleans, France, Nov. 2017. IEEE.

(50) P. Lagree, B. Cautis, and H. Vahabi. A Network-Aware Approach for Searching As-You-Type in Social Media. In *24th ACM International Conference on Information and Knowledge Management - CIKM 2015*, Melbourne, Australia, Oct. 2015.

(51) P. Lagree, C. Vernade, and O. Cappé. Multiple-Play Bandits in the Position-Based Model. In *Neural Information Processing Systems (NIPS)*, Barcelone, Spain, Jan. 2016.

(52) Y.-C. Lin, V. Christen, S. D. Cardoso, M. Da Silveira, C. Pruski, and E. Rahm. Evaluating and improving annotation tools for medical forms. In *12th International Conference on Data Integration in Life Sciences*, Luxembourg, Luxembourg, 2017.

(53) S. Maniu and B. Cautis. Context-Aware Top-k Processing using Views. In *ACM Conference on Information And Knowledge Management (CIKM)*, San Francisco, United States, Oct. 2013.

(54) S. Maniu and B. Cautis. Network-aware Search in Social Tagging Applications: Instance Optimality versus Efficiency. In *ACM Conference on Information And Knowledge Management (CIKM)*, San Francisco, United States, Oct. 2013.

(55) G. Quercini and C. Reynaud-Delaître. Entity Discovery and Annotation in Tables. In *EDBT: Inernational Conference on Extending Database Technology*, Genoa, Italy, Mar. 2013.

(56) K. Stefanidis, V. Efthymiou, M. Herschel, and V. Christophides. Entity Resolution in the Web of Data. In *International World Wide Web Conference (WWW)*, Seoul, South Korea, Apr. 2014.

(57) D. Symeonidou, L. Galárraga, N. Pernelle, F. Saïs, and F. Suchanek. VICKEY: Mining Conditional Keys on Knowledge Bases. In *International Semantic Web Conference (ISWC)*, volume 10587 of *Lecture Notes in Computer Science*, pages 661–677, Vienne, Austria, Oct. 2017. Springer.

(58) D. Symeonidou, V. Armant, N. Pernelle, and F. Saïs. SAKey: Scalable Almost Key Discovery in RDF Data. In S. Verlag, editor, *In proceedings of the 13th International Semantic Web Conference, ISWC 2014*, volume Lecture Notes in Computer Science, pages 33–49, Riva del Garda, Italy, Oct. 2014.

(59) L. Ye, P. Dague, and F. Nouioua. Predictability Analysis of Distributed Discrete Event Systems. In *52nd IEEE Conference on Decision and Control*, pages 5009–5015, Florence, Italy, Dec. 2013.

Theses and habilitations

(60) C. Alec. *Ontology enrichment and population from texts and data from LOD : Application to automatic annotation of documents*. Theses, Université Paris-Saclay, Sept. 2016.

(61) R. Bonaque. *Top-k search over rich web content*. Theses, Université Paris-Saclay, Sept. 2016.

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7/ ModHel

Modélisation hétérogène

équipe ModHel

Responsable: Frédéric Boulanger, Nacéra Seghouani Bennacer

L'équipe ModHel, créée le 1er janvier 2015, est composée d'enseignants-chercheurs de CentraleSupélec qui étaient auparavant membres de l'équipe d'accueil 4454 E3S. Son objectif scientifique est la prise en compte de l'hétérogénéité dans la conception de modèles. Elle se divise selon deux thématiques principales.

Une moitié de l'équipe s'intéresse à la prise en compte de l'hétérogénéité des paradigmes dans la modélisation et la vérification des systèmes logiciels, et a vocation à rejoindre l'équipe VALS.

L'autre moitié s'intéresse à l'intégration de données hétérogènes et de connaissances, et a vocation à rejoindre l'équipe LaHDAK.



ModHel

Head: Frédéric Boulanger, Nacéra Seghouani Bennacer

ModHel is a team that was created on January 1st 2015, and is composed of researchers from CentraleSupélec who were previously members of the E3S "équipe d'accueil" #4454. Its scientific goal is to take heterogeneity into account in the design of models. ModHel is split into two main themes.

One half of the team is interested in the modeling and verification of software systems using different modeling paradigms, and should join the VALS team.

The other half is interested in heterogeneous data and knowledge integration, and should join the LaHDAK team.

Synthetic presentation

Nom du responsable de l'équipe : **Frédéric BOULANGER**

Effectifs de l'équipe
Au 1er janvier 2015, l'équipe comprenait 12 membres permanents.

Personnels ayant quitté l'équipe pendant le contrat en cours
Aucun

Nombre de recrutements réalisés au cours de la période considérée et origine des personnels
Aucun

Production scientifique au cours de la période écoulée

1. Définition d'un cadre sémantique formel outillé pour les langages de spécification de relations temporelles entre événements.
2. Définition d'une sémantique compositionnelle des patrons de Dwyer.
3. Développement du cadriciel VerChor pour la conception de systèmes distribués corrects.
4. Définition d'une nouvelle approche et d'algorithmes pour vérifier la diagnosticabilité des systèmes.
5. Développement de sémantiques opérationnelles et dénotationelles pour des modèles algébriques de calcul: probabilistes, quantiques, et vectoriels en général.
6. Modélisation des sémantiques implicites des données pour la validation des systèmes.
7. Définition d'approches non supervisées pour l'extraction d'information à partir de documents multilingues.
8. Définition d'approches d'apprentissage de profils des utilisateurs à partir de réseaux sociaux combinant des données hétérogènes comme les posts, la structure des graphes, temporelles et localisation.
9. Définition de modèles de représentation de données NoSQL hétérogènes.

Bilan quantitatif des publications de l'équipe

- Articles de revues: majeure internationale: 9, autres: 8
- Article de conférences: majeures internationales: 12, autres: 38
- Édition de livres: 0
- Chapitres de livres: 5

5 publications majeures

- (8, 4, 6, 9, 20)

5 (max) documents majeurs (autres que publications)

- The TESL plug-in for Eclipse for specifying and solving temporal constraints on events.
- The RiseClipse Eclipse toolset for handling IEC standards in a model driven engineering approach.
- The OntoEvent-B generator of Event-B contexts from ontologies.

5 (max) faits illustrant le rayonnement ou l'attractivité académique

- Participation à l'organisation de conférences et workshops internationaux.
- Participation à plusieurs GdR et réseaux.
- Participation a des instances de normalisation (AFNOR, ISO).

5 (max) faits illustrant les interactions de l'équipe avec son environnement socio-économique ou culturel

- Actions de dissémination et de médiation scientifique (émission de radio, intervention dans les écoles).
- Contrats bi-latéraux (hors projets ANR ou européens) avec des industriels.

Principales contributions de l'équipe à des actions de formation

- Définition et réalisation du programme de la majeure « Systèmes informatiques » en troisième année du cursus ingénieur Supélec.
- Responsabilité de la mention « Science du logiciel » en troisième année du cursus ingénieur CentraleSupélec.
- Coresponsabilité du mastère spécialisé « Architecte des systèmes d'information » et du certificat de qualification professionnelle « Architecte technique ».
- Définition et réalisation du programme du Master Paris-Saclay de la mention informatique « Decision Support and Business Intelligence » qui inclut le programme Erasmus Mundus IT4BI ainsi que sa poursuite BDMA.

Research Group Members and evolution since 2013

The ModHel team includes 12 permanent members (5 Professors, 7 Assistant Professors), and 6 doctoral students.

Permanent Members (October 1st, 2017)				
Name	*First name*	*Position*	*Institution*	*Remarks*
AIT-SADOUNE	Idir	MCF	CentraleSupélec	
BOULANGER	Frédéric	PR	CentraleSupélec	
BOURDA	Yolaine	PR	CentraleSupélec	
BUGIOTTI	Francesca	MCF	CentraleSupélec	
DOAN	Bich-Liên	MCF	CentraleSupélec	
MARCADET	Dominique	PR	CentraleSupélec	
POPINEAU	Fabrice	PR	CentraleSupélec	
QUERCINI	Gianluca	MCF	CentraleSupélec	
SEGHOUANI BEN-NACER	Nacéra	PR	CentraleSupélec	
TAHA	Safouan	MCF	CentraleSupélec	
VALIRON	Benoît	MCF	CentraleSupélec	
YE	Lina	MCF	CentraleSupélec	

PhD. students (October 1st, 2017)				
Name	*First name*	*Funding*	*Institution*	*Remarks*
GHUFRAN	Mohammad	CIFRE MindMatcher	CentraleSupélec	
NANA JIPMO	Coriane	CIFRE Wepingo	CentraleSupélec	
CHOFFIN	Benoît	e-FRAN "Parcours Connectés" project	CentraleSupélec	
GOUBAULT DE BRUGIERE	Timothée	CIFRE Atos/Bull	Université Paris Saclay	Co-tutelle avec Marc Baboulin (ParSys)
HAJRI	Hiba	Doctoral school grant	CentraleSupélec	
HAY	Julien	CIFRE Octopeek	CentraleSupélec	
MEDIMEGH	Slim	CEA	CentraleSupélec	
SOARES DE OLIVEIRA NETO	Joao	Erasmus Mundus SMART^2 grant	CentraleSupélec	
TODOROV	Vassil	PSA corporate PhD	CentraleSupélec	

Group evolution

Temporary members					
Name	*First name*	*Position*	*Funding*	*Arrival*	*Departure*
Mohand-Oussaïd	Linda	Post-doc	ANR IMPEX	May 2016	May 2017
Ghufran	Mohammad	ATER		September 2017	August 2018

Research Description

Heterogeneous modeling and verification of systems

Participants: Idir AIT-SADOUNE, Frédéric BOULANGER, Dominique MARCADET, Safouan TAHA, Benoît VALIRON, Lina YE.

This research activity aims at building models that take heterogeneity into account for designing, analyzing and verifying systems. Heterogeneity means that several modeling paradigms are used jointly to

model a whole system. This activity is made in collaboration with the VALS team, and with the ParSys team for quantum computing.

Coordination of heterogeneous models in order to specify how the behavior of heterogeneous components are glued to produce the behavior of the whole system.

The semantics of the TESL language, which was designed to specify the coordination of the execution of heterogeneous models, has been formalized in Isabelle/HOL, with applications to monitoring and testing heterogeneous systems. This work has been done in collaboration with the VALS team through the co-direction of the PhD thesis of Hai Nguyen Van (A168, 20).

Specification of temporal properties of the behavior of systems.

Dynamic properties are commonly specified using temporal logics. These formalisms are difficult to appropriate by system designers and validation engineers. In order to ease their understanding and writing, Dwyer et al. propose in late 90's a language of properties based on the composition of predefined patterns and scopes. Besides the natural semantics of the patterns and scopes, Dwyer et al. provide formal semantics by translation into classical temporal logics, mapping each pattern/scope combination to a corresponding temporal formula. This approach arises many limitations in terms of extensibility, genericity, faithfulness and homogeneity. We developed compositional and automata-based semantics for these patterns/scopes (4). In our approach, we use automata composition to overcome all the translational limitations enumerated before.

The TemporalOCL plug-in for Eclipse implements our compositional approach. It allows the specification of temporal constraints on UML models (Object-Oriented). We do so by enriching OCL (Object Constraint Language) to handle temporal properties.

Choreography (A4, A34). A new framework called VerChor based on the choreography-based development approach has been developed allowing you to design correct distributed systems. VerChor checks automatically for the realizability of a system interaction protocol that is modeled in your favorite language and retrieve peer interaction skeletons. Furthermore, one can use VerChor to generate peer controllers to ensure the conformance to the system specification of a set of peers you want to reuse.

Composition of transactional Web services (A72) Several languages for describing Web service compositions make use of fault and compensation constructs to handle internal and/or external runtime errors of the composed service. This situation particularly occurs for transactional services. However, the absence of a rigorous definition of these constructors makes it difficult to correctly define the Web service transactional behaviour. Our contribution proposes an approach to formally define the semantics of these operators (fault and compensation handlers introduced by the BPEL language specification). It also proposes a methodology showing how we can use Event-B method to design transactional BPEL processes.

Diagnosticability of systems (18, 7, 15, A61, A50, A76, A69, A70, A60) The diagnosis for complex systems is to determine whether faults have occurred in the system based on a sequence of observations. Diagnosis algorithms normally work in contexts with low observability since many events are invisible to the supervisor. Diagnosability is a system property to describe whether any fault can be always deduced with certainty from observations emitted from the system. Several algorithms have been proposed to verify diagnosability for distributed discrete event systems. The undecidability of this problem has also been studied when observations can only be observed by local components. Furthermore, recently, a new approach based on counterexample-guided abstraction refinement has been developed to verify this property for hybrid systems (modeled as hybrid automata), where the verification on an abstract level as timed automata is performed with SMT.

Models of computation for quantum computing. (A16, A64, A15, 5, A50). Quantum computation is a paradigm where one uses the properties of particles governed by the law of quantum physics to endode information. Such technique can be used to obtain a speed-up for solving certain problems, compared to conventional techniques. In the large spectrum of open questions offered by the field, the Modhel team is specialized in the software and programming side: how to interact and safely program with a quantum memory.

Formal semantics of modeling and programming languages.

A formal model based on clock indexed Kripke models has been developed for describing causality and temporal relation between time-stamped events. This model has been used to define a denotational and an operational semantics of TESL, and to prove the equivalence of these semantics.

With collaborators around the globe we also investigated models of computation with algebraic side-effects such as non-determinism, probabilistic and general vectorial behaviors. We analyzed how these generalized models can help in understanding the structure of quantum computation (13, A65, 1, A27).

Explicit domain modelling in refinement-based modelling design (A46, 19, A56, A57) When designing a hardware or a software system, the integration of domain constraints becomes a determining factor to ensure a great match with the system requirements. This domain knowledge is most often modeled using ontologies that allow to express the domain data properties. In the IMPEX project, we propose an approach to integrate domain ontologies into a system development process based on Event-B. It consists to annotate Event-B models using the ontology concepts, this assumes a formalization of the domain ontology in the Event-B method. Therefore, we propose an extensible generic transformation approach which develops an Event-B specification based on an ontology described in an ontological language. The integration of the Event-B description of a do- main ontology allows to constrain the system under design with the domain ontology and to validate domain properties.

Modeling and verifying Multi-modal HCI using formal proofs and refinement. (A12, A13). The use of multi-modal interfaces increases interactions capabilities of machines and improves communication between users and interactive systems. In such systems, the combination of interaction modalities increases the development and the validation processes complexity. When these interfaces are used in critical interactive systems, their development requires rigorous design methods as well as for the functional core. Our proposal consists in defining a generic formal model for describing, formalising and verifying the output multi-modal interaction. In this work, we have presented a generic and formal model handling output multi-modal system interaction specification. The proposed model includes a fission model refined by an allocation model. An Event-B formalisation of the two models are proposed. We show how the first Event-B model, obtained from the fission model, is refined and linked with the second Event-B model obtained from the allocation model.

Heterogeneous data and knowledge integration

Participants: Yolaine BOURDA, Francesca BUGIOTTI, Bich-Liên DOAN, Fabrice POPINEAU, Gianluca QUERCINI, Nacéra SEGHOUANI BENNACER.

This research activity deals with integrating heterogenous data coming from different sources including textual, ambiguous, multilingual data and large graphs for different purposes:

Personalization for Intelligent Tutoring Systems. (A17, A75, 17, 6, A67, A71, A85, A66, 14, A42, A47)
Intelligent Tutoring Systems are floating around for quite a long time now. MOOCs (EdX, Coursera, ...) and large ITS platforms (Moodle) have pushed them at scale. We now have the opportunity to gather massive amounts of data about learners. Learning analytics is born as a new discipline. The next step is to use those data to build smart(er) tutors, which would adapt their behavior to each learner individually. In this context, we studied differents aspects of personalization that occur in ITS:

- Personalization of the behavior of companion agents
- Personalization of the recommendation of external pedagogical resources in the context of a MOOC
- Adaptive testing where the goal is to shorten the length of a test for a student. This question is closed to the recommendation problem: what is the next question to ask to the student which will give me the most information about his skills?

Information extraction from texts. (A51, A52, A45, 9, A51, A82, A5)
Large part of valuable information is available online in an unstructured textual documents. Traditional information extraction approaches involve the use of natural-language processing to identify references to specific named entities as well their relationships or to capture targeted concepts and semantic. In the context of the Web, textual documents are by nature massive, real time, ambiguous and multilingual. The use of heavy and constrained advanced traditional techniques is doomed to fail. In this context we defined, evaluated on real datasets and compared with existing approaches efficient (scaling-up) and automatic approaches combining external sources such as Wikipedia and BabelNet which are large multilingual encyclopedia graphs and machine learning algorithms for different purposes such as:

- Identifying topics of interest of social network users.

- Identifying frequent named entities for Interpreting reputation in Twitter.
- Augmenting resumes using key n-grams by crawling information from the Web.
- Discovering hidden dimensions of the words revealing some of psychological and personality traits of a person.
- Temporal evolution of the users' profile.
- Recommendation of online resources according to user reactions.

Learning models from large graphs. (A36, A14, 10, 8, A36)
Nowadays data available online is structured and linked as large and rich graphs such as social media networks. Combining information provided by graph structures with information extracted from texts, time and location information and other kind of resources such as images provides a powerful source of information. We defined new and efficient approaches to build and learn unsupervised models that allow us:

- Reconciling individual profiles through the information they disclosed as names, location, links to other documents, ... and their dynamic activities (for ex. posts) across multiple social network platforms.
- Building models to learn user interests from their personality traits discovered in texts for recommendation systems.
- Building user profiles from resumes by retrieving, identifying and reconciling user Web resources for human resource management systems in order to have a holistic view of an applicant.
- Exploring Wikipedia graph to discover new cross-language links or to detect false ones.

Integration of cloud data and NoSQL heterogeneous database requests. (A10, 11, 12, A39, A40, A41, A73, A77)
Digital data is being produced at an increasingly fast pace and has become central to daily life in modern societies. In this context using heterogeneous data of significant size is a central objective for new applications. Moreover multiple NoSQL databases have been defined in the last years in order to effectively store data in this context but those systems provide different data models, query languages, and performances. Given this heterogeneity it becomes essential for modern applications to take benefit from new techniques that easily access data stored in these systems. In this context we defined multiple techniques that support the development of new applications hiding the specific details of the various systems and allow to access multiple NoSQL databases at the same time. More in detail our research work in this area:

- defined new techniques for storing and querying data stored in the cloud;
- explored new methodologies for integrating data coming from multiples heterogeneous data sources;
- developed a new data model on the top of NoSQL databases;
- defined a general methodology for querying heterogeneous NoSQL databases.

Quantum modeling for information retrieval

- Analyzing the mathematical and geometrical Hilbert space framework in order to adapt it to conventional IR. Researching analogies bridging IR needs with known results from QM both in theory and experiment
- Finding new formulations for the models of information retrieval: "Boolean, vectorial and probabilistic" and "assistance to the reformulation of contextual queries" enabling the integration of Hilbert space.
- Adapting existing test platforms and evaluating the classical formalization algorithms with the new developed algorithms issued from QM models.
- Formalizing and then experimentally evaluating the procedure of the proposed methods for the development of query measures of relevance.

Team Organisation

Team Organisation

Since its creation, the ModHel team aims at integrating its members into the VALS and LaHDAK teams. It is therefore organized following the organization of these two teams (participation in the seminars and meetings). This is facilitated by the location of the offices: members of ModHel who work with one of the other teams have their office on the same floor as that team.

Self Assessment

Strengths: Both parts of ModHel are very connected to the industry through CentraleSupélec. This brings us funding (PhD thesis grants, industrial projects), but also real issues that are used as benchmarks for our academic tools, and as hints on which directions should be investigated more deeply.

Weaknesses: Being a relatively young team, ModHel lacks HdRs, which may be an issue if it limits the number of PhD students in the team. Also, the split nature of the team, with two almost independent research themes, makes this team quite artificial.

Opportunities: Joining LRI has been a great opportunity for ModHel. The merge of its members into the VALS and LaHDAK teams will also be an opportunity to reinforce the existing collaborations, and to work in a more focused research landscape.

Threats: A major issue in the approach ModHel has of research is maintaining the balance between theoretical results and the connection to real industrial problems. Spending too much time on the development of tools for real case studies is not always rewarding. On the contrary, developing only theoretical concepts may cut us from the reality which brings us new ideas. Our limited resources make it impossible to compete with the research labs of companies such as Microsoft or Google, and the ecosystem in which we can survive is limited and fragile.

Strategy and five-year project

The future of the ModHel team is to dissolve into the LaHDAK and VALS teams. Its rôle has been to allow for an observation phase in the integration of former members of the E3S team at Supélec. During this phase, we developed collaborations with the LaHDAK and VALS teams, as well as with the PARSYS team. Our projects for the five coming years are therefore aligned with the projects of these teams.

Scientific Programme

Future LaHDAK part of the team

Heterogenous Data and Knowledge Integration Considering the thematic proximity, the common research interests and current/past collaborations between Heterogeneous data and knowledge integration team members and LaDHAK team members it is expected that this part of ModHel joins LaDHAK team.

At the end of January 2018, we submitted to the SATT Paris-Saclay maturation project with DataForYou, a newly formed start-up company, that passed the pre-selection step. The project aims at developing a decision-support system that will help city councils to take informed decisions in their cities based on the knowledge of their inhabitants interests and behaviors. This project allows us to extend and adapt our approaches related to building user profiles and data integration to other data sources and will bring together Data For You and researchers from both ModHel and LaDHAK.

The current grant from the e-FRAN "Parcours Connectés" project is funding a PhD for Benoît Choffin where we investigate how to increase the durability of learning together with shortening the training period. We would also like to carry on with the research developed during the previous PhD thesis by Hiba Hajri and open up the recommendation of educational resources to resources that are not indexed by the LOD. Many such resources exist especially as YouTube channels and it would be great to be able to automatically point a student at them.

This work about personalized recommendation has also many aspects in common with a previous line of work concerning the personalized recommendation of online news articles. For this reason and with

the intent to deepen our knowledge about this specific personalization process, we have started another PhD work about how to construct users' profiles from social networks interaction to pinpoint users' interests and help recommendation of news articles.

In the same time we are preparing a new ANRT project with Schlumberger company. The proposal involves working on heterogenous data coming from different sources and massive NoSQL databases, documents (text, tables, images) and other sources about geological data and oil/petroleum reservoir locations to define new approaches based on deep learning, for extracting entities and their relationships and building/querying large NoSQL knowledge database.

Future VALS part of the team

The part of ModHel which is connected to the VALS team has been working since 2015 on the use of formal methods for modeling and verifying heterogeneous systems. Through several common projects, PhD thesis, and work leading to common publications, we have identified three main research objectives for the coming years.

The first objective is the formal modeling and verification of heterogeneous systems, with an emphasis on the coordination of the heterogeneous components in a system. This objective is strongly connected to two other objectives: linking the formal and the semi-formal in order to capture requirements and to trace them all along the design of the system, and formal testing of programs and systems, which is already a strong research theme in the VALS team. Our roadmap is to combine model driven engineering with formal methods in order to improve the confidence in the design of heterogeneous systems and to ease the certification of critical systems.

Positioning in the local, national and international context

Future LaHDAK part of the team

Many projects are starting or are being built at local, national and international levels, involving academic partners and company partners such as ANRT project with Schlumberger, SATT Paris-Saclay maturation project with DataForYou, TUB Berlin University (DIMA group) and other local projects. The purpose is to continue to work on the following main topics:

- Heterogeneous data integration with a focus on user/person data, in a multilingual context
- Storage and querying this kind of data in a big data environment
- Defining efficient and distributed algorithms to build and learn models from this data

Future VALS part of the team

In the domain of the modeling and verification of heterogeneous systems, the ModHel team is strongly connected to the VALS team, with a common internal project and a co-supervised PhD thesis, as well as common meetings about the Isabelle/HOL platform and model-based testing. In the local context, we have collaborations with CEA-LIST and EDF Research Lab through PhD thesis (CIFRE or funded by CEA).

At the national level, we have fruitful collaborations with other teams (DiverSE, ACADIE, KAIROS), either through ANR projects or through the participation in GdR GPL.

At the international level, the GEMOC initiative and the organization of several workshops help us to disseminate our results and to keep in touch with other leading laboratories. New connections have been made recently with the University of Iowa in the domain of inductive model-checking.

In the domain of quantum computation, the ModHel team develops collaborations with the ParSys team through a "projet interne", a shared CIFRE, a student from CentraleSupelec in "parcours recherche" and several internships. In the plateau de Saclay area, a collaboration with CEA-LIST has started with a renewable one-year CEA funded post-doc and a co-supervised CEA-funded PhD student.

At the national level, we have collaborations with LORIA and Atos/Bull through an ANR and a BPI-GDN projects.

At the international level, our expertise is recognized, as attested by several invited talks in international events. Backed up by the current national projects, the objective for the near future is to position our team on the European scene with as a first step answers to calls in the context of the Quantum Flagship.

Annex 4

Collaborations

Participation to national and international collaborative research projects

International projects

- ECOS-Sud QuCa, 2018–2020. Coordinator: Quilmes University (Argentina). Partners: Universidad de la República Uruguay INRIA, LRI, LORIA, Université Aix-Marseille.
- SticAmSud FoQCoSS, 2015–2017. Coordinator: Quilmes University (Argentina). Partners: Universidade Federal de Santa Maria (Brasil), INRIA, LRI, LORIA, Université Aix-Marseille.
- Uruguayan research grant, 2015–2017. Partners: LRI, Universidad de la República Uruguay, Montevideo.

National projects

- CORAC, Coordinator: THALES Avionics. Partners: LRI, THALES Avionics.
- ANR IMPEX, Coordinator: LORIA. Partners: CentraleSupelec/LRI, LORIA, IRIT/INPT-ENSEEIHT, Télécom-Sud-Paris, Systerel.
- ANR SoftQuPro, Coordinator: LRI+LORIA Partners: Atos/Bull, LRI, LORIA, CEA-LIST/LSL.
- FUI NEXPERTSANTE, Coordinator: Meta-Coaching. Partners: LRI, Meta-Coaching, Yseop, Sen.SE, CHU Montpellier.
- e-FRAN "Parcours Connectés", Coordinator: Synlab association. Partners: LRI, Synlab association, Pôle numérique académie Créteil, Créteil ESPE, Didask, LIS (Paris-Est University), ENS.
- BPI/GDN Quantex, Coordinator: Atos/Bull. Partners: CEA-LETI, LORIA, LRI.

Local projects

- Center for Data Science 2.0 : Heterogeneous social data management and mining. Nacéra Seghouani Bennacer, Francesca Bugiotti, Gianluca Quercini, 2016-2017.
- FreeReg, Regularity for Free, Project ModHel (Benoît Valiron) and VALS (Thibault Balabonski and Chantal Keller), 2016–2017.
- Vers une résolution quantique des systèmes linéaires, Project ModHel (Benoît Valiron) and ParSys (Marc Baboulin), 2018–2019
- Webstore, Project ModHel (Nacéra Seghouani Bennacer et Francesca Bugiotti) and LaHDAK (Benoit Groz et Silviu Maniu), 2016 - 2018.
- Veracity in the Web, Project ModHel (Gianluca Quercini) and LaHDAK (Fatiha Saïs), 2018 - 2019.
- Modélisation logique, simulation et vérification de systèmes techniques intégrant les facteurs humains, Frédéric BOULANGER and Safouan TAHA, PEPS S2IH INS2I 2018

Collaborations with other laboratories leading to joint publications

International collaborations

- Frédéric Boulanger, Université de Montreal: Composition of models of computation (Organization of the GEMOC workshop)
- Frédéric Boulanger, Université de Montreal: Model driven engineering (Steering committee of the MoDeVVa workshop)
- Francesca Bugiotti, University of Tuscia: Big data and energy
- Francesca Bugiotti, Roma Tre University: Big data and NoSQL (2, A10, A41)
- Francesca Bugiotti, University of San Diego, California: Heterogeneous databases (12, 11, A39)
- Benoît Valiron, Bologne University: Geometry of interaction (13, A23)
- Benoît Valiron, Quilmes University, Argentina: Quantum computation (1)
- Benoît Valiron, Universidad de la República Uruguay, Montevideo: Models of computation for Quantum Computing (Uruguayan research grant)
- Benoît Valiron, Federal University of Santa Maria, Brasil: Quantum computing
- Benoît Valiron, University of Maryland, USA: Quipper language (5)
- Benoît Valiron, University of Indiana, USA: Quantum computing (A27)
- Benoît Valiron, Dalhousie University, Canada: Quipper language (5)
- Bich-Liên Doan, Fabrice Popineau, Free University of Bozen-Bolzano, Italy: news articles recommendation (A5)
- Lina Ye, Australian National University, Australia: Diagnosability Planning (A50, 15)
- Francesca Bugiotti, Nacéra Seghouani Bennacer, TUB Berlin University (Ralf-Detlef Kutsche): NoSQL Datastore Models and Integration.

National collaborations

- Idir Ait-Sadoune, ENSEEIHT/IRIT: Multimodal MMI & Service composition (A72, A12, A13)
- Idir Ait-Sadoune, LIAS/ENSMA: Requirement modeling (3)
- Frédéric Boulanger, LISE lab of CEA-LIST: Qualitative simulation (A55, A54)
- Frédéric Boulanger, EDF Research Lab: Modeling of smart grids (16, A62, A84)
- Frédéric Boulanger, INRIA AOSTE, Sophia Antipolis: Composition of languages (GEMOC initiative[1], Organization of the GEMOC workshop)
- Frédéric Boulanger, IRIT, Toulouse: Composition of languages (GEMOC initiative, Organization of the GEMOC workshop)
- Francesca Bugiotti, INRIA/LIX: Heterogeneous databases (12, 11, A39)
- Dominique Marcadet, EDF Research Lab: Use of MDE technologies for IEC standards (A53)
- Benoît Valiron, IRIF: rewriting theory (A65, 13)
- Benoît Valiron, LORIA: quantum computing (ANR and BPI/GDN projects)
- Benoît Valiron, CEA-LIST/LSL: formal methods for quantum computing (ANR project SoftQPro)
- Yolaine Bourda, Fabrice Popineau: STEF ENS Cachan: adaptive testing, co-supervision of Jill-Jênn Vie PhD thesis, (17, A75, A71, A66)
- Lina Ye, Labri, University of Bordeaux: Diagnosability Planning (A50, 15)
- Lina Ye, LISE lab of CEA-LIST: Verification by abstraction refinement (A76, A70)
- Lina Ye, Convecs INRIA, Université Grenoble Alpes: design and verification of communicating systems (A34, A4)

Visiting professors and students (more than one week)

- May 2018 - Benoît Valiron visited the Ciudad Universitaria de Buenos Aires (Argentina) for 2 weeks.
- April 2017 - Benoît Valiron visited the University of Montevideo (Uruguay) for 2 weeks.
- December 2016 - Benoît Valiron visited Quilmes University (Buenos Aires, Argentina) for 2 weeks.
- August 2016 - Juliana Vizzotto (Federal University of Santa Maria, Brasil) visited the LRI for 1 week.
- June 2018 - Ralf-Detlef Kutsche (TUB Berlin University) visited the LRI (F. Bugiotti and N. Seghouani Bennacer) for 1 week.
- July 2018 - F. Bugiotti and N. Seghouani Bennacer visited TUB Berlin University - DIMA research team for 1 week.

Group seminar

- Feb 25, 2016 – Method B – Safouan Taha and Idir Ait Sadoune
- Feb 7, 2017 – Inclusive Smart Cities – João Neto
- Participation in the "Isabelle club" meetings (**https://modhel.lri.fr/IsabelleClub/**)
- Participation in the "Test club" meetings (**https://vals.lri.fr/mbt/**)

Participation to national and international networks

- GEMOC Initiative: Frédéric Boulanger, member since 2013
- ORPHEE ANR network : Yolaine Bourda, Fabrice Popineau, 2014-2018
- GdRI Linear Logic : Benoît Valiron (since its creation in 2016)
- CNRS GdR Informatique Mathématique
  - GT Informatique Quantique (Benoît Valiron)
  - GT Geocal (Benoît Valiron)
- CNRS GdR Information Quantique, Fondements & Applications (IQFA) : Benoît Valiron
- ACM : SIGPLAN, SIGLOG : Benoît Valiron
- Digicosme Work group D2K (Data to Knowledge): Nacéra Seghouani Bennacer and Francesca Bugiotti
- Center for Data Science (CDS 2): Nacéra Seghouani Bennacer and Francesca Bugiotti and Gianluca Quercini

Volunteer Professional Service

Organisation of Conferences and Scientific Events

- GEMOC 2017, 5th Workshop on the Globalization of Modeling Languages, Austin, TX, USA, 2017: Frédéric Boulanger, organizing committee
- POPL 2017, 44th ACM SIGPLAN Symposium on Principles of Programming Languages, Paris, France, 2017: Benoît Valiron, organizing committee
- ISOLA 2016, 7th International Symposium on Leveraging Applications of Formal Methods, Verification and Validation, Corfu, Greece, 2016: Idir Ait-Sadoune, organizing committee
- MoDeVVa, Workshop on Model-Driven Engineering, Verification and Validation, 2015-: Frédéric Boulanger, steering committee

Honors

[1] **http://gemoc.org**

Awards

- Yolaine Bourda received the *IEC 1906 Award* (2016) in recognition to her major contribution to the work of the international standardisation committee ISO/IEC JTC1 SC36 « Information technology for Learning, Education and training »
- Yolaine Bourda, *Chevalier dans l'ordre des palmes académiques* (2016)
- Jill-Jênn Vie has been awarded the *Machine Learning and Data Science* "Trophies K2" from "Cercle K2" for his PhD thesis co-supervised by Yolaine Bourda and Fabrice Popineau. The Trophies K2's objective is to value and support researchers who, owing to their imagination and creativity, but also to they working force, have made a discovery in their field of research or found an application likely to address the challenges that our societies are faced with.

Keynote Addresses and invited talks

International

- Benoît Valiron, CVQT – Combining Viewpoints in Quantum Theory, Edinburgh, 2018: From Symmetric Pattern Matching to Quantum Control.
- Benoît Valiron, ICCAD Workshop on Design Automation for Quantum Computers, Irvine, 2017: Quantum Compilation: from High-Level to Low-Level.
- Benoît Valiron, FDL – Forum on specification & Design Languages, Verona, 2017: On Programming Quantum Computers.
- Benoît Valiron, Aspen Winter Conference on Advances in Quantum Algorithms and Computation, 2016: Quantum algorithms from the programmer's perspective.
- Benoît Valiron, Aspen Winter Conference on Advances in Quantum Algorithms and Computation, Waterloo, 2015: A Scalable Quantum Programming Language.
- Bich-Liên Doan, keynote at the ACM international conference IML 2017.

Evaluation of Research

Journal Reviews

- Theoretical Computer Science, Benoît Valiron
- Logical Methods in Computer Science, Benoît Valiron.
- Quantum Information & Computation, Benoît Valiron.
- Quantum Information Processing, Benoît Valiron.
- Journal of Automated Reasonning, Benoît Valiron.
- New Journal of Physics, Benoît Valiron.
- Nature, Benoît Valiron.
- Journal of Systems and Software, Lina Ye, Frédéric Boulanger
- IEEE Transactions on Automatic Control, Lina Ye
- ACM Transactions on Embedded Computing Systems, Frédéric Boulanger
- Software and Systems Modeling, Frédéric Boulanger
- Frontiers of Computer Science, Frédéric Boulanger
- Systems Engineering, Frédéric Boulanger
- Science of Computer Programming, Lina Ye, Frédéric Boulanger
- Journal of Intelligent Information and Database Systems, Frédéric Boulanger
- Information Processing & Management, Fabrice Popineau
- Journal of Graph Algorithms and Applications, Gianluca Quercini
- RNTI Journal Special Issue on Open Data, Nacéra Seghouani Bennacer
- Advances in Knowledge Discovery and Management (AKDM) Springer Journal , Nacéra Seghouani Bennacer
- Knowledge-Based Systems (KNOSYS) Elseiver Journal , Nacéra Seghouani Bennacer
- American Journal of Applied Sciences Journal, Nacéra Seghouani Bennacer
- Frontiers of Computer Science Springer Journal, Nacéra Seghouani Bennacer
- International journal of cybernetics, systems and management sciences, Bich-Liên Doan

Program Committees

Member (international events)

- QPL 2018, 15th International Conference on Quantum Physics and Logics, Benoît Valiron (2018)
- MFPS 2018, 34th Conference on the Mathematical Foundations of Programming Semantics, Benoît Valiron (2018)
- QPL 2017, 14th International Conference on Quantum Physics and Logics, Benoît Valiron (2017)
- IJCAI-ECAI 2018, 27th International Joint Conference on Artificial Intelligence and the 23rd European Conference on Artificial Intelligence, Fabrice Popineau (2018)
- MEDI, International Conference on Model and Data Engineering, Idir Ait-Sadoune (2015–2018)

- CBDCom, IEEE International Conference on Cloud and Big Data Computing, Idir Ait-Sadoune (2016–2018)
- TASE 2017, 11th International Symposium on Theoretical Aspects of Software Engineering, Frédéric Boulanger (2017)
- MoDeVVa, Workshop on Model-Driven Engineering, Verification and Validation, Frédéric Boulanger (2015–2017)
- FOCLASA'17, 15th International Workshop on Foundations of Coordination Languages and Self-Adaptative Systems, Lina Ye (2017)
- RC 2016, 8th Conference on Reversible Computation, Bologna, Italy, Benoît Valiron (2016)
- ISOLA 2016, 7th International Symposium On Leveraging Applications of Formal Methods, Verification and Validation, Idir Ait-Sadoune (2016)
- VALID, International Conference on Advances in System Testing and Vali- dation Lifecycle, Lina Ye (2015–2016)
- DeCPS 2015, Second International Workshop on Challenges and new Approaches for Dependable and Cyber-Physical Systems Engineering, Safouan Taha (2015)
- SAC'15, 30th ACM/SIGAPP Symposium On Applied Computing, Lina Ye (2015)
- eBISS, European Business Intelligence and Big Data Summer School, Nacéra Seghouani Bennacer (2016, 2017)
- ACM GIS, International Conference on Advances in Geographic Information Systems, Gianluca Quercini (2015, 2016, 2017, 2018)

Member (national events)

- AFADL, Journées Approches Formelles dans l'Assistance au Développement de Logiciels, Safouan Taha (2015–2017)
- IC, Ingéniérie des connaissances, Nacéra Seghouani Bennacer (2014, 2015, 2016, 2017, 2018)
- EGC, Extraction et Gestion des Connaisances, Gianluca Quercini (2014, 2015, 2016, 2017, 2018)
- Gestion de données – Principes, Technologies et Applications BDA, Francesca Bugiotti

Standardization Committees

AFNOR CN36 (Technologies de l'information pour l'éducation, la formation et l'apprentissage)

- Yolaine Bourda, expert since 2002

ISO/IEC JTC1 SC36 (Information technology for Learning, Education and training)

- Yolaine Bourda, expert and member of the french delegation since 2002
- Yolaine, co-editor of the ISO/IEC 19788 multipart standard

ISO/IEC JTC1 SC42 (Artificial Intelligence)

- Fabrice Popineau, member of the standardization committee since 2018

Evaluation Committees and Invited Expertise

- Evaluation of the MODMED ANR project proposal, Frédéric Boulanger (2015)
- Evaluation of a Research Grant Application for the Israel Science Foundation, Frédéric Boulanger (2016)
- member of the committee of experts for the HCERES evaluation of the ESTIA-Research laboratory (2015)
- Halfway evaluation of the MODMED ANR project, Frédéric Boulanger (2017)
- Halfway evaluation of the CIDRE ANR project, Yolaine Bourda (2016)

Other evaluation activities

- Report on the PhD thesis of Sonia Ben Ticha, Yolaine Bourda, 2015
- Report on the PhD thesis of Yann Hourdel, Frédéric Boulanger, 2015
- Report on the HdR of Jérôme Hugues, Frédéric Boulanger, 2016
- Report on the PhD thesis of Bruce People, Yolaine Bourda, 2016
- Jury member for the PhD thesis of Yakoub Nemouchi, Frédéric Boulanger, 2016
- Jury member (Pr) for the PhD thesis of Florent Latombe, Frédéric Boulanger, 2016
- Jury member for the PhD thesis of Sana Hamdi, Yolaine Bourda, 2016
- Jury member for the PhD thesis of Matthieu Cisel, Yolaine Bourda, 2016
- Jury member for the PhD thesis of Lina Fahed, Yolaine Bourda, 2016
- Jury member (Pr) for the PhD thesis of Hanane OUKSILI, Yolaine Bourda, 2016
- Jury member for the PhD of Ge Song, Bich-Liên Doan, 2016
- Jury member for the PhD thesis of Anthony Legendre, Frédéric Boulanger, 2017
- Jury member for the PhD thesis of Sahar Guermazi, Frédéric Boulanger, 2017
- Jury member (Pr) for the PhD thesis of Eilean von Lautz Cauzanet, Yolaine Bourda, 2018
- Jury member (Pr) for the PhD thesis of Adnan El Moussawi (Advisor: Arnaud Giacometti, Tours University) , Nacéra Seghouani Bennacer, 2018

Interactions with the social, economic and cultural environment

Interaction with the economic environment

Numerous contracts with the industry for one-year projects (CEI, see 7.6.8).

CIFRE PhD thesis (see 7.6.9).

FUI NEXPERTSANTE Project

SATT Data4You Project.

Dissemination

- Benoît Valiron – 2018. A formal analysis of quantum algorithms. (A16)
- Benoît VAliron – 2017. Programmer un ordinateur quantique. Presentation during a saturday event organized by Maths en Mouvement and the Fondation des Sciences Mathematiques de Paris. (A78)
- Benoît Valiron – 2015. Programming the Quantum Future. Youtube Video featured on CACM website. Produced by Tom Geller, following a three-hour discussion.

Popularisation of Research Results

- Benoît Valiron – 2016. À la découverte de l'ordinateur quantique. Radio show La tête au carré on the French public station France Inter.
- Participation à la fête de la science de l'Université Paris Sud: atelier "le binaire". 2017, primaires, Benoît Valiron.
- Introduction to programming with robots, 2015–2017, pupils from CE2 to CM2, DigiCosme project, Frédéric Boulanger
- Convention Big Data event, HEC 24-25 November 2015, ModHel - Heterogeneous Data & Knowledge Integration team Poster.

Contracts and grants

Public contracts and grants (jan 2013 - jun 2018)

Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*		*Amount*
Projet FUI	Meta-Coaching	NEXPERTSANTE	CentraleSupélec	2014	36	200
Projet e-FRAN	Fabrice Popineau	"Parcours Connectés"	CentraleSupélec	02.2017	36	115
Projet PIA	Dominique Marcadet	CORAIL	CentraleSupélec	03.2015	22	81
Projet BPI/GDN	Benoît Valiron	Quantex	Université Paris Sud	12.2017	36	251
Projet ANR	Benoît Valiron	SoftQPro	Université Paris Sud	03.2015	48	96
Projet ANR	Idir Ait-Sadoune	IMPEX	CentraleSupelec	12.2013	48+12	

NEXPERTSANTE

Type: FUI
Amount: 200 k€
Duration: 36 months
Scientific director for LRI: Nacéra Seghouani Bennacer

Partners: Meta-Coaching, Yseop, Sen.Se and the University Hospital of Montpellier

See **https://systematic-paris-region.org/fr/projet/nexpertsante/**

Project labelled by 3 competitiveness clusters: Medicen, Cap Digital and Systematic. The goal of the project was to build an online platform and a protocol for cognitive-behavioral therapy to help people with insomnia.

CORAIL

Type: PIA
Amount: 81 k€
Duration: 22 months
Scientific director for LRI: Frédéric Boulanger, Dominique Marcadet, Safouan Taha, Benoît Valiron

Partners: Thales Avionics

The CORAIL project aims to develop the AME (Avionique Modulaire Étendue) platform to replace the IMA (Integrated Modular Avionics) architecture used in current aircrafts. The Modhel team has designed a system for establishing, maintaining and distribute a time reference above an ARINC A664 network.

SoftQPro

Type: ANR
Amount: 81 k€
Duration: 22 months
Scientific director for LRI: Benoît Valiron

Partners: LORIA, Atos/Bull, CEA-LIST

The SoftQPro project aims at developing a complete compiler toolchain for quantum computation: from a front-end with a quantum programming language down to various low-level representation and emulation backends. The approach followed consists in using the ZX calculus as an intermediate representation

Quantex

Type: BPI/GDN
Amount: 81 k€
Duration: 22 months
Scientific director for LRI: Benoît Valiron

Partners: LORIA, Atos/Bull, CEA-Leti

The goal of this project is to develop a comprehensive toolbox for adapting industrial-scale problems to a quantum computing plateform.

Private contracts and grants (jan 2013 - jun 2018)						
Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*		*Amount*
Industriel	PERSONNE_LRI	FIRME	TYPE_CONTRAT	12.2010	31	25.00
CIFRE		OctoPeek	LRI	04.2017	36	45
CIFRE		Wepingo	LRI	6.2014	36	45
CIFRE		MindMatcher	LRI	6.2014	36	6
CIFRE		Atos/Bull	LRI	9.2017	36	45

CIFRE

Type: Privé
Amount: 45 k€
Duration: 36 months
Scientific director for LRI: Nacéra Seghouani Bennacer, Gianluca Quercini

Partners: Wepingo

In the context of this contract, we have developed multilingual approaches able to build user profiles, including their interests and personality.

CIFRE

Type: Privé
Amount: 6 k€
Duration: 36 months
Scientific director for LRI: Nacéra Seghouani Bennacer, Gianluca Quercini

Partners: MindMatcher

In the context of this contract, we have developed approaches for digital Identity discovery and reconciliation for human resources management.

CIFRE

Type: Privé
Amount: 45 k€
Duration: 36 months
Scientific director for LRI: Benoît Valiron and Marc Baboulin

Partners: Atos/BULL

The goal of this contract is to develop synthesis and optimization techniques for quantum computation. The contract is shared between Modhel and ParSys.

CIFRE

Type: Privé
Amount: 45 k€
Duration: 36 months
Scientific director for LRI: Yolaine Bourda, Bich-Liên Doan and Fabrice Popineau

Partners: Octopeek

The goal of this contract is to build users' profiles from their actions on social networks.

Normalization standards

- ISO/IEC 19788-7 Information technology – Learning, education and training – Metadata for learning resources – Part 7: Bindings,IS, Yolaine Bourda co-editor, (2017)
- ISO/IEC 19788-1 Information technology – Learning, education and training – Metadata for learning resources – Part 1: Framework, Working Draft, Yolaine Bourda lead editor (2017) Information technology – Learning, education and training – Metadata for learning resources – Part 1: Framework

Training and Education

Management

- Yolaine Bourda, head of the Computer science department at CentraleSupélec
- Frédéric Boulanger, in charge of the "Science of software engineering" track in the "Ingénieur CentraleSupélec" curriculum.
- Dominique Marcadet, in charge of the "Information systems architect" professional master
- Nacéra Seghouani Bennacer, in charge of the Paris-Saclay master mention ComputerScience "DecisionSupport and Business Intelligence", including IT4BI Erasmus Mundus Program.

Master Internships

- Almas ZHANIBEK
  Master 2 internship entitled *Determining the Interests of Social Media Users: Two Approaches*.
  Advisor Nacéra Seghouani Bennacer & co-advisor Gianluca Quercini. March-August 2018.
- Moditha HEWASINGHAGE
  Master 2 internship entitled *Modeling strategies for storing data in distributed heterogeneous NoSQL databases*.
  Advisor Nacéra Seghouani Bennacer & co-advisor Francesca Bugiotti. March-August 2017.
- Suela ISAJ
  Master 2 internship entitled *Reconciliation of profiles across social networks*.
  Advisor Nacéra Seghouani Bennacer & co-advisor Gianluca Quercini. March-August 2017.
- Yifei ZHANG
  Master 2 internship entitled *Designing a time synchronization protocol for AFDX*
  Advisors: Frédéric BOULANGER, Dominique MARCADET & Safouan TAHA. March-August 2017
- Guillaume CHINAL
  Master 1 internship entitled *an Omnet++ implementation of a time synchronization protocol for AFDX*
  Advisors: Frédéric BOULANGER, Dominique MARCADET & Safouan TAHA. April-June 2017
- Lulu HE
  Master 2 internship entitled *Formal verification for real-time systems with SMT*
  Advisors: Philippe Dague & Lina Ye. September 2016-August 2017
- Bahadir AKYUZ
  Master 2 internship entitled *Social Web Data Storage and Retrieval*.
  Advisors: Francesca Bugiotti, Benoît Groz, Silviu Maniu & Nacéra Seghouani Bennacer. June-September 2016.
- Hanene AYARI
  Master 2 internship entitled *Vérification de systèmes intégrant les facteurs humains*
  Advisors: Frédéric BOULANGER & Safouan TAHA. March-July 2016
- Pierre CARTIER
  Master 1 internship entitled *Simulation de systèmes intégrant les facteurs humains*
  Advisors: Frédéric BOULANGER & Safouan TAHA. March-June 2016
- Nicolas BLANCO
  Master 2 internship entitled *Denotational semantics of probabilistic lambda-calculi*
  Advisors: Benoît Valiron. May-August 2015

Graduate Courses

- Master 2 Paris-Saclay mention Computer Science, Decision Support and Business Intelligence, including IT4BI Erasmus Mundus Program. Coordinator Nacéra Seghouani Bennacer (CS referent). This Master includes IT4BI Erasmus Mundus program, partners Université Libre de Bruxelles (ULB)/Esteban Esteban Zimányi, Université François-Rabelais de Tours/ Patrick Marcel Universitat Politècnica de Catalunya (UPC) de Barcelone/Oscar Romero et l'université Technische Universität Berlin (TUB)/Ralf-Detlef Kutsche, CentraleSupélec/Nacéra Seghouani Bennacer).
- Master 1 Paris-Saclay mention Computer Science, Computer Science - International track, Coordinator Nacéra Seghouani Bennacer. (Télécom Sud-Paris referent, CS Partner)
- Introduction to Innovation and Resaerch (IIR), 5 ECTS, Decision Support and Business Intelligence, Nacéra Seghouani Bennacer, Francesca Bugiotti and Gianluca Quercini
- Introduction to BigData: data and massively parallel computing, 5 ECTS, Computer Science - International track, Nacéra Seghouani Bennacer, Francesca Bugiotti and Gianluca Quercini
- Master 2 Paris-Saclay, Master Nuclear Energy (options : Nuclar Plan design (NPD) and operations (O)): Introduction to formal methods, Safouan TAHA.

Third year of the "Ingénieur Supélec" curriculum

Majors

- Concepts et langages de programmation, 1.5 ECTS, Dominique Marcadet
- Langages et calcul, 2 ECTS, Fabrice Popineau
- Logique mathématique et programmation en logique, 2 ECTS, Yolaine Bourda
- Modélisation des systèmes, 1.5 ECTS, Frédéric Boulanger, Lina Ye
- Sémantique des langages et vérification des systèmes, 2 ECTS, Frédéric Boulanger, Safouan Taha
- Traitement des langages, 1 ECTS, Benoît Valiron

Minors (2 ECTS)

- Applications Web, Benoît Valiron
- Informatique décisionnelle, Nacéra Seghouani Bennacer & Gianluca Quercini
- Intelligence artificielle, Fabrice Popineau
- Programmation d'applications scientifiques en C et C++, Dominique Marcadet
- Web sémantique, Yolaine Bourda

Industrial projects (CEI) These projects are made by third year students majoring in computer science on a topic provided by an industrial partner, under the supervision of one or two staff members.

- 2014/2015, CNES, Génération de scénarios de pannes pour la reconfiguration d'architecture de l'avionique lanceur, Safouan Taha & Frédéric Boulanger
- 2014/2015, TnP, Objets connectés et Big data, Nacéra Seghouani Bennacer & Gianluca Quercini
- 2014/2015, LUSIS, deep learning, Fabrice Popineau
- 2014/2015, LUSIS, Dempster Shafer, Fabrice Popineau
- 2014/2015, Intrinsec, Ontologie Modulaire pour la gestion d'une plateforme de Cloud, Nacéra Seghouani Bennacer
- 2014/2015, EDF, Conversion de profils Modsarus en contraintes OCL pour RiseClipse, Dominique Marcadet
- 2014/2015, EDF, RiseClipse: refonte du support du standard 61850, Dominique Marcadet
- 2014/2015, EDF, Support d'un modèle de données hydrauliques, Dominique Marcadet
- 2014/2015, 4D, Compilation du langage 4D avec LLVM, Gianluca Quercini & Idir Aït Sadoune
- 2015/2016, CNES, Détection des pannes dans le lanceur Ariane, Safouan Taha & Frédéric Boulanger
- 2015/2016, TnP, Système d'authentification utilisant des objets connectés, Nacéra Seghouani Bennacer & Gianluca Quercini
- 2015/2016, LUSIS, Fraude CB, Fabrice Popineau
- 2015/2016, LUSIS, Estimation du temps de parcours des wagons, Fabrice Popineau
- 2015/2016, EDF, Ajout de nouveaux types dans OCL, Dominique Marcadet
- 2015/2016, EDF, Support du profil CDPSM du CIM dans RiseClipse, Dominique Marcadet
- 2015/2016, EDF, Support de données descriptives de tranches nucléaires dans RiseClipse, Dominique Marcadet
- 2016/2017, TnP, ETP Advisor, Nacéra Seghouani Bennacer & Gianluca Quercini
- 2016/2017, Schlumberger, Développement d'une appli web pour automatiser le contrôle qualité des analyses de roches mères, Fabrice Popineau
- 2016/2017, EDF, Mise en œuvre de l'approche DevOps pour RiseClipse, Dominique Marcadet
- 2016/2017, EDF, Comparaison au niveau modèle pour RiseClipse, Dominique Marcadet
- 2016/2017, EDF, Utilisation par RiseClipse de bases de données, Dominique Marcadet
- 2017/2018, EDF, Optimisation des performances de RiseClipse, Dominique Marcadet
- 2017/2018, EDF, Affichage de réseaux avec Zest dans RiseClipse, Dominique Marcadet
- 2017/2018, EDF, Client Web pour RiseClipse, Dominique Marcadet
- 2017/2018, TnP, SmartCar, Nacéra Seghouani Bennacer
- 2017/2018, TnP, SmartAlarm, Nacéra Seghouani Bennacer
- 2017/2018, Sopra/Steria, Opportunités Mobilités et métiers de la Douane, Safouan Taha
- 2017/2018, Schlumberger, Wellbore Data Analytics on Elassandra , Francesca Bugiotti
- 2017/2018, DATAWORDS, Smart Dispatch, Nacéra Seghouani Bennacer
- 2017/2018, LUSIS, Qobuz, Fabrice Popineau
- 2017/2018, LUSIS, Prédiction de marché, Fabrice Popineau

"Ingénieur Centrale Paris" curriculum

"Parcours recherche"

- 2017/2018, Nicolas Heurtel, Quantum Algorithms for Machine Learning.
- 2017/2018, David Haas, Une machine pour penser l'homme : Prendre en compte les comportements humains pour le bon fonctionnement des systèmes.

Thesis

Defended thesis				
Name	*Start*	*Defense*	*Funding*	*Advisor*
Coriane NANA JIPMO	06.2014	12.2017	CIFRE Wepingo	Nacéra Seghouani Bennacer advisor, Gianluca Quercini co-advisor
Mohammad NANA JIPMO	06.2015	11.2017	CIFRE MindMatcher	Nacéra Seghouani Bennacer advisor, Gianluca Quercini co-advisor
Roza LEMDANI	1.10.2009	11.07.2016	Fondation Suéplec	Yolaine Bourda advisor, Nacéra Seghouani Bennacer co-advisor
Rachida SEGHIRI	01.10.2012	04.07.2016	CIFRE EDF	Frédéric Boulanger
Daniel CHAVES CAFÉ	01.02.2012	10.07.2015	Institut Carnot Centrale-Supélec	Frédéric Boulanger
Jill-Jênn VIE	01.02.2014	24.11.2016	Financement par crédits ANR ISN	Yolaine Bourda advisor, Fabrice Popineau co-advisor
Youssef MEGUEBLI	01.2012	03.2015	Supélec funding	Bich-Liên Doan advisor, Fabrice Popineau co-advisor

Position after the thesis	
Name	*Position*
Rachida SEGHIRI	Machine Learning Engineer with RealtyShares, San Francisco
Daniel CHAVES-CAFÉ	Assistant professor at University of Brasilia, Brasil
Jill-Jênn VIE	post-doc at Riken AIP, Tokyo, Japan
Youssef MEGUEBLI	Senior data scientist with Nokia, Paris

Thesis in progress			
Name	*Start*	*Funding*	*Advisor*
David OUDART	01.11.2016	CIFRE EDF	Frédéric Boulanger co-advisor
Slim MEDIMEGH	01.01.2016	CEA-LIST	Frédéric Boulanger
Vassil TODOROV	01.10.2015	PSA corporate PhD	Frédéric Boulanger & Safouan Taha co-advisor
Hai NGUYEN-VAN	01.10.2014	Doctoral school grant	Frédéric Boulanger co-advisor
Benoît CHOFFIN	01.10.2017	e-FRAN "Parcours Connectés" project	Yolaine Bourda & Fabrice Popineau
Hiba HAJRI	01.11.2014	Doctoral school grant	Yolaine Bourda & Fabrice Popineau
Julien HAY	01.03.2017	CIFRE OCTOPEEK	Yolaine Bourda & Fabrice Popineau& Bich-Liên Doan
João SOARES DE OLIVEIRA NETO	01.01.2016	Erasmus Mundus SMART^2 grant	yolaine Bourda

Software Licensing and Distribution

ModHelX - ModHel'X - A framework for heterogeneous modeling

http://wdi.supelec.fr/software/ModHelX/

Contact: Frédéric BOULANGER

ModHel'X is a framework for simulating multi-formalism models. A multi-formalism model is a model in which several modeling formalisms (or languages) are jointly used. The main issue in this context is to determine the global behavior of the model. To address this issue, ModHel'X is based on the concept of Model of Computation. ModHel'X is able to simulate the behavior of multi-formalism models using the

descriptions of the different Models of Computation involved in the model and the descriptions of the glues to use for adapting the semantics between the heterogeneous parts of the model. In ModHel'X, the execution of a multi-formalism model is a sequence of snapshots of its behavior. Each snapshot is computed by combining observations of the components of the model using the rules expressed by the involved Models of Computation.

TemporalOCL - Temporal OCL Plugin for Eclipse

http://wdi.supelec.fr/software/TemporalOCL/
Contact: Safouan TAHA

Temporal OCL is a temporal extension of OCL that enables modelers/developers to specify temporal constraints on object-oriented models. We do so by relying on Dwyers's specification patterns. You can write temporal OCL constraints without any technical knowledge of formalisms commonly used to describe temporal properties such as LTL or CTL logics. This extension is integrated into the Eclipse/MDT current OCL plug-in, it provides a framework not only to constrain dynamic behavior of object-oriented systems, but other to generate functional tests for objects and verify their properties.

OntoEvent-B - A Generator of Event-B contexts from Ontologies

http://wdi.supelec.fr/software/OntoEventB
Contact: Idir AIT-SADOUNE

In the context of IMPEX project, two modeling approaches are proposed to formalize ontology description using the Event-B models. The first one defines a formal approach to encode ontologies directly as Event-B Contexts elements (shallow approach). The second approach uses deep modeling in which first ontology generic concepts are defined in Event-B Contexts and then ontologies are defined as specific instances of these generic models in other Event-B Contexts. The OntoEventB Rodin plug-in implements the proposed approaches and it has been developed to automatically support the formalisation of ontologies, described with ontology description languages like OWL, PLIB and RDFS, using set theory and predicate logic supported by the Event-B method.

RiseClipse - MDE for IEC standards

http://wdi.supelec.fr/software/RiseClipse/
Contact: Dominique MARCADET

RiseClipse is an umbrella name for tools based on Model Driven Engineering (MDE) technologies and dedicated to IEC standards. These tools are developed in the context of RISEGrid and used within or based on Eclipse or its plugins.

TESL - Tagged Events Specification Language

http://wdi.supelec.fr/software/TESL/
Contact: Frédéric BOULANGER

TESL is a declarative language for specifying discrete event behaviors for simulation. It takes many features from CCSL, the Clock Constraints Specification Language, keeping only the synchronous operators on clocks. TESL also takes ideas from the Tagged Signal Model by adding support for time tags and relations between the time scales of different clocks. The algorithm for solving TESL specifications also relies on ideas from the constructive semantics of the Esterel synchronous language.

Patents

Synchro CORAC - Synchronization mechanism for critical systems

Contact: Frédéric BOULANGER

Synchronization mechanism for critical software systems (avionics) providing an improved robustness and a guarantee on the precision of the time reference shared on a network, while avoiding synchronization based on a temporal measurement inside this network.

ModHel team publications (20 %)

Journal articles

Major international journals

(1) P. Arrighi, A. Díaz-Caro, and B. Valiron. The Vectorial Lambda-Calculus. *Information and Computation*, 254(1):105–139, June 2017.

(2) P. Atzeni, L. Bellomarini, F. Bugiotti, and M. De Leonardis. Executable Schema Mappings for Statistical Data Processing. *Distributed and Parallel Databases*, 2017.

(3) I. Boukhari, S. Jean, I. Ait-Sadoune, and L. L. Bellatreche. The role of user requirements in data repository design. *International Journal on Software Tools for Technology Transfer*, 20(1):19–34, 2018.

(4) S. Taha, J. Julliand, F. Dadeau, K. Castillos, and B. Kanso. A Compositional Automata-based Semantics and Preserving Transformation Rules for Testing Property Patterns. *FAC, Formal Aspects of Computing*, 27(4):641–664, 2015.

(5) B. Valiron, N. J. Ross, P. Selinger, D. S. Alexander, and J. M. Smith. Programming the quantum future. *Communications of the ACM*, 58(8):52–61, Aug. 2015.

(6) J.-J. Vie, F. Popineau, E. Bruillard, and Y. Bourda. Automated Test Assembly for Handling Learner Cold-Start in Large-Scale Assessments. *International Journal of Artificial Intelligence in Education*, Feb. 2018.

(7) L. Ye and P. Dague. An Optimized Algorithm of General Distributed Diagnosability Analysis for Modular Structures. *IEEE Transactions on Automatic Control*, 15(1086), May 2017.

Conference articles

Major international conferences and workshops

(8) N. Bennacer, F. Bugiotti, J. Galicia, M. Patricio, and G. Quercini. Eliminating Incorrect Cross-Language Links in Wikipedia. In *International Conference on Web Information Systems Engineering (WISE)*, volume 10570 of *Lecture Notes in Computer Science*, Puschino-Moscow, Russia, Oct. 2017.

(9) N. Bennacer, F. Bugiotti, M. Hewasinghage, S. Isaj, and G. Quercini. Interpreting Reputation Through Frequent Named Entities in Twitter. In *Web Information Systems Engineering - WISE*, volume 10569 of *Lecture Notes in Computer Science*, pages 49–56, Puschino - Moscow, Russia, Oct. 2017. Springer.

(10) N. Bennacer, M. Johnson Vioulès, A. López Maximiliano, and G. Quercini. A Multilingual Approach to Discover Cross-Language Links in Wikipedia. In L. N. in Computer Science. Springer., editor, *16th International Conference Web Information Systems Engineering (WISE)*, volume Lecture Notes in Computer Science. Springer. of *16th International Conference Web Information Systems Engineering (WISE)*, Miami, United States, Nov. 2015.

(11) F. Bugiotti, D. Bursztyn, A. Deutsch, I. Ileana, and I. Manolescu. Invisible Glue: Scalable Self-Tuning Multi-Stores. In *Conference on Innovative Data Systems Research (CIDR)*, Asilomar, United States, Jan. 2015.

(12) F. Bugiotti, D. Bursztyn, A. Deutsch, I. Manolescu, and S. Zampetakis. Flexible Hybrid Stores: Constraint-Based Rewriting to the Rescue. In *32nd IEEE International Conference on Data Engineering*, Helsinki, Finland, May 2016.

(13) U. Dal Lago, C. Faggian, B. Valiron, and A. Yoshimizu. The Geometry of Parallelism: Classical, Probabilistic, and Quantum Effects. In *POPL 2017 - Principles of Programming Languages*, Proceedings of the 44th ACM SIGPLAN Symposium on Principles of Programming Languages, pages 833–845, Paris, France, Jan. 2017.

(14) H. Hajri, Y. Bourda, and F. Popineau. Querying Repositories of OER Descriptions: The Challenge of Educational Metadata Schemas Diversity. In *Design for Teaching and Learning in a Networked World - 10th European Conference on Technology Enhanced Learning, EC-TEL 2015*, volume LNCS of *Design for Teaching and Learning in a Networked World - 10th European Conference on Technology Enhanced Learning, EC-TEL 2015*, pages 582–586, Toledo, Spain, Sept. 2015. Springer.

(15) H. Ibrahim, P. Dague, A. Grastien, L. Ye, and L. Simon. Diagnosability Planning for Controllable Discrete Event Systems. In *31st National Conference on Artificial Intelligence AAAI-17*, San Francisco, United States, Feb. 2017.

(16) R. Seghiri, F. Boulanger, C. Lecocq, and V. Godefroy. An executable model driven framework for enterprise architecture application to the Smart Grids context. In *HICSS 2016 : 49th Hawaii International Conference on System Sciences*, pages 4546 – 4555, Koloa, Hawaii, United States, Jan. 2016. IEEE Computer Society.

(17) J.-J. Vie, F. Popineau, E. Bruillard, and Y. Bourda. Adaptive Testing Using a General Diagnostic Model. In *11th European Conference on Technology Enhanced Learning, EC-TEL 2016*, Lyon, France, Sept. 2016.

(18) L. Ye, P. Dague, D. Longuet, L. Brandán Briones, and A. Madalinski. Fault Manifestability Verification for Discrete Event Systems. In *22nd European Conference on Artificial Intelligence ECAI-16*, La Haye, Netherlands, Aug. 2016.

Other conferences and workshops

(19) Y. Ait Ameur, I. Ait-Sadoune, K. Hacid, and L. Mohand Oussaïd. Formal modelling of ontologies within Event-B. In *First International Workshop on Handling IMPlicit and EXplicit knowledge in formal system development*, Xi'an, China, Nov. 2017.

(20) H. Nguyen Van, T. Balabonski, F. Boulanger, C. Keller, B. Valiron, and B. Wolff. A Symbolic Operational Semantics for TESL with an Application to Heterogeneous System Testing. In A. Abate and G. Geeraerts, editors, *15th International Conference on Formal Modelling and Analysis of Timed Systems FORMATS 2017*, Formal Modeling and Analysis of Timed Systems, Berlin, Germany, Sept. 2017. Springer.

ModHel team publications (all)

Journal articles

Major international journals

(A1) P. Arrighi, A. Díaz-Caro, and B. Valiron. The Vectorial Lambda-Calculus. *Information and Computation*, 254(1):105–139, June 2017.

(A2) P. Atzeni, L. Bellomarini, F. Bugiotti, and M. De Leonardis. Executable Schema Mappings for Statistical Data Processing. *Distributed and Parallel Databases*, 2017.

(A3) I. Boukhari, S. Jean, I. Ait-Sadoune, and L. L. Bellatreche. The role of user requirements in data repository design. *International Journal on Software Tools for Technology Transfer*, 20(1):19–34, 2018.

(A4) M. Güdemann, P. Poizat, G. Salaün, and L. Ye. VerChor: A Framework for the Design and Verification of Choreographies. *IEEE Transactions on Services Computing*, 9(4):647–660, July 2016.

(A5) Y. Meguebli, M. Kacimi, B.-L. Doan, and F. Popineau. Towards better news article recommendation. *World Wide Web*, 20(6):1293–1312, Feb. 2017.

(A6) S. Taha, J. Julliand, F. Dadeau, K. Castillos, and B. Kanso. A Compositional Automata-based Semantics and Preserving Transformation Rules for Testing Property Patterns. *FAC, Formal Aspects of Computing*, 27(4):641–664, 2015.

(A7) B. Valiron, N. J. Ross, P. Selinger, D. S. Alexander, and J. M. Smith. Programming the quantum future. *Communications of the ACM*, 58(8):52–61, Aug. 2015.

(A8) J.-J. Vie, F. Popineau, E. Bruillard, and Y. Bourda. Automated Test Assembly for Handling Learner Cold-Start in Large-Scale Assessments. *International Journal of Artificial Intelligence in Education*, Feb. 2018.

(A9) L. Ye and P. Dague. An Optimized Algorithm of General Distributed Diagnosability Analysis for Modular Structures. *IEEE Transactions on Automatic Control*, 15(1086), May 2017.

Other journals

(A10) P. Atzeni, F. Bugiotti, L. Cabibbo, and R. Torlone. Data Modeling in the NoSQL World. *To appear* , 2017.

(A11) N. Bennacer, F. Bugiotti, M. Hewasinghage, S. Isaj, and G. Quercini. A Frequent Named Entities Based Approach for Interpreting Reputation in Twitter. *Data Science and Engineering*, 2018.

(A12) L. Mohand Oussaïd, I. Ait-Sadoune, Y. Ait Ameur, and M. Ahmed-Nacer. A formal model for output multimodal HCI - An Event-B formalization. *Computing*, 97(7):713–740, July 2015.

(A13) L. Mohand Oussaïd, I. Ait-Sadoune, Y. Ait Ameur, and A.-N. Mohamed. Modélisation formelle d'IHM multimodales en sortie avec B Événementiel : approche par généralisation et instanciation. *Revue des Sciences et Technologies de l'Information - Série TSI : Technique et Science Informatiques*, 34(5):521–546, 2015.

(A14) G. Quercini, N. Bennacer, M. Ghufran, and C. N. Jipmo. LIAISON: reconciLIAtion of Individuals Profiles Across SOcial Networks. *Advances in Knowledge Discovery and Management (AKDM)*, 665, 2017.

(A15) A. Scherer, B. Valiron, M. Siun-Chuon, D. S. Alexander, E. Van Den Berg, and T. Chapuran. Concrete Resource Analysis of the Quantum Linear System Algorithm used to Compute the Electromagnetic Scattering Cross Section of a 2D Target. *Quantum Information Processing*, page 16:60, Jan. 2017.

(A16) B. Valiron. A Formal Analysis of Quantum Algorithms. *ERCIM News*, 112:23–24, Jan. 2018.

(A17) J.-J. Vie, E. Bruillard, F. Popineau, and Y. Bourda. Simulation and validation of adaptive assessments in MOOCs. *Sciences et Technologies de l'Information et de la Communication pour l'Éducation et la Formation*, 24(2), Apr. 2018.

Conference articles

Major international conferences and workshops

(A18) N. Bennacer, F. Bugiotti, J. Galicia, M. Patricio, and G. Quercini. Eliminating Incorrect Cross-Language Links in Wikipedia. In *International Conference on Web Information Systems Engineering (WISE)*, volume 10570 of *Lecture Notes in Computer Science*, Puschino-Moscow, Russia, Oct. 2017.

(A19) N. Bennacer, F. Bugiotti, M. Hewasinghage, S. Isaj, and G. Quercini. Interpreting Reputation Through Frequent Named Entities in Twitter. In *Web Information Systems Engineering - WISE*, volume 10569 of *Lecture Notes in Computer Science*, pages 49–56, Puschino - Moscow, Russia, Oct. 2017. Springer.

(A20) N. Bennacer, M. Johnson Vioulès, A. López Maximiliano, and G. Quercini. A Multilingual Approach to Discover Cross-Language Links in Wikipedia. In L. N. in Computer Science. Springer., editor, *16th International Conference Web Information Systems Engineering (WISE)*, volume Lecture Notes in Computer Science. Springer. of *16th International Conference Web Information Systems Engineering (WISE)*, Miami, United States, Nov. 2015.

(A21) F. Bugiotti, D. Bursztyn, A. Deutsch, I. Ileana, and I. Manolescu. Invisible Glue: Scalable Self-Tuning Multi-Stores. In *Conference on Innovative Data Systems Research (CIDR)*, Asilomar, United States, Jan. 2015.

(A22) F. Bugiotti, D. Bursztyn, A. Deutsch, I. Manolescu, and S. Zampetakis. Flexible Hybrid Stores: Constraint-Based Rewriting to the Rescue. In *32nd IEEE International Conference on Data Engineering*, Helsinki, Finland, May 2016.

(A23) U. Dal Lago, C. Faggian, B. Valiron, and A. Yoshimizu. Parallelism and Synchronization in an Infinitary Context. In *LICS 2015*, Proceedings of LICS 2015, Kyoto, Japan, July 2015.

(A24) U. Dal Lago, C. Faggian, B. Valiron, and A. Yoshimizu. The Geometry of Parallelism: Classical, Probabilistic, and Quantum Effects. In *POPL 2017 - Principles of Programming Languages*, Proceedings of the 44th ACM SIGPLAN Symposium on Principles of Programming Languages, pages 833–845, Paris, France, Jan. 2017.

(A25) H. Hajri, Y. Bourda, and F. Popineau. Querying Repositories of OER Descriptions: The Challenge of Educational Metadata Schemas Diversity. In *Design for Teaching and Learning in a Networked World - 10th European Conference on Technology Enhanced Learning, EC-TEL 2015*, volume LNCS of *Design for Teaching and Learning in a Networked World - 10th European Conference on Technology Enhanced Learning, EC-TEL 2015*, pages 582–586, Toledo, Spain, Sept. 2015. Springer.

(A26) H. Ibrahim, P. Dague, A. Grastien, L. Ye, and L. Simon. Diagnosability Planning for Controllable Discrete Event Systems. In *31st National Conference on Artificial Intelligence AAAI-17*, San Francisco, United States, Feb. 2017.

(A27) A. Sabry, B. Valiron, and J. K. Vizzotto. From Symmetric Pattern-Matching to Quantum Control. In *21st International Conference, FOSSACS 2018, Held as Part of the European Joint Conferences on Theory and Practice of Software, ETAPS 2018*, Thessalonique, Greece, Apr. 2018.

(A28) R. Seghiri, F. Boulanger, C. Lecocq, and V. Godefroy. An executable model driven framework for enterprise architecture application to the Smart Grids context. In *HICSS 2016 : 49th Hawaii International Conference on System Sciences*, pages 4546 – 4555, Koloa, Hawaii, United States, Jan. 2016. IEEE Computer Society.

(A29) J.-J. Vie, F. Popineau, E. Bruillard, and Y. Bourda. Adaptive Testing Using a General Diagnostic Model. In *11th European Conference on Technology Enhanced Learning, EC-TEL 2016*, Lyon, France, Sept. 2016.

(A30) L. Ye, P. Dague, D. Longuet, L. Brandán Briones, and A. Madalinski. Fault Manifestability Verification for Discrete Event Systems. In *22nd European Conference on Artificial Intelligence ECAI-16*, La Haye, Netherlands, Aug. 2016.

Other conferences and workshops

(A31) Y. Ait Ameur, I. Ait-Sadoune, P. Castéran, J. P. Gibson, K. Hacid, S. Kherroubi, D. Mery, L. Mohand Oussaïd, N. K. Singh, and L. Voisin. On the Importance of Explicit Domain Modelling in Refinement-Based Modelling Design. Experiments with Event-B. In *Abstract State Machines, Alloy, B, TLA, VDM, and Z - 6th International Conference, ABZ 2018*, Abstract State Machines, Alloy, B, TLA, VDM, and Z - 6th International Conference, ABZ 2018, Southampton, UK, June 5-8, 2018, Proceedings, pages 425–430, Southampton, United Kingdom, June 2018.

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(A35) C. Allouche, M. Baboulin, T. Goubault De Brugiere, and B. Valiron. Reuse method for quantum circuit synthesis. In *International Conference: Applied Mathematics, Modeling and Computational Science (AMMCS 2017)*, Waterloo, Canada, Aug. 2017.

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(A42) B. Choffin. PLUME : un Plugin Moodle pour Générer des Feuilles d'Exercices Personnalisées. In *Rencontres Jeunes Chercheurs en EIAH 2018*, Besançon, France, Apr. 2018.

(A43) F. Galofaro, B.-L. Doan, and Z. Toffano. Why quantum computing will be the next turn in information retrieval: a semiotic overview on language and probability. In *9th Italian Quantum Information Science Conference (IQIS 2016)*, Roma, Italy, Sept. 2016.

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(A45) M. Ghufran, G. Quercini, and N. Bennacer. Wikipedia-based extraction of key information from resumes. In *2017 11th International Conference on Research Challenges in Information Science (RCIS)*, Brighton, United Kingdom, May 2017. IEEE.

(A46) J.-P. Gibson, I. Ait-Sadoune, and M. Pantel. Semantic Heterogeneity in the Formal Development of Complex Systems: An Introduction. In *7th International Symposium, ISoLA 2016*, number 9952 in Leveraging Applications of Formal Methods, Verification and Validation: Foundational Techniques, Corfu, Greece, Oct. 2016. Lecture Notes in Computer Science.

(A47) H. Hajri, Y. Bourda, and F. Popineau. MORS: A System for Recommending OERs in a MOOC. In *2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT)*, Timisoara, France, July 2017. IEEE.

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(A51) C. N. Jipmo, G. Quercini, and N. Bennacer. Catégorisation et Désambiguïsation des Intérêts des Individus dans le Web Social. In *EGC 2016*, volume RNTI-E-30 of *EGC 2016. Revue des Nouvelles Technologies de l'Information*, Reims, France, Jan. 2016.

(A52) C. N. Jipmo, G. Quercini, and N. Bennacer. FRISK: A Multilingual Approach to Find twitteR InterestS via wiKipedia. In *ADMA 2017*, volume 10604 of *Lecture Notes in Computer Science*, Singapour, Singapore, Nov. 2017.

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(A54) S. Medimegh, J.-Y. Pierron, and F. Boulanger. Qualitative Simulation of Hybrid Systems with an Application to SysML Models. In *6th International Conference on Model-Driven Engineering and Software Development*, Proceedings of the 6th International Conference on Model-Driven Engineering and Software Development, Funchal, Portugal, Jan. 2018. SCITEPRESS - Science and Technology Publications.

(A55) S. Medimegh, J.-Y. Pierron, J.-P. Gallois, and F. Boulanger. A New Approach of Qualitative Simulation for the Validation of Hybrid Systems. In *GEMOC International Workshop on The Globalization of Modeling Languages at MODELS 2016*, number 1731 in Proceedings of the GEMOC International Workshop on The Globalization of Modeling Languages at MODELS 2016, Saint Malo, France, Oct. 2016. Julien DeAntoni, Jeff Gray, Eugene Syriani.

(A56) L. Mohand Oussaïd and I. Ait-Sadoune. Formal Modelling of Domain Constraints in Event-B. In *Model and Data Engineering - 7th International Conference, MEDI 2017*, volume 10563 of *Lecture Notes in Computer Science*, pages 153–166, Barcelone, Spain, Oct. 2017. Springer.

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(A58) H. Nguyen Van, T. Balabonski, F. Boulanger, C. Keller, B. Valiron, and B. Wolff. A Symbolic Operational Semantics for TESL with an Application to Heterogeneous System Testing. In A. Abate and G. Geeraerts, editors, *15th International Conference on Formal Modelling and Analysis of Timed Systems FORMATS 2017*, Formal Modeling and Analysis of Timed Systems, Berlin, Germany, Sept. 2017. Springer.

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(A62) R. Seghiri, F. Boulanger, C. Lecocq, and V. Godefroy. Simulation des Systèmes d'Information des Smart Grids - Une approche par points de vue. In *XXXIIIème Congrès INFORSID*, Actes du XXXIIIème Congrès INFORSID, pages 65–80, Biarritz, France, May 2015.

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(A65) B. Valiron, M. Pagani, and A. Polonski. Toward analytic rewriting theory. In *Informal Electronic Proceedings of the 8th International Workshop on Higher-Order Rewriting (HOR'16)*, Porto, Portugal, 2016.

(A66) J.-J. Vie, F. Popineau, J.-B. Grill, E. Bruillard, and Y. Bourda. Prédiction de performance sur des questions dichotomiques: comparaison de modèles pour des tests adaptatifs à grande échelle. In *Atelier Évaluation des Apprentissages et Environnements Informatiques, EIAH 2015*, Agadir, Morocco, June 2015.

(A67) J.-J. Vie, F. Popineau, F. Tort, B. Marteau, and N. Denos. A Heuristic Method for Large-Scale Cognitive-Diagnostic Computerized Adaptive Testing. In *Learning @ scale (L@S'17)*, Proceedings of the Fourth (2017) ACM Conference on Learning @ Scale (L@S '17), Cambridge, MA, United States, Apr. 2017.

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(A69) L. Ye, P. Dague, and F. Nouioua. A Predictability Algorithm for Distributed Discrete Event Systems. In *The 17th International Conference on Formal Engineering Methods*, Paris, France, Nov. 2015.

(A70) H. Zaatiti, L. Ye, P. Dague, and J.-P. Gallois. Counterexample-Guided Abstraction-Refinement for Hybrid Systems Diagnosability Analysis. In *28th International Workshop on Principles of Diagnosis DX'17*, volume 4 of *Kalpa Publications in Computing*, pages 124–143, Brescia, Italy, Sept. 2017.

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(A71) J.-J. Vie, F. Popineau, J.-B. Grill, E. Bruillard, and Y. Bourda. Predicting Performance over Dichotomous Questions: Comparing Models for Large-Scale Adaptive Testing. 8th International Conference on Educational Data Mining (EDM 2015), June 2015.

Books and book chapters

(A72) I. Ait-Sadoune and Y. Ait Ameur. Formal Modelling and Verification of Transactional Web Service Composition: A Refinement and Proof Approach with Event-B. In *Correct Software in Web Applications and Web Services*, Texts & Monographs in Symbolic Computation, pages 1–27. Springer, 2015.

(A73) F. Bugiotti, J. Camacho-Rodríguez, F. Goasdoué, Z. Kaoudi, I. Manolescu, and S. Zampetakis. SPARQL Query Processing in the Cloud. In A. Harth, K. Hose, and R. Schenkel, editors, *Linked Data Management*, Emerging Directions in Database Systems and Applications. Chapman and Hall/CRC, Apr. 2014.

(A74) C. Dürr and J.-J. Vie. *Programmation efficace*. ellipses, Mar. 2016.

(A75) J.-J. Vie, F. Popineau, E. Bruillard, and Y. Bourda. A Review of Recent Advances in Adaptive Assessment. In *Learning Analytics: Fundaments, Applications, and Trends*, volume 94 of *Studies in Systems, Decision and Control*, pages 113–142. Springer International Publishing, Feb. 2017.

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(A77) F. Bugiotti, L. Cabibbo, P. Atzeni, and R. Torlone. Database Design for NoSQL Systems. Technical report, Università degli studi Roma Tre, 2014.

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Theses and habilitations

(A79) D. Chaves Cafe. *Multi-level modeling for verification and synthesis of complex systems in a multi-physics context.* Theses, Supélec, July 2015.

(A80) M. Ghufran. *Digital Identity Discovery and Reconciliation for Human Resources Management.* Theses, Université Paris-Saclay, Nov. 2017.

(A81) R. Lemdani. *A hybrid and adaptive framework for recommender systems.* Theses, Université Paris-Saclay, July 2016.

(A82) Y. Meguebli. *Leveraging User-Generated Content for Enhancing and Personalizing News Recommendation.* Theses, Supélec, Mar. 2015.

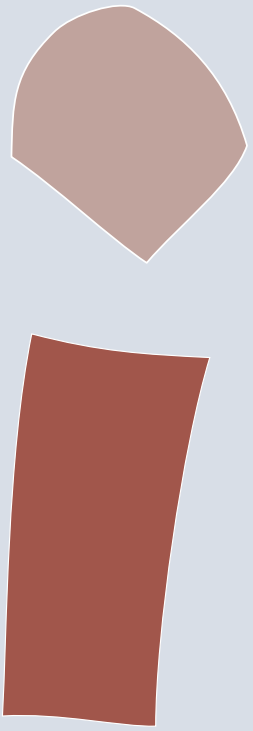
(A83) C. Nana Jipmo. *Social web integration in recommendation systems.* Theses, Université Paris-Saclay, Dec. 2017.

(A84) R. Seghiri. *Modeling and simulation of enterprise architecturesApplication to the Smart Grids.* Theses, Université Paris-Saclay, July 2016.

(A85) J.-J. Vie. *Cognitive diagnostic computerized adaptive testing models for large-scale learning.* Theses, Université Paris-Saclay, Dec. 2016.

8/ ParSys

Parallel Systems



équipe
Systèmes Parallèles

Responsable: Marc Baboulin, Janna Burman

L'équipe ParSys est un groupe de recherche qui comprend des chercheurs de l'Université Paris-Sud et d'Inria Saclay.

ParSys est spécialisée dans la recherche avancée sur les algorithmes parallèles et distribués, à la fois au niveau de la théorie et de l'implémentation.

Cette activité de recherche inclut la conception, la preuve, l'analyse de complexité et l'implémentation d'algorithmes distribués, et du calcul haute-performance ou quantique. Notre activité implique également l'utilisation des architectures parallèles et des paradigmes de programmation les plus récents pour obtenir une performance optimales des codes développés. Les préoccupations communes concernant les algorithmes étudiés dans ParSys sont la performance, le passage à l'échelle, la tolérance aux défaillances et l'économie d'énergie.

Les nombreuses applications de notre recherche (gestion de données massives, biologie, physique...) ont le potentiel de promouvoir le développement de liens plus étroits et pluridisciplinaires au sein de la communauté de Paris-Saclay et répondent à des besoins importants du monde industriel.



Parallel Systems

Head: Marc Baboulin, Janna Burman

The ParSys team is a research group that involves researchers from University Paris-Sud and Inria Saclay.

ParSys specializes in achieving extensive research in parallel and distributed algorithms, both at the theoretical and implementation level.

This research activity includes the design, proof, complexity analysis and implementation of distributed, high-performance computing (HPC) or quantum algorithms. Our activity also involves the use of the most recent parallel architectures and programming paradigms in order to achieve optimal performance of the developed codes. The common concerns about the algorithms studied in ParSys are performance, scalability, fault-tolerance and energy savings.

The numerous applications of our research (massive data analytics, biology, physics...) have the potential to promote the development of closer and interdisciplinary ties within the community of Paris-Saclay and address important issues from industry.

Synthetic presentation

Head of ParSys: Marc Baboulin (deputy: Janna Burman)

Members of the group
On January, 2013, the group had 11 permanent members including 9 university faculty and 2 Inria research scientists (1DR, 1CR).
On June 30, 2018, the team includes 11 permanent members including 10 university faculty (3 PR, 6 MdC, 1 Emeritus PR) and 1 INRIA DR.
Note that a new assistant professor and a new CNRS researcher (in the HPC domain) will join the group in Sept. 2018, that will lead to a number of 13 permanent members.

Permanent members who left the group 5
Cédric Bastoul left the group on August 31, 2013, to join University of Strasbourg as full professor; Brigitte Rozoy retired on August 31, 2014; Grigori Fursin left the group (and Inria) on October 31, 2014; Frédéric Gruau left the group on June 14, 2018; Lionel Lacassagne left the group on August 31, 2015, to join Université Pierre et Marie Curie as full professor.

Permanent members who joined the group 5
Janna Burman, postdoc at Université Paris-Sud, joined in September 2013 as assistant professor; Amal Khabou, postdoc at University of Manchester, UK, joined in September 2014 as assistant professor; Thomas Nowak, postdoc at Ecole Normale Supérieure, France, joined in September 2015 as assistant professor; Alain Lambert, Institut d'Electronique Fondamentale, assistant professor at Université Paris-Sud, joined in September 2016. Stéphane Vialle, Professor at CentraleSupélec and previously associate member, joined in June 2018 as permanent member of the team. Note that Marc Baboulin who was assistant professor at Université Paris-Sud was promoted to full professor in September 2013.

Highlights of the scientific activity

1. Research activity in the Inria teams Grand-Large (2013), Postale (2014-2015) associate-team with University of Tennessee, excellence research chair Inria/Université Paris-Sud (M. Baboulin, 2013-2015).
2. Multiple international collaborations leading to joint publications, leadership in C++ normalization (J. Falcou).
3. Creation and participation to DigiCosme GT and Saclay HPC GT, co-organization of workshop WENDY in Paris in October 2018.
4. Contributions to major international software libraries (cTuning, MAGMA).
5. Industrial collaborations, projects and seminars (ATOS, CEA, EDF, ONERA, ST Microelectronics).

Number of publications 145
- Articles in major international journals: 12, Other journals: 7
- Articles in major international conferences: 28 – Other conferences: 54
- Books and book chapters: 6

Top five publications

- M. Baboulin, J. Dongarra, A. Remy, S. Tomov, and I. Yamazaki. Solving dense symmetric indefinite systems using GPUs. Concurrency and Computation: Practice and Experience, 29(9):1 - 17, May 2017.
- A. Khabou, J. W. Demmel, L. Grigori, and M.Gu. LU Factorization with Panel Rank Revealing Pivoting and its Communication Avoiding Version. SIAM Journal on Matrix Analysis and Applications, 34(3), 2013.
- P. Esterie, J. Falcou, M. Gaunard, J.-T. Lapresté, and L. Lacassagne. The Numerical Template toolbox: A Modern C++ Design for Scientific Computing. Journal of Parallel and Distributed Computing, 74(12):pp. 3240-3253, 2014.
- J. Beauquier, J. Burman, F. Dufoulon, and .S. Kutten. Fast Beeping Protocols for Deterministic MIS and (Δ + 1)-Coloring in Sparse Graphs. IEEE International Conference on Computer Communications, INFOCOM 2018. To appear.
- M. Függer, T. Nowak, and M. Schwarz. Tight Bounds for Asymptotic and Approximate Consensus. ACM Symposium on Principles of Distributed Computing, PODC'18. To appear.

Top five documents (other than publications)

- MAGMA (Matrix Algebra on GPU and Multicore Architectures): M. Baboulin, co-author (release Nov. 2017).
- J. Falcou and E. Alligand, Practical C++ Metaprogramming, O'Reilly Media, Inc. (2016).
- G. Fursin, Collective Mind framework.

Top five facts illustrating the scientific visibility

- M. Baboulin had an Excellence Research Chair INRIA - Université Paris-Sud from 2013 to 2015.
- M. Baboulin was General Vice-Chair of the 24th High Performance Computing Symposium,Pasadena, USA (HPC 2016) and member of the steering committee from 2013 to 2015.
- J. Falcou was invited speaker at major C++ conferences in 2015 and 2016.
- J. Beauquier, J. Burman and M. Laveau, L. Pilard obtained the Best Paper Award at the SSS conference in 2017.
- Seminal publication and several invited talks for D. Etiemble about "45-year CPU evolution: one law and two equations" (see `http://wp3workshop.website/pdfs/WP3_etiemble.pdf`).

Top five facts illustrating the interactions with the socio-economic and cultural environment

- J. Falcou created the startup company Numscale.
- J. Falcou founded and organized the "User Group C++ Francophone" (C++ Frug), the first french meetup about C++ (more than 900 members).
- M. Baboulin had research contracts with EDF R&D on HPC solvers and ATOS on quantum computing.
- B. Rozoy was awarded "chevalière de l'ordre du mérite".
- J. Burman was involved in the committee of ACM WomENcourage, ACM Europe Celebration of Women in Computing (2017).

Top five contributions to teaching and training

- M. Baboulin, head of the computer science department of Polytech Paris-Sud (2014-2018).
- A. Khabou, responsible for the 4th year (apprentissage) of Polytech Paris-Sud (2017-2018).
- J. Burman, member of the teaching and recruitment committee of Master COMASIC.
- D. Etiemble, responsible for Master 2 NSI (2013-2014).
- M. Baboulin, J. Beauquier, J. Burman, J. Falcou, A. Khabou, L. Lacassagne, T. Nowak have been involved in creating courses and teaching in the Paris-Saclay Master 2 FIIL.

Research Group Members and evolution since 2013

On June 30, 2018, the PARSYS team includes 11 permanent researchers (3 Professors, 1 Professor Emeritus, 1DR-INRIA, 6 Assistant-Professors), 6 PhD students, 3 temporary researchers and 5 associate-members.

Permanent Members (January 2013 - June 2018)				
Name	*First name*	*Position*	*Institution*	*Remarks*
BABOULIN	Marc	PR	PARIS SUD	Team leader
BEAUQUIER	Joffroy	PR	PARIS SUD	
BASTOUL	Cédric	MCF	PARIS SUD	Départ 31/08/2013
BURMAN	Janna	MCF	PARIS SUD	Arrivée 01/09/2013
EISENBEIS	Christine	DR	INRIA	
ETIEMBLE	Daniel	PR	PARIS SUD	Professeur Emérite
FALCOU	Joël	MCF	PARIS SUD	
FURSIN	Grigori	CR	INRIA	Départ 31/10/2014
GRUAU	Frédéric	MCF	PARIS SUD	Départ 14/06/2018
KHABOU	Amal	MCF	PARIS SUD	Arrivée 01/09/2014
LACASSAGNE	Lionel	MCF	PARIS SUD	Départ 31/08/2015
LAMBERT	Alain	MCF	PARIS SUD	Arrivée 21/09/2016
NOWAK	Thomas	MCF	PARIS SUD	Arrivée 01/09/2015
ROSAZ	Laurent	MCF	PARIS SUD	
ROZOY	Brigitte	PR	PARIS SUD	Retraite 31/08/2014
VIALLE	Stéphane	PR	CentraleSupélec	Arrivée 14/06/2018

Doctoral Students (June 30, 2018)				
Name	*First name*	*Funding*	*Institution*	*Remarks*
DUFOULON	Fabien	Alloc. Ministère	PARIS SUD	
GOUBAULT de BRUGIERE	Timothée	CIFRE	PARIS SUD	
HAN	Cheng-Yu	MOE scholarship (Taiwan)	PARIS SUD	
LAVEAU	Marie	Digicosme	PARIS SUD	
PEOU	Kenny	CIFRE	PARIS SUD	
WANG	Zhan	CSC scholarship (China)	PARIS SUD	

Postdocs/ATER (June 30, 2018)				
Name	*First name*	*Funding*	*Institution*	*Remarks*
CHO	Da Jung	Postdoc	PARIS SUD	
JAMAL	Aygul	ATER	PARIS SUD	
XU	Chuan	ATER	PARIS SUD	

Associate members (June 30, 2018)				
Name	*First name*	*Position*	*Institution*	*Remarks*
CABARET	Laurent	Professor	CentraleSupélec	
JUBERTIE	Sylvain	Assistant Professor	Université Orléans	
LACASSAGNE	Lionel	Professor	UPMC	
PILARD	Laurence	Assistant Professor	UVSQ	
SOSONKINA	Masha	Professor	Old Dominion University (USA)	

Group evolution

Cédric Bastoul left the group on August 31, 2013, to join University of Strasbourg as full professor; Brigitte Rozoy retired on August 31, 2014; Grigori Fursin left the group (and Inria) on October 31, 2014; Frédéric

Gruau left the group on June 14, 2018; Lionel Lacassagne left the group on August 31, 2015, to join Université Pierre et Marie Curie as full professor.

Janna Burman, postdoc at Université Paris-Sud, joined in September 2013 as assistant professor; Amal Khabou, postdoc at University of Manchester, UK, joined in September 2014 as assistant professor; Thomas Nowak, postdoc at Ecole Normale Supérieure, France, joined in September 2015 as assistant professor; Alain Lambert, Institut d'Electronique Fondamentale, assistant professor at Université Paris-Sud, joined in September 2016. Note that Marc Baboulin who was assistant professor at Université Paris-Sud was promoted to full professor in September 2013.

Note that, at the end of the evaluation period (June 2018), Stéphane Vialle (Pr CentraleSupélec, associate member of the team) has become permanent member. Note also that a new assistant professor (Oguz Kaya, coming from Inria Bordeaux) and a new CNRS researcher (Laércio Lima Pilla, coming from Inria Grenoble) have been hired in June 2018 (in the HPC domain), starting September 2018. Joffroy Beauquier (Pr Université Paris-Sud) will retired in Sept. 2018 and become Emeritus.

8/ ParSys

Research Description

We describe here the research activity of the ParSys team which covers, from 2013 to 2018, the area of architectures and program optimization, high performance scientific and quantum computing, and distributed algorithms. These topics are central for many crucial applications and interdisciplinary fields including for instance big data applications, physical simulations, robotics, blockchain technology, mobile networks, microbiological circuits, etc.

During the period 2013-2015, the research activities of the team related to parallel architectures and high-performance computing were also achieved in the joint teams Grand-Large[1] and Postale[2] between LRI and Inria Saclay.

Architectures and program optimization

In this research topic, we developed methods and software for program transformations/optimizations for a given algorithm/application. We also addressed the design of efficient algorithms for parallel architectures that deal with image processing and computer vision. A major issue in these approaches concern energy minimization. Note that part of this research was also achieved in the framework of the Inria joint team with LRI Postale (2014-2015).

Auto-tuning and optimization techniques for data and energy

Participants: L. Bagnères, C. Bastoul, C. Eisenbeis, A. Ferreira Leite, G. Fursin, M. Kruse

Our research on data/memory and energy/power optimizations includes handmade or automatic compiler, code and algorithm optimizations. The optimization for data has been addressed in the ANR PetaQCD project (A58). We have described handmade data layout optimizations for optimizing a 4D stencil computation taking into account the BlueGene Q features (A154). We developed the Molly software based on the LLVM (Low Level Virtual Machine) Polly optimizing compiler that automatically generates code for MPI data transfers. We have also focused on profiling and optimizing energy and power, where the objective is to monitor precise energetic behavior of current programs (6), which is a difficult task for the programmer or the compiler. This research axis also includes the analysis of programming features that are the key parameters for saving energy. The ultimate goal is to have a cost model that describes the energetic behavior of programs that allows a monitoring by the programmer or the compiler.

Our research in automatic program optimization developed in (7) is based on an holistic approach to systematize characterization and optimization of computer systems by gradually exposing various tuning choices, properties and characteristics at multiple granularity levels in existing systems through universal plugins, combined extensible repositories of knowledge, data mining, machine learning and crowdsourc-

[1] https://www.inria.fr/equipes/grand-large
[2] https://www.inria.fr/equipes/postale

ing. We have proposed a cooperative approach where multi-objective program and architecture tuning is transparently distributed among multiple users (A43).

Embedded high-performance systems & computer vision

Participants: L. Cabaret, D. Etiemble, L. Lacassagne, M. Gouiffès, A. Romero Mier Y Teran.

An important aspect when designing an embedded system is the tradeoff between speed (and power consumption) and numerical accuracy (and stability). Such a tradeoff leads to 16-bit computation (and storage) and to the design of less accurate algorithms. In image processing, our effort concerns the redesign of data-dependent algorithms for parallel architectures. A representative example of such an algorithm is the connected-component labeling and analysis (that this to compute some features, like the bounding-box or the first raw moments) (CCL / CCA) algorithm which is used in industrial or medical imaging and classical computer vision like optical character recognition. As far as we know our algorithm (*Light Speed Labeling*) (A66) still outperforms other existing CCL algorithms. Regarding computer vision (smart camera, autonomous robot, aerial drone), we developed in collaboration with LIMSI an application that run in realtime on embedded parallel systems with some accuracy tradeoffs. This application relies on covariance matching and tracking (A159). By extension to computer vision, we also address *interactive sensing HPC applications* where we studied the parallelization of Non Destructive Testing applications on COTS processors (super-charged workstation with GPUs and Intel Xeon Phi manycore processor) (A155).

High-performance scientific computing

This research activity aims at providing innovative algorithms and efficient implementations in high-performance computing (HPC) libraries for current highly parallel and heterogeneous systems, and explore current barriers to performance. This performance is obtained by using algorithms that minimize data communication and exploit the most recent parallel architectures and by using high-level methods that generate automatically optimized HPC codes. We have also started a research activity on quantum computing which represents the future of HPC for some applications. Note that part of this research was also achieved in the framework of the Inria joint teams with LRI Grand-Large (2013) and Postale (2014-2015).

Generative programming for HPC architectures

Participants: M. Baboulin, P. Esterie, J. Falcou, I. Masliah, A. Tran Tan

As hardware and programming tools and models are becoming more complex, the development and maintenance of efficient and portable HPC codes is a daunting task. In this research topic, we investigate the impact and applicability of software design methods based on Domain Specific Languages (DSL) to parallel programming in order to enable portability and forward scalability of such programs. We apply generative programming techniques to build active libraries that can be easily re-targeted, optimized and deployed on a large selection of hardware systems. Our developments in the field include the BOOST.SIMD (A69) library for portable SIMD computations and the NT^2 (5) library which implements a DSEL similar to MATLAB while providing automatic parallelization on SIMD systems, multicores and GPGPUs. We investigated a generic description of the linear system to be solved in order to exploit numerical and structural properties of matrices to get fast and accurate solutions with respect to a specific type of problem. Available information about targeted architectures and resources will be also taken into account so that the most appropriate routines are used or generated. An application of this generative approach is the possibility of prototyping new algorithms or new implementations of existing algorithms for various hardware. This works has been extended to the computation of tensor contractions, which require to process a very large number of small size matrix-matrix products.

Randomized and communication-avoiding algorithms for direct HPC solvers

Participants: M. Baboulin, A. Khabou, A. Rémy

Our activity in the field consists of designing algorithms that minimize the cost of communication and optimize data locality in numerical linear algebra solvers. Due to the heterogeneity of current supercomputers, we combine different architectures in our algorithms by ensuring balanced workload and optimal scheduling/mapping on multicore CPUs and accelerators (GPUs and Xeon Phi). An example concerns the solution of linear systems using the LU factorization, where the main challenge is to reduce the communication overhead due to pivoting. We developed several algorithms to achieve this objective for hybrid CPU/GPU platforms. In one of them the panel factorization is performed using a communication-

avoiding pivoting heuristic (8). We also developed a class of randomized algorithms to avoid pivoting in general or symmetric indefinite linear systems (see e.g., (2, 22), collaboration with University of Tennessee) and to estimate statistically the condition number of linear least squares problems (29) (collaboration with University of California Los Angeles).

We also developed a new algorithm for the LU decomposition based on LU with panel rank revealing pivoting that uses new pivoting strategy based on strong rank revealing QR factorization. We also designed a communication avoiding version of this algorithm which is asymptotically optimal in terms of both bandwidth and latency and also more stable than the communication avoiding LU factorization based on Gaussian elimination with partial pivoting in terms of growth factor upper bound.

Our routines have been integrated into the MAGMA[3] public domain library. We also addressed the impact of non-uniform memory accesses (NUMA) on the solution of HPC applications by proposing appropriate placement of the threads (30) on the different available cores (collaboration with Old Dominion University, USA).

Performance optimization of iterative HPC solvers on heterogeneous platforms

Participants: M. Baboulin, A. Jamal, A. Khabou, Y. Wang

In the framework of a contract with EDF R&D (2014-2018), we worked on accelerating the solution of fluid mechanics problems coming from real applications using GPU as accelerators. More precisely, for sparse linear systems arising from finite volume discretization, we evaluated and optimized the performance of Conjugate Gradient (CG) routines designed for manycore accelerators and compare them against the EDF R&D CPU-based implementation (20). We also investigated how recently developed preconditioners for GPU (here based on iterative Incomplete Cholesky, as symmetric case of ILU) can accelerate the convergence of the solvers. This work on preconditioner evaluation for GPU was achieved in a collaboration with Karlsruhe Institute of Technology, Germany.

Another research activity on iterative methods concerns a new preconditioning approach for least squares problems (27) which provides better convergence and less less storage for the Conjugate Gradient algorithm (collaboration with North Carolina State University, USA).

We also worked on enhancing the performance of some iterative Krylov methods by improving the performance of preconditioners for linear systems (A55). In the framework of a collaboration with Old Dominion University on the parallel algebraic recursive multilevel solver pARMS, we improved the performance of different preconditioners, first by modifying some preconditioners using randomization techniques, and second by integrating some GPU kernels making the solver suitable for heterogeneous CPU/GPU architectures (A82).

Due to the increasing number of processors in current HPC systems, the mean time between failures (MTBF) continues to decrease and the resilience of solvers to software or hardware faults has become a major issue. We specifically studied the effects of soft fault error on the convergence on a parallel version of the GMRES iterative method, commonly used in many physical applications. We consider several error models and preconditioners in solving an elliptical PDE problem (24). Note that we are currently working on transforming our error models into a public domain sofware that can be used to simulate the impact of soft error on other solvers (collaboration with Software Development support team at LRI).

Quantum computing

Participants: M. Baboulin, T. Goubault de Brugière

This exploratory research activity started in 2017 and corresponds to the future of high-performance computing. It started from the observation that some applications will remain intractable even for the future Exascale supercomputers expected at the beginning of the 2020's. The use of quantum co-processors is currently studied by major players of computer science (e.g., Microsoft, Google...) and HPC (e.g., ATOS/BULL, IBM...)

Programming a quantum co-processor relies on the description of a quantum circuit which performs a series of elementary operations acting on the quantum memory to generate the final desired state. Our research concerns the optimisation of quantum circuits. This requires to decompose efficiently unitary matrices (of size 2^n, where n is the number of qubits) in a minimal number of elementary gates easily

[3] Matrix Algebra on GPU and Multicore Architectures, `http://icl.cs.utk.edu/magma/`

implementable (19). This work is performed in the framework of the PhD thesis of T. Goubault de Brugière, started in September 2017 (joint supervision with B. Valiron, LRI/Modhel team) and two research projects (ANR and BPI) in collaboration with BULL/ATOS, CEA, and University de Nancy (LORIA).

Distributed algorithms

In this research topic we focus on algorithmic aspects and modeling of distributed systems of entities having limited resources (in terms of memory, communication capabilities, or available energy). Many emerging mobile sensor networks, following ubiquitous computing technology, correspond to these characteristics. The goal is to better understand how to design efficient future networks and to influence their conception. To model and analyze such networks formally, we use distributed computing models making a priori very weak (and thus more general) assumptions. Among those are the models of *population protocols* and *autonomous robots* - models of resource-limited mobile agents, and *the beeping model* assuming extremely weak communications, by only bursts of energy. For dealing with unreliability due to faults, dynamics and large-scale, we frequently use *fault-tolerance* and *self-stabilization* approaches. In these frameworks, we develop and analyze algorithms for fundamental distributed system tasks, like *consensus*, *leader election*, *data collection*, *synchronization*, *counting*, *coloring* and more. Below, we describe some of our recent achievements.

Population protocols and self-stabilization

Participants: J. Beauquier, P. Blanchard, J. Burman, M. Laveau, T. Nowak, C. Xu

Time and space-optimality of non-initialized population protocols. In *population protocols*, the space complexity of protocols is crucial, since the considered network nodes (the agents) are memory-limited anonymous devices. Moreover, in the context of large scale networks of mass-produced devices or in biologically inspired networks, it is unrealistic to assume that these entities cannot be faulty or can be easily accessed and initialized. Thus, in a recent work, we studied necessary and sufficient conditions of the state space requirements in a setting where possibly non-initialized agents can be prone to transient failures, similarly to the *self-stabilizing* setting (10). We started by considering the fundamental problem of *counting* (exactly) the non-initialized agents. This work significantly improves the previous results known for counting in the same setting, in terms of exact space complexity. We presented and proved correct the first space-optimal protocols solving the problem for two classical types of fairness. In (21), we gave lower bounds on asymptotic time complexities for space-optimal counting and proposed such protocols reaching the presented time bounds.

Power-aware population protocols. For determining the feasibility limits due to energy restrictions of agents in population protocols, we introduced an energy consumption scheme extending the original model (18). Using this extended scheme, we studied energy consumption of *data collection*, a fundamental problem in mobile sensor networks (one of the target networks of the model). We proved lower and upper bounds for this task, when designing power-efficient protocols under both non-deterministic bounded (18) and non-uniformly random (23) schedulers.

Self-stabilization. We recently presented a self-stabilizing distributed algorithm for the *stable matching (or marriage)* problem (between nodes of two sets in a bipartite communication graph, having matching preferences) (28). This problem was introduced in an economic context by Gale and Shapley and has a lot of useful applications, e.g., for two sided markets, migration of virtual machines in Cloud computing, for content delivery on the Internet, etc. Numerous algorithms have been designed for solving this problem (and its variants). However, none of them before was designed for asynchronous distributed and self-stabilizing setting at once.

Communication by beeps

Participants: J. Beauquier, J. Burman, F. Dufoulon

The *beeping* model is an extremely restrictive broadcast communication model that relies only on carrier sensing. Applications of this model range from radio networks with reduced network stacks, such as energy-limited sensor networks, which can provide improved speed, low cost and less transmission errors, to biological networks, where the beeping model allows to study the efficiency of natural protocols. In a recent work concerning beeping communication we devise deterministic time efficient algorithms for *maximal independent set* (MIS) and *coloring*, while improving on the existing solutions in terms of time complexity (11). Solving these problems is important for dealing with the interferences inherent to the

beeping model. Our results apply to general graphs and are asymptotically optimal in sparse graphs (like bounded degree graphs, trees and planar graphs).

In an ongoing work (A123) on beeping communication, we obtain the first asymptotically time-optimal *deterministic* leader election algorithm. Using this result, we also give an asymptotically optimal randomized leader election algorithm for anonymous networks, as well as improved algorithms for symmetry-breaking and communication primitives. The techniques that we introduce give a new insight as to how local constraints on the exchangeable messages can result in efficient algorithms, when dealing with the beeping model.

Dynamic networks and mobility

Participants: J. Beauquier, P. Blanchard, J. Burman, C.-H. Han, A. Lambert, T. Nowak, Z. Wang, C. Xu

Due to the scalability and dynamics of modern systems, fault-tolerance, gracefully degrading algorithms and robustness to environmental changes in general, are major and necessary requirements. Much of our research focuses on dynamic communication topologies, resulting both from communication faults and because of the mobility of the participants in wireless settings. The solvability boundaries and complexities of problems change when passing from static to dynamic communication topologies, and becomes more challenging.

Specifically, we study the problems (and their solutions) occurring in networks of mobile agents, such as ad-hoc networks of smart-phones, IoT devices, sensors, drones, or vehicles. In this setting, we study a wide range of problems, from data gathering to localization and synchronization, passing by construction of stable pairing and minimal independent sets. One important string of research in this vein is that of consensus problems, in particular asymptotic and approximate consensus (A30, 13, A122, A37, 14, A61) and its applications, especially clock synchronization (26) for low-powered mobile devices with limited computational capabilities.

Circuit models

Participants: D.-J. Cho, T. Nowak

This line of research, in collaboration with Vienna University of Technology, views electronic circuits as a distributed system of interconnected components, in particular for being able to apply methods from the study of fault-tolerant distributed systems to circuits. This becomes more and more necessary with the advent and proliferation of smaller and smaller low-powered semiconductor technologies and the need for more aggressive clocking or clock-less designs to boost performance, rendering a monolithic view inefficient. In particular, we are studying fast and accurate delay models for VLSI circuits, which necessarily have to capture emerging phenomena related to glitch propagation and suppression. Indeed, we developed the first model that is both fast and accurate with regard to these phenomena, and we continue to develop it (25). This has significant implications for the design and verification of circuits, seeing as these accurate models can easily be integrated into industrial-grade software suites. In fact, prototypical implementation are already available for use. Our models are also interesting from the standpoint of another important practical challenge, namely non-perfect information and process variation of the components. Indeed, we showed that our models are robust with respect to slight parameter variations, which opens up their applicability to a much larger class of steps of VLSI circuit design.

8/ ParSys

Self Assessment

Strengths: High performance and quantum computing is a high visibility topic at the international level that benefits from significant public funding (see Section "Strategy and five-year project"). This domain is also strategic for the development of the University of Paris-Saclay due to the resulting interdisciplinary aspect and possible collaborations with other public institutions (e.g., Maison de la Simulation) and industries. Moreover the importance of distributed computing has been strengthened due to the emergence of very large-scale networks deploying tiny, basic entities, prone to failures, as well as the development of new network technologies (e.g., Cloud Computing, Blockchain). The members of the team bring al-

gorithmic solutions to such networks and technologies, while publishing in the top conferences of the domain.

Weaknesses: There is a competition with industry for hiring best researchers, with also a lack of specific education programs for HPC and distributed computing in France. After the retirement of J. Beauquier in Sept. 2018 there will be only 2 professors in the group (one from Université Paris-Sud and one from CentraleSupëlec). Moreover most of the team in composed of faculty members (only one Inria researcher, and one CNRS researcher was just hired).

Opportunities: HPC algorithms and software for big data analytics have huge perspectives. Exascale computing opens the doors for new research tracks to address the extremely high level of concurrency in future supercomputers, with significant public and private funding. The development of bio-inspired distributed algorithms together with the possibility of creating micro-biological computers open a large scope to a novel research in distributed computing.

Threats: Associating research in HPC to specific architectures or specific applications presents a threat. Most of the efforts to design innovative algorithms for Exascale (in schedulers, in minimizing energy and communication), must be generic enough to be applied to a wide range of applications (e.g., data analytics, biology, physics, chemistry, finance, ...). More effort should be made at the national level to combine academic and industrial research in the area of distributed algorithms.

8/ ParSys

Strategy and five-year project

We describe in this section the main research tracks of the ParSys team for the next five years. They are focusing on high-performance and quantum computing, and distributed algorithms. We also point out that ParSys will integrate in 2018 the following new permanent members:

- Stéphane Vialle, Professor at CentraleSupélec (HPC with application to Big Data),
- Oguz Kaya, Assistant-Professor at Université Paris-Sud (HPC for tensor computations),
- Laèrcio Lima Pilla, Chargé de Recherche CNRS (scheduling algorithms for HPC systems).

The common concerns for all topics that will be addressed in the ParSys team are performance, scalability, resilience and energy saving. These activities will have the potential to promote the development of closer and interdisciplinary ties within the community of Paris-Saclay.

Parallel algorithms for Exascale computing

The first Exascale supercomputers (that will achieve 10^{18} arithmetic operations per second) are expected to appear in the early 2020's, opening the road for new progress in many scientific areas (physics, biology, data analytics...). Below are the main algorithmic issues that we plan to address in our research activity to take advantage of the upcoming Exascale machines and new parallel architectures. Note that 5 billion euros are expected to be invested in public research in Europe (country governments and European Union) for Exascale computing during the coming years, in addition to system purchases (source: Hyperion Research, 2017).

Achieving optimal performance on highly parallel architectures

Since data communication represents a major bottleneck in supercomputing applications, we will continue our effort in minimizing the cost of communication and optimizing data locality in numerical linear algebra solvers, and in data analytics algorithms. We will further work on randomized algorithms that outperform deterministic methods while performing less computation and/or communication, and in data structures and storage, in collaboration with University of Tennessee (J. Dongarra's group).

Algorithmic issues in extreme scale applications (energy, fault-tolerance)

The next generations of supercomputers will provide an unprecedented level of concurrency with higher probability of errors in the hardware (e.g., processor crash) or the software (e.g., bit flip). Therefore,

failures cannot be avoided and must be taken into account. Our research will consist in analyzing and modifying algorithms in order to achieve inexpensive checkpoints and recovery after failures. A project related to resilience of Multilevel Monte Carlo methods in quantification of uncertainties for Exascale applications is in preparation for submission to the ANR generic call (coordinator: M. Baboulin, partners: EDF and CERFACS).

Minimizing energy consumption is also essential to achieve sustainable large scale computations. For instance, exploiting reduced precision in iterative solvers while keeping a satisfying accuracy is a promising track to reduce energy. The use of simple or even half precision for statistic computing in data analysis is also possible (like in deep learning applications). This is particularly relevant for the latest generations of GPUs and will correspond to a new CIFRE PhD thesis with EDF R&D, starting end of 2018 (supervisor: M. Baboulin).

Development and maintenance of complex parallel codes

The design, implementation and maintenance of parallel codes is becoming one of the main issue in high performance computing. The increasing complexity of hardware requires programming tools and models that satisfy constantly evolving applications. This will be the main motivation for continuing our research in software design methods based on Domain Specific Languages (DSL) and generative programming. These techniques will be applied intensively to scientific and data analytics applications.

In the area of High-Performance Data Analytics (HPDA), two PhD theses will be proposed (supervisor: S. Vialle). They will address optimal cloud ressource management for HPDA (partner: ANEO) and resilient algorithms for HPDA (partner: Sondra Singapore).

Quantum computing for linear systems

We will investigate the possibility of designing quantum algorithms to the solution of linear systems with the objective of overcoming the drawbacks of the existing HHL algorithms (e.g., constraints on the sparsity and the conditioning of the considered matrix). We will first study the influence of various parameters of the system on the complexity of the algorithm. Then we will study the cost of a quantum algorithm for a wave diffusion problem.

Note also that two major projects started in 2018: the ANR project SoftQPRO and the BPI project QUANTEX (member: M. Baboulin). Our research on designing and simulating quantum algorithms using HPC platforms (CIFRE PhD thesis with ATOS) will be fully included in these two projects.

Innovative distributed algorithms

The central activity is the conception, proof and complexity analysis of distributed algorithms. Our approach is analytical and based on distributed computation models, allowing analyzing our networks of interest (e.g., large-scale mobile networks, networks arising form different natural phenomena). Below are the main issues that we will address.

Distributed algorithms for limited elements

Recently, there has been a great interest in distributed systems composed of limited devices. The obvious motivation for these studies is the emergence of large scale sensor networks, where each sensor is a tiny, very cheap computer that is limited in energy, computing power and communication. An important special case of such a network is where each sensor is attached to some mobile agent (e.g., an animal or a human) whose movements are not controlled by the sensor. Another motivation is found in the area of biologically inspired distributed algorithms. For example, one can model a biological system (e.g., the body of an animal) as a distributed one, and seek to understand the cooperation between its different entities. Studying the "algorithms" provided by nature can suggest algorithms useful in the electronic world. For instance, observation of ant colonies has given new ideas for routing. Mimicking the behavior of bees allows optimizing resource searching in the internet. Generally, applying the ideas from the nature in practical implementations requires only very basic and efficient structures and systems.

For being able to study different systems of limited devices analytically, many models have been suggested. We would like to perform a general study of the power of such basic systems as a function of their limitations. That is, certain tasks may be possible or easy in one model (say, when the computation ability is severely limited but the communication is not), and impossible (or much harder) in a model with other limitations (e.g., when the computation ability is not limited, but the communication ability is). In addition

to the theoretical interest, such a methodical approach may be useful in designing algorithms. That is, when we find that one model is weaker than the other, the solutions developed for the first model may be useful for the other. Moreover, our study may suggest to the manufacturer of a system deciding on the minimum hardware resources required to include in each system element.

There is an ongoing project submission related to the comprehensive study on the power of distributed models of limited elements, submitted to the ANR JCJC call (coordinator: J. Burman). Moreover, two French-Israeli projects are in preparation for submissions to CNRS-MOST calls: one focusing on the development of efficient nature inspired algorithms, and another one on fault-tolerance and self-stabilization (coordinators: J. Beauquier and J. Burman, partner: Technion - Israel).

Microbiological circuits

On another related stream of research we are pushing in the converse direction: taking lessons learned and established design principles from electronical computer systems back to biology. Specifically, we started doing research in the domain of computation in bacterial colonies, i.e., bacteria producing outputs as a function of several inputs. Implementation of Boolean gates as well as basic oscillation mechanisms already exist in the literature, which motivated us to start this research. Of course, in order to build a fully-fledged computing system out of bacterial colonies, many hurdles have to be overcome. One major hurdle is the question of a design of a process for microbiological circuits, akin to the mature processes of electronical circuits. Another fundamental difficulty is that of fault-tolerance and robustness: there are very few hard guarantees on the behavior of individual bacteria, leading to a view of bacterial colonies as a set of individual agents, a number of which will fail, but who have to complete a task as a group. Our expertise in both VLSI design as well as fault-tolerant distributed algorithms crucially comes into play here.

Regarding distributed computing modeling of biological circuits, we have an ANR project proposal ready for submission at next year's call, as well as for the CHIST-ERA and FET-OPEN calls (partner: ENS Saclay/LSV).

Annex 4

Collaborations

Participation to national and international collaborative research projects

International projects

- Inria associate-team R-LAS (Randomized Linear Algebra Software), coordinator: M. Baboulin, 2014-2015. Partner: University of Tennessee (USA).
- "Joint Laboratory for Petascale Computing", member: M. Baboulin, 2013-2014. Partners: Inria, University of Urbana-Champaign (USA).
- BPI project: Quantex (Quantum Simulation and Emulation), member: M. Baboulin, 2018-2021. Partners: BULL, CEA, LORIA).
- Franco-Israeli PHC MAIMONIDE project on Cloud Computing (sponsored by MOST, MAEDI and MENESR), 2013-2015, members: J. Beauquier and J. Burman. Partners: Technion, Israel (S. Kutten and I. Keidar).
- European project from ITEA2: SPY (Surveillance imProved sYstem), member: L. Lacassagne, 2010-2013. Partner: EADS/Cassidian.

National projects

- DigiCosme project DIGIT (Distributed Pulse Generation in Bacterial Colonies), T. Nowak, started May 2018. Partner: LSV (M. Függer)
- ANR project SoftQPRO (Solutions logicielles pour l'optimisation des programmes et ressources quantiques), M. Baboulin and B. Valiron, started March 2018. Partners: ATOS, CEA/List, LORIA, LRI.
- BPI project QUANTEX (SImulation et émulation quantique), M. Baboulin and B. Valiron, started March 2018. Partners: ATOS/BULL, CEA/Leti, LORIA, LRI.
- BULL/ATOS (CIFRE PhD thesis), M. Baboulin and B. Valiron.
- Collaboration contract with EDF R&D (CFD on accelerators (20)), M. Baboulin, 2014-2018.
- Digiteo project CALIFHA (Parallel solver for incompressible fluid flows), coordinator: M. Baboulin, 2011-2014. Partner: LIMSI (Olivier Le Maître, Yann Fraigneau).

- PEPS/CNRS project QUARENUM (Numerical reproducibility in HPC), coordinator: M. Baboulin, 2013. Partners: LIRMM, LIP6, LIP.
- LRI-internal DyReCtion project (Dynamicité dans les Réseaux de Communications), 2016-2017, members: J. Beauquier, J. Burman, T. Nowak, L. Pilard. Partner: equipe GALaC (J. Cohen).
- Digiteo-DigiCosme CENERGY project (Consommation d'Energie dans les Réseaux Dynamiques), 2015-2018, members: J. Beauquier and J. Burman.
- PEPS JCJC INS2I 2015 PoLiNoM project (Possibilities and Limitations of Networks of Mobile Agents), 2015, coordinator: J. Burman. Partner: Pierre and Marie Curie University, Paris 6 (S. Dubois)
- ALPINES - INRIA project, 2013-2014, members: J. Beauquier and J. Burman. Partner: Pierre and Marie Curie University, Paris 6 (L. Grigori)
- ANR project MARS (MARS = MRAM based Architecture for Reliable and low power Systems, aka "un mars et ça repart"), member: L. Lacassagne, 2011-2013. Partners: CEA List, EADS/Innovation Works, IEF, LRI, Spintec and CNRS.
- French project from Systematic: Oparus (Optimization and Parallelization for Analysis and Reconstruction of ultrasonic non-destructive testing), member: L. Lacassagne, 2010-2013. Partners: EADS/Airbus, EDF-R & D, Cap Entreprise M2M.

Collaborations with other laboratories leading to joint publications

International collaborations

- M. Schwarz, TU Wien, Austria: asymptotic consensus (A37, A38)
- J. Maier, R. Najvirt, and U. Schmid, TU Wien, Austria: binary circuit models (A75)
- S. Sergeev, University of Birmingham, UK: transient behavior of max-plus linear systems (A143).
- H. Anzt, Karlsruhe Institute of Technology, Germany: preconditioners for GPU accelerators (20).
- M. Sosonkina, Old Dominion University, Norfolk, USA: acceleration and resilience of iterative solvers, publications (A55, A82, 30, 24).
- J. Dongarra, University of Tennessee, MAGMA (Matrix Algebra on GPU and Multicore Architectures) and PLASMA (Parallel Linear Algebra for Scalable Multi-core Architectures), M. Baboulin, 9 joint publications in 2013-2018.
- Lawrence Berkeley National Laboratory, Berkeley, USA: randomized algorithms in sparse linear solvers (A57)
- North-Carolina State University (G. Howell), Raleigh, USA: solvers for sparse least squares, publications (A80, 27).
- J. Aspnes, Yale University, USA: "Time and Space Optimal Counting in Population Protocols" (21).
- R. Guerraoui, LPD, EPFL, Lausanne, Switzerland: "The entropy of a distributed schedule" (A60).
- S. Kutten, Technion, Israel: Population Protocols and Beeping (11, 23, A61).
- S. Dolev, Ben-Gourion University, Israel: "Practically Self-stabilizing Paxos Replicated State-Machine" (A65).
- D. Doty, Department of Computer Science, University of California, Davis: "Time-Space Efficient Self-stabilizing Leader Election Population Protocols".
- L. Rodrigues and O. Denysyuk, Distributed Systems Group, INESC-ID, and Departamento de Engenharia Informàtica, Instituto Superior Técnico (IST), Universidade Técnica de Lisboa: "Byzantine Eventual Agreement in Mobile Networks of Finite State Agents" and "Self-stabilizing Leader Election Population Protocols" (A59).

National collaborations

- M. Függer, LSV: asymptotic consensus, binary circuit models (A30, A31, A122, A37, A38, A75)
- B. Charron-Bost, LIX: asymptotic consensus (A30, A31, A122)
- G. Merlet, Aix-Marseille Université: transient behavior of max-plus linear systems (A143).
- Paul Mycek, CERFACS Toulouse, Resilience in numerical linear algebra solver.
- Olivier Le Maître, LIMSI Orsay: Parallel solvers in Computational Fluid dynamics (17, A98).
- T. Bernard, University of Reims, Champagne Ardenne, "Self-stabilizing Marriage" (A86).
- D. Sohier, University of Versailles, LI-PaRAD : "Time and Space Optimal Counting in Population Protocols" (21, 10).
- L. Blin, University Paris 6, LIP6: "Exclusive Graph Searching" (3).
- N. Nisse, COATI (MASCOTTE) project, INRIA, I3S (CNRS/UNS), Sophia-Antipolis: "Exclusive Graph Searching" (3).
- C. Delporte-Gallet and H. Fauconnier, University Paris 7, LIAFA: "Byzantine Eventual Agreement in Mobile Networks of Finite State Agents".

Visiting professors and students (more than one week)

- M. Sosonkina, 2016, Old Dominion University, Norfolk, USA: "Fault Tolerance Solution in HPC Applications" (24).
- L. Rodrigues, 2018, Distributed Systems Group, INESC-ID, and Departamento de Engenharia Informàtica, Instituto Superior Técnico (IST), Universidade Técnica de Lisboa: "Byzantine Eventual Agreement in Mobile Networks of Finite State Agents".
- D. Doty, 2017, Department of Computer Science, University of California, Davis: "Time-Space Efficient Self-stabilizing Leader Election Population Protocols".
- R. Guerraoui, 2014, LPD, EPFL, Lausanne, Switzerland: "The entropy of a distributed schedule" (A60).

Group seminar

The team organizes a group seminar on a roughly monthly schedule, inviting leading researchers from France and abroad. See **https://parsys.lri.fr/seminar.html** for details.

Participation to national and international networks

- GT "Modélisation et simulation, calcul intensif" of the Paris-Saclay University, started in 2015: M. Baboulin, A. Khabou.
- GT DigiCosme *HicDiesMeus*: J. Beauquier, J. Burman, D.-J. Cho, T. Nowak, co-organization, started in 2017.

Volunteer Professional Service

Management Positions in Scientific Organisations

- Inria Project team Grand-Large: M. Baboulin, team leader (2013)
- Inria Project team Postale: M. Baboulin, team leader (2014-2015)
- Polytech Paris-Sud: M. Baboulin, head of the computer science department (2014-2018)
- Polytech Paris-Sud: B. Rozoy, head of the computer science department (2013)

Organisation of Conferences and Scientific Events

- WENDY, *Workshop on Emergent Algorithms and Network Dynamics*, Paris, France, 2018: T. Nowak, co-organizer.
- SIAM PP'18, *Minisymposium "Innovative methods for high performance iterative solvers"*, Tokyo, Japan, 2018: M. Baboulin, organizer.
- TWHPC, *Tunisian Workshop on High Performance Computing*, Tunis, Tunisia, 2017-2018: A. Khabou, organizer.
- SIAM CSE'17, *Minisymposium "Sparse Least Squares"*, Atlanta, USA, 2017: M. Baboulin, organizer.
- HPC 2016, *24th High Performance Computing Symposium*, Pasadena, USA, 2016: M. Baboulin, General Vice-Chair.
- SIAM CSE'15, *Minisymposium "Randomized algorithms in numerical linear algebra"*, Salt Lake City, USA, 2015: M. Baboulin, organizer.
- ILAS 2014, *Workshop "Linear least squares and applications"*, Seoul, Korea, 2014: M. Baboulin, organizer.
- SIAM PP'14, *Minisymposium "Randomized algorithms in parallel matrix computations"*, Portland, USA, 2014: M. Baboulin, organizer.
- SIAM CSE'13, *Minisymposium "Numerical and reliability issues in high-performance computing"*, Boston, USA, 2013: M. Baboulin, organizer.
- SSS, International Symposium Stabilization, Safety, and Security of Distributed Systems, Canada, Edmonton, 2016: J. Burman, Publicity Committee Chair

Honors

Awards

- J. Beauquier, J. Burman, M. Laveau, L. Pilard: *Best Paper Award - International Symposium Stabilization, Safety, and Security of Distributed Systems (SSS)*, 2017 (28).

Keynote Addresses and invited talks

International

- T. Nowak, *Second Workshop on Computing in Dynamic Networks*, Vienna, Austria, Oct. 20, 2017: Invited speaker.
- M. Baboulin, *International Workshop on Recent Topics in High Performance Computing*, Kagaku Kaikan, Tokyo, Japan, Sept. 21, 2017: Invited speaker.
- M. Baboulin, *Workshop on High Performance Computing*, University of Hokkaido, Sapporo, Japan, Aug. 22, 2016: Invited speaker.
- M. Baboulin, *High Performance Computing in Science and Engineering (HPCSE 2015)*, Solan, Czech Republic, 2015: Invited plenary speaker.
- M. Baboulin, *International Conference on Numerical Linear Algebra and Scientific Computing (NASC 2014)*, Shanghai, China, 2014: Invited speaker.
- M. Baboulin, invited seminars at National Institute of Informatics, Japan (Aug. 2015 and Aug. 2016), University of Manchester, UK (May 2016), Old Dominion University, USA (Oct. 2015), Fudan University, China (Oct. 2014), Czech Academy of Sciences (June 2015), University of Tennessee, USA (June 2014).
- J. Falcou, *The 2016 International Conference on High Performance Computing & Simulation (HPCS 2016)*, Innsbruck, Austria, July 18 – 22, 2016: Invited speaker.
- J. Falcou, *Meeting C++ 2015*, Berlin, Germany, December 4 - 5, 2015: Invited speaker.
- J. Falcou, *CppCon 2015, the c++ conference*, Bellevue, Washington, USA, September 19 – 25, 2015: Invited speaker.
- J. Falcou, *The 2015 International Conference on High Performance Computing & Simulation (HPCS 2015)*, Amsterdam, the Netherlands, July 20 – 24, 2015: Invited speaker.

France

- M. Baboulin, *Séminaire Panorama de la recherche*, ENS Saclay, May 2017: Invited speaker.
- M. Baboulin, *Workshop "HPC pour les études industrielles"*, EDF R&D, Saclay, March 2017: Invited speaker.
- M. Baboulin, *Séminaire Aristote*, Ecole Polytechnique, May 2013: Invited speaker.
- M. Baboulin, invited seminars at ENS Saclay/LSV (April 2018), Maison de la Simulation (Dec. 2016), Inria Bordeaux (March 2015), Ecole Centrale Paris (Dec. 2014), UPMC/J.L. Lions (March 2014), ENS Lyon/LIP (Oct. 2013), UPMC/LIP6 (Feb. 2013).
- J. Burman, *GT Vérification annual meeting*, Paris-Est - Créteil University, 2017: Invited speaker.
- D. Etiemble, *Séminaire CNAM : Histoire de l'informatique et du numérique*, Dec.12, 2016: Invited speaker.

Other honors

- M. Baboulin: Excellence Research Chair INRIA - Université Paris-Sud (2013-2015).

Evaluation of Research

Editorial Boards

- PPL, Parallel Processing Letters: J. Beauquier, associate editor.
- Techniques de l'ingénieur: D. Etiemble, scientific advisor.

Program Committees

Chair

- HPC 2016, *24th High Performance Computing Symposium*, Pasadena, USA: M. Baboulin (General Vice-Chair, 2016).

Member (international events)

- DASIP *The Conference on Design and Architectures for Signal and Image Processing*: L. Lacassagne (member of the Program Committee, 2014-2018).
- PPoPP *Principles and Practice of Parallel Programming*: L. Lacassagne (member of the Program Committee, 2014-2018).
- WPMVP *Workshop on Programming Models for SIMD/Vector Processing*: L. Lacassagne (member of the Program Committee, 2014-2018).
- SSS, *International Symposium on Stabilization, Safety, and Security of Distributed Systems*: T. Nowak (member of the Program Committee, 2018).
- HPC Asia, *ACM International Conference on High Performance Computing in Asia-Pacific Region*: M. Baboulin (member of the Program Committee, 2018).
- PPAM, *International Conference on Parallel Processing and Applied Mathematics*: M. Baboulin (member of the Program Committee, 2017).
- EuroPar, *International European Conference on Parallel and Distributed Computing*: M. Baboulin (member of the Program Committee, 2016).
- HPC, *High Performance Computing Symposium*: M. Baboulin (member of the Steering Committee, 2013- 2015).
- PODC, ACM Symposium on Principles of Distributed Computing: J. Beauquier (member of the Program Committee, 2014, 2018)
- OPODIS, International Conference on Principles of Distributed Systems: J. Burman (member of the Program Committee, 2018)
- DISC, Distributed Computing International Symposium: J. Burman (member of the Program Committee, 2018)
- PODC, ACM Symposium on Principles of Distributed Computing: J. Burman (member of the Program Committee, 2018)
- ACM WomENcourage, ACM Europe Celebration of Women in Computing: J. Burman (member of the Program Committee, 2017)
- SSS, International Symposium Stabilization, Safety, and Security of Distributed Systems: J. Burman (member of the Program Committee, 2014-2015)
- C++Con, The C++ Conference: J. Falcou (program chair 2013-2018)
- C++Now, C++ Conference: J. Falcou (program chair 2013-2018)
- HPCS, The International Conference on High Performance Computing & Simulation: J. falcou (member of the Program Committee, 2016-2018)
- HLPP, International Symposia on High-Level Parallel Programming and Applications: J. falcou (member of the Program Committee, 2015-2018)
- TWHPC, Tunisian Workshop on High Performance Computing: A. Khabou (member of the Program Committee, 2017-2018)

Member (national events)

- ALGOTEL, French National Conference on the Algorithmic Aspects of Telecomunications (Rencontre Francophones sur les Aspects Algorithmiques des Télécommunications): J. Burman (member of the Program Committee, 2016-2017)

Evaluation Committees and Invited Expertise

- IUF Jury, Senior: J. Beauquier (2017).
- American University of Beirut grant review: A. Khabou (2018).
- Digicosme: Marc Baboulin (2018).

Other evaluation activities

- Ecole Doctorale Paris-Saclay, member of "comité de pôle": M. Baboulin (2015-2016).
- Ecole Doctorale Paris-Saclay, member of "comité de pôle": J. Beauquier (2017- till now).
- University Paris-Sud HDR correspondent, section 27: J. Beauquier (2017-2018).
- University Paris-Sud HDR member of committee, section 27: M. Baboulin (2017- till now).
- Research paper reviews for "Concurrency and Computation: Practice and Experience", "Linear Algebra and its applications", "ACM Transactions on Mathematical Software": M. Baboulin (2016-2018).
- Research paper review for International "Journal of High Performance Computing Applications", "Transactions on Parallel and Distributed Systems": A. Khabou (2016-2018).
- Research paper reviews for international journals and conferences: IC, TCS, PODC, DISC, OPODIS, SIROCCO, SSS, ICDCN, NETYS: J. Beauquier (2013-2018).
- Research paper reviews for international journals and conferences: DC, IC, TCS, JSC, COMPJ, IEEE TPDS, PODC, SODA, DISC, OPODIS, SIROCCO, SSS, ICDCN, NETYS: J. Burman (2013-2018).
- Research paper reviews for international journals and conferences: DAM, CC, PODC, DISC, SPAA, ICDCS, CDC, SSS: T. Nowak (2013-2018).
- Reviewer of 3 PhD theses and 1 HDR: M. Baboulin.
- Reviewer of 2 PhD theses: J. Beauquier.
- President of 1 hiring committee PRAG: Marc Baboulin.
- President of 2 hiring committees Pr : J. Beauquier.
- Member of 4 hiring committees MdC (1 as president): M. Baboulin.
- Member of 2 hiring committees MdC: J. Beauquier.
- Member of 3 hiring committees MdC: J. Burman.

Interactions with the social, economic and cultural environment

Interaction with the economic environment

- Industrial contracts and collaborations with EDF R&D, ONERA, ATOS: M. Baboulin.
- Industrial contracts and collaborations with CEA, ST Microelectronics: L. Lacassagne.
- J. Falcou is co-founder of NumScale, a start-up company created with the support of the Digiteo/University Paris Sud technological transfer program (Digiteo OMTE).

Dissemination

- K. Al Agha and D. Etiemble: Introduction to Internet of Things. Techniques de l'ingénieur (to appear, 2018).
- D. Etiemble, traductions (in french) of scientific books for Dunod Editions (2014-2016).
- J. Falcou, Founder and Organiser of "User Group C++ Francophone" (C++ Frug): the first french meetup about C++ (more than 900 members).

Contracts and grants

Public contracts and grants (jan 2013 - jun 2018)					
Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*	*Amount*
Chaire d'excellence	M. Baboulin	Chaire INRIA/Univ. Paris-Sud	INRIA	01.2013 36	30
Equipe associée	M. Baboulin	R-LAS	INRIA	01.2014 24	20
Digitéo	M. Baboulin	CALIFHA	Université Paris-Sud	01.2013 21	56.7
PEPS	M. Baboulin	QUARENUM	CNRS	04.2013 9	5
ITEA	C. Bastoul	MANY	INRIA	01.2013 20	111.6
PEPS JCJC	J. Burman	PoLiNoM	CNRS	04.2015 9	11.1
PHC	J. Beauquier	Maïmonide	Université Paris-Sud	01.2014 24	47
Digitéo	J. Beauquier	DISCOVER	Université Paris-Sud	01.2013 21	56.7
Digitéo	J. Falcou	FLUCTUS	Université Paris-Sud	01.2013 8	21.6
DigiCosme	J. Beauquier	CENERGY	Université Paris-Sud	09.2015 36	109
PEPS JCJC	T. Nowak	DEMO	Université Paris-Sud	02.2018 11	8
PostDoc DigiCosme	T. Nowak	DIGIT	CNRS	05.2018 12	50

Private contracts and grants (jan 2013 - jun 2018)					
Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*	*Amount*
EDF	M. Baboulin	CFD on accelerators	Université Paris-Sud	10.2014 48	75.2
ATOS	M. Baboulin	Quantum computing	Université Paris-Sud	01.2018 36	24.4
CEA	L. Lacassagne	Collaboration CEA/LRI	Université Paris-Sud	01.2013 25	15
ST Microelectronics	L. Lacassagne	CIFRE	Université Paris-Sud	01.2014 20	15.2

Training and Education

Master Internships

- Valentin Labourdette, M2 Univ. P&M Curie, *Stability analysis for mixed precision algorithms*, M. Baboulin and A. Khabou, 2015.
- Aygul Jamal, M2 Univ. Paris-Sud, *Randomized algorithms in iterative methods*, M. Baboulin, 2014.
- Ian Masliah, M2 Univ. Paris-Sud, *Generative programming for linear systems*, M. Baboulin, 2013.
- Malik Kazi Aoual and Nouredine Nour, M1 Univ. Paris-Sud, *Blockchain of the Bitcoin*, J. Beauquier and J. Burman, 2018.
- Fabien Dufoulon, M2 Univ. Paris-Sud, *Verification Algorithms in the Beeping Model*, J. Beauquier, J. Burman and S. Kutten, 2016.
- Marie Laveau, M2 Univ. Paris-Sud, *Self-stabilizing Stable Marriage*, J. Beauquier and J. Burman, 2015.
- Amira Kamli, M2 Univ. Paris-Sud, *Data Collection in Population Protocols over Arbitrary Communication Graphs*, J. Beauquier, J. Burman and L. Pilard, 2015.
- Nicole Elhaddad, M2 Univ. Paris-Sud, *Chemical Reaction Networks vs. Population Protocols*, J. Beauquier, J. Burman and L. Pilard, 2015.

Graduate Courses

- Master Informatique, Université Paris-Sud, Parcours FIIL, *Modèles de la Nature*: J. Beauquier, J. Burman and T. Nowak, 2015-2018.
- Master Informatique, Université Paris-Sud, M1, *Algorithmes distribués Tolérant aux Défaillances*: J. Beauquier and J. Burman, 2013-2018.
- Master Informatique, Université Paris-Sud with Ecole Polytechnique, ENSTA ParisTech, Télécom ParisTech and more, Parcours COMASIC, *Algorithmes distribués*: J. Burman, 2015-2018.
- Master Informatique, Université Paris-Sud, Parcours FIIL, *Calcul Haute Performance*: M. Baboulin and A. Khabou, 2015-

2018.

- Master Informatique, Université Paris-Sud, Parcours FIIL, *C++ avancé*: J. Falcou, 2016-2018.
- Master Informatique, Université Paris-Sud, Parcours FIIL, *Programmation CUDA*: J. Falcou, 2015-2016.
- Master Advanced Communication Networks, École polytechnique, *Algorithms for Networked Information*: T. Nowak, 2015-2016.
- Master Informatique, Université Paris-Sud, Parcours SETI, *Calcul Haute Performance*: L. Lacassagne, 2013-2015.
- Master Informatique, Université Paris-Sud, Parcours NSI, *Calcul Haute Performance*: M. Baboulin, J. Falcou, L. Lacassagne, 2013-2015.
- Poytech Paris-Sud, years 3 and 4, computer science department, *Algorithmes distribués, Architectures des ordinateurs, Calcul haute performance, Méthodes numériques, Programmation parallèle, Programmation générative*: M. Baboulin, J. Beauquier, J. Burman, D. Etiemble, J. Falcou, A. Khabou.

Internships

- N. Heurtel, Parcours recherche CentraleSupélec, *Quantum computing for machine learning*: M. Baboulin, 2018-2020.
- F. Cravo, Parcours Recherche CentraleSupélec, *Dynamics of wireless networks*: T. Nowak, 2018-2020.
- J. Penuchot, Parcours J. Herbrand, Magistère Université Paris-Sud, *Generative programming for task scheduling*: J. Falcou, A. Khabou, 2017-2018.

Other

- Polytech Paris-Sud: M. Baboulin, head of the computer science department (2014-2018)
- Polytech Paris-Sud: A. Khabou, responsible for the 4th year, apprentissage (2017-2018).
- Master COMASIC: J. Burman, member of the teaching and recruitment committee.

Honors

- In 2014, B. Rozoy was awarded "chevalière de l'ordre du mérite".

Theses

Habilitation à Diriger des Recherches	
Name	*Defense*
Joël FALCOU	01.12.2014

Defended theses				
Name	*Start*	*Defense*	*Funding*	*Advisor*
Lenaïc BAGNERES	01.10.2012	30.09.2016	Alloc. Ministère	C. Eisenbeis and C. Bastoul
Peva BLANCHARD	01.09.2011	01.10.2014	Digiteo DISCOVER project	J. Beauquier
Laurent CABARET	01.11.2012	28.09.2016	Ecole Centrale Paris	L. Lacassagne
Pierre ESTERIE	01.10.2010	20.06.2014	Alloc. Ministère	Joël Falcou and B. Rozoy
Alessandro FERREIRA LEITE	01.10.2012	02.12.2014	ETR (Brésil)	C. Eisenbeis
Aygul JAMAL	01.10.2014	28.09.2017	Alloc. Ministère	M. Baboulin and A. Khabou
Amal KHABOU	01.10.2009	11.02.2013	Alloc. Ministère	L. Grigori
Michael KRUSE	13.09.2010	26.09.2014	INRIA	C. Eisenbeis
Ian MASLIAH	01.10.2013	08.07.2015	Alloc. Ministère	M. Baboulin and Joël Falcou
Jason LAMBERT	01.10.2011	03.07.2015	CEA	L. Lacassagne
Adrien REMY	01.10.2011	08.07.2015	Alloc. Ministère	M. Baboulin
Andres ROMERO MIER Y TERAN	01.01.2010	03.12.2013	CONACYT (Méxique)	L. Lacassagne and M. Gouiffès
Antoine TRAN TAN	01.09.2012	08.10.2015	Alloc. Ministère	D. Etiemble and Joël Falcou
Chuan XU	01.09.2013	15.12.2017	Chinese government fellowship	J. Beauquier and J. Burman
Yushan WANG	01.10.2011	09.04.2015	Digiteo CALIFHA project	M. Baboulin and O. Le Maître

Position after the thesis	
Name	*Position*
Lenaïc BAGNERES	Engineer, NumScale
Peva BLANCHARD	Computer science consultant, NESTLÉ
Laurent CABARET	PRAG, CentraleSupélec
Alessandro FERREIRA LEITE	Engineer, SAFRAN
Aygul JAMAL	ATER, Univ. Paris-Sud
Amal KHABOU	Assistant Professor, Univ. Paris-Sud
Michael KRUSE	Postdoc, Argonne National Lab.
Ian MASLIAH	Postdoc, UPMC
Adrien REMY	Postdoc, Inria Lyon
Antoine TRAN TAN	PRAG, IUT Cachan
Chuan XU	ATER, Univ. Paris-Sud
Yushan WANG	Postdoc, CEA

Theses in progress			
Name	*Start*	*Funding*	*Advisor*
Fabien DUFOULON	01.10.2016	Alloc. Ministère	J. Beauquier and J. Burman
Timothée GOUBAULT de BRUGIERE	01.09.2017	CIFRE (ATOS)	Marc Baboulin and B. Valiron
Cheng-Yu HAN	01.10.2015	MOE scholarship (Taiwan)	Alain Lambert and Thomas Nowak
Marie LAVEAU	01.09.2015	DigiCosme CENERGY project	J. Beauquier, J. Burman and T. Bernard
Kenny PEOU	01.07.2016	CIFRE (NUMSCALE)	Joël Falcou and Cécile Germain
Zhan WANG	01.09.2015	CSC scholarship (China)	Alain Lambert

Software Licensing and Distribution

CLooG - Chunky Loop Generator

http://www.cloog.org

Contact: Cédric BASTOUL

CLooG is a free software and library to generate code for scanning Z-polyhedra. That is, it finds a code (e.g. in C, FORTRAN...) that reaches each integral point of one or more parameterized polyhedra. CLooG has been originally written to solve the code generation problem for optimizing compilers based on the polytope model. Nevertheless it is used now in various area e.g. to build control automata for high-level synthesis or to find the best polynomial approximation of a function. CLooG may help in any situation where scanning polyhedra matters. While the user has full control on generated code quality, CLooG is designed to avoid control overhead and to produce a very effective code.

Clay - Clay

http://repo.or.cz/w/clay.git

Contact: Cédric BASTOUL

Clay (Chunky Loop Alteration wizardrY) is a scripting system for high-level loop transformations.

cTuning - public repository and tools for collaborative and statistical program and architecture characterization and optimization

http://ctuning.org

Contact: Grigori FURSIN

cTuning is a collaborative tuning center to develop free common open-source extensible collaborative infrastructure, benchmarks and collective optimization repository based on multiple research techniques and production tools to parametrize, abstract, automate, simplify and systematize program, compiler and architecture design and optimization using collective tuning, run-time adaptation, statistical and machine learning techniques. It enables sharing of benchmarks, datasets, optimization cases through unified web-services and tools with common APIs to be able to predict better optimizations or architecture designs provided there is enough information collected in the repository from multiple users.

myNRC2.0 - Smart memory allocator
Contact: Lionel LACASSAGNE

MyNRC is an image-oriented and multi-platform library for allocation and manipulation of SIMD 1D, 2D and 3D structures. MyNRC can handle SSE, AVX, Neon and ST VECx registers.

covTrack - Robust and realtime multitarget covariance tracking
Contact: Lionel LACASSAGNE

covTrack is an agile, realtime, and multi-target tracking algorithm, co-developped with Michèle Gouiffès at LIMSI.

Candl - Chunky Dependance Analyzer
http://www.lri.fr/~bastoul/#DEVELOPMENT
Contact: Cédric BASTOUL

Candl is a free software and a library devoted to data dependences computation. It has been developed to be a basic bloc of our optimizing compilation tool chain in the polyhedral model. From a polyhedral representation of a static control part of a program, it is able to compute exactly the set of statement instances in dependence relation. Hence, its output is useful to build program transformations respecting the original program semantics. This tool has been designed to be robust and precise.

OpenScop - OpenScop
http://repo.or.cz/w/openscop.git
Contact: Cédric BASTOUL

OpenScop is an open specification that defines a file format and a set of data structures to represent a static control part (SCoP for short), i.e., a program part that can be represented in the polyhedral model. The goal of OpenScop is to provide a common interface to the different polyhedral compilation tools in order to simplify their interaction. To help the tool developpers to adopt this specification, OpenScop comes with an example library (under 3-clause BSD license) that provides an implementation of the most important functionalities necessary to work with OpenScop.

Quaff - Quaff: Dataflow EDSL for Parallel Programming
https://github.com/NumScale/quaff
Contact: Joël FALCOU

Quaff is a C++ library for specifying dataflow applications using meta-programming techniques to generate an efficient parallel code from a compact description of the program structure.

NT2 - The Numerical Template Toolbox
https://github.com/NumScale/nt2/
Contact: Joël FALCOU

The Numerical Template Toolbox (NT^2) is an open source C++ library that aims at simplifying the development, debugging and optimization of high-performance computing applications by providing a MATLAB-like syntax that eases the transition between prototype and real applications.

SUNFLUIDH (collaboration LIMSI) - CPU/GPU solver for Navier-Stokes equations
Contact: Marc BABOULIN

We developed new algorithms and routines for solving 3D Navier-Stokes equations, in collaboration with LIMSI (Olivier Le Maître, Yann Fraigneau). We developed a tridiagonal solver using vectorization techniques. We also modified the solver for clusters of multicores, combining MPI and OpenMP, and we adapted he Helmholtz-like and Poisson solvers to GPUs.

RBT solver - Random Butterfly Transformations
Contact: Marc BABOULIN

The Random Butterfly Transformation (RBT) is used to randomized a given linear system such that, with probability one, the LU factorization (or LDLT factorization in case of a symmetric indefinite matrix) of the transformed matrix can be performed without pivoting. The corresponding routines have been developed for hybrid multicore/GPU systems for the general case and integrated into the MAGMA library (dgerbt). For the symmetric case, we developed a tiled algorithm that was implemented for multicore (PLASMA library) and distributed architectures (combine with the ParSec runtime system).

MAGMA - Contribution to numerical linear algebra libraries

http://icl.cs.utk.edu/magma/
Contact: Marc BABOULIN

Contribution to the numerical linear algebra library MAGMA in collaboration with University of Tennessee. MAGMA offers dense linear algebra solvers similar to LAPACK but for heterogeneous/hybrid architectures, in particular Multicore+GPU systems. Our contribution is mainly related to solvers for general and symmetric indefinite linear systems and optimized matrix-matrix products.

ParSys team publications (20 %)

Journal articles

Major international journals

(1) M. Baboulin, J. Dongarra, J. Herrmann, and S. Tomov. Accelerating linear system solutions using randomization technique. *ACM Transactions on Mathematical Software*, 39(2), Feb. 2013.

(2) M. Baboulin, J. Dongarra, A. Remy, S. Tomov, and I. Yamazaki. Solving dense symmetric indefinite systems using GPUs. *Concurrency and Computation: Practice and Experience*, 29(9):1 – 17, May 2017.

(3) L. Blin, J. Burman, and N. Nisse. Exclusive Graph Searching. *Algorithmica*, 77(3):942–969, 2017.

(4) B. Charron-Bost, M. Függer, and T. Nowak. New transience bounds for max-plus linear systems. *Discrete Applied Mathematics*, 219:83 – 99, Mar. 2017.

(5) P. Esterie, J. Falcou, M. Gaunard, J.-T. Lapresté, and L. Lacassagne. The Numerical Template toolbox: A Modern C++ Design for Scientific Computing. *Journal of Parallel and Distributed Computing*, 74(12):pp. 3240–3253, July 2014.

(6) A. Ferreira Leite, A. Boukerche, A. C. Magalhaes Alves de Melo, C. Eisenbeis, C. Tadonki, and C. Ghedini Ralha. Power-Aware Server Consolidation for Federated Clouds. *Concurrency and Computation: Practice and Experience*, 28(12):3427–3444, June 2016.

(7) G. Fursin, R. Miceli, A. Lokhmotov, M. Gerndt, M. Baboulin, A. D. Malony, Z. Chamski, D. Novillo, and D. D. Vento. Collective mind: Towards practical and collaborative auto-tuning. *Scientific Programming*, 22(4):309–329, July 2014.

(8) A. Khabou, J. W. Demmel, L. Grigori, and M. Gu. LU Factorization with Panel Rank Revealing Pivoting and its Communication Avoiding Version. *SIAM Journal on Matrix Analysis and Applications*, 34(3), 2013.

Conference articles

Major international conferences and workshops

(9) A. Abdelfattah, M. Baboulin, V. Dobrev, J. J. Dongarra, C. Earl, J. Falcou, A. Haidar, I. Karlin, T. V. Kolev, I. Masliah, and S. Tomov. High-performance Tensor Contractions for GPUs. In *International Conference on Computational Science 2016 (ICCS 2016)*, volume 80 of *International Conference on Computational Science*, pages 108–118, San Diego, CA, United States, June 2016. Elsevier.

(10) J. Beauquier, J. Burman, S. Claviere, and D. Sohier. Space-Optimal Counting in Population Protocols. In Y. Moses and M. Roy, editors, *DISC 2015*, volume LNCS 9363 of *29th International Symposium on Distributed Computing*, Tokyo, Japan, Oct. 2015. Toshimitsu Masuzawa and Koichi Wada, Springer-Verlag Berlin Heidelberg.

(11) J. Beauquier, J. Burman, F. Dufoulon, and S. Kutten. Fast Beeping Protocols for Deterministic MIS and $(\Delta + 1)$-Coloring in Sparse Graphs. In *IEEE INFOCOM 2018*, Honolulu, United States, Apr. 2018.

(12) L. Cabaret, L. Lacassagne, and L. Oudni. A Review of World's Fastest Connected Component Labeling Algorithms: Speed and Energy Estimation. In *International Conference on Design and Architectures for Signal and Image Processing*, Madrid, Spain, Oct. 2014.

(13) B. Charron-Bost, M. Függer, and T. Nowak. Fast, Robust, Quantizable Approximate Consensus *. In I. Chatzigiannakis, M. Mitzenmacher, Y. Rabani, and D. Sangiorgi, editors, *43rd International Colloquium on Automata, Languages, and Programming (ICALP 2016)*, Rome, Italy, July 2016. Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik.

(14) M. Függer, T. Nowak, and M. Schwarz. Tight Bounds for Asymptotic and Approximate Consensus. In *ACM Symposium on Principles of Distributed Computing (PODC'18)*, Egham, United Kingdom, July 2018.

(15) L. Lacassagne, L. Cabaret, D. Etiemble, F. Hebbache, and A. Petreto. A new SIMD iterative connected component labeling algorithm. In *Principles and Practice of Parallel Programming / WVMVP*, Barcelone, Spain, Mar. 2016. ACM.

(16) I. Masliah, M. Baboulin, and J. Falcou. Meta-programming and Multi-stage Programming for GPGPUs. In *10th IEEE International Symposium on Embedded Multicore/Many-core Systems-on-Chip (MCSOC 2016)*, pages 369 – 376, Lyon, France, Sept. 2016. IEEE Computer Society.

(17) Y. Wang, M. Baboulin, J. Dongarra, J. Falcou, Y. Fraigneau, and O. Le Maitre. A parallel solver for incompressible fluid flows. In *International Conference on Computational Science*, Barcelona, Spain, June 2013.

(18) C. Xu, J. Burman, and J. Beauquier. Power-Aware Population Protocols. In *2017 IEEE 37th International Conference on Distributed Computing Systems (ICDCS)*, ATLANTA, United States, June 2017.

Other conferences and workshops

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(A153) A. Khabou. *Calculs pour les matrices denses : coût de communication et stabilité numérique*. Theses, Université Paris Sud - Paris XI, Feb. 2013.

(A154) M. Kruse. *Lattice QCD Optimization and Polytopic Representations of Distributed Memory*. Theses, Université Paris Sud - Paris XI, Sept. 2014.

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9/ ROCS

Networking and Stochastic Combinatorial Optimization

équipe
Réseaux et Optimisation Combinatoire Stochastique

Responsable: Steven Martin, Dominique Quadri

L'équipe ROCS est composée de chercheurs en Réseaux et en Optimisation Combinatoire Stochastique. Elle se décline en trois activités: Réseaux, Optimisation Combinatoire et Stochastique, Optimisation dans les réseaux.

L'activité "réseaux" traite des problèmes liés à la qualité de service, principalement dans les réseaux sans fil, avec ou sans infrastructure. De nouvelles solutions sont étudiées pour améliorer les performances, que ce soit en termes de capacité, de débit, de robustesse, de consommation énergétique ou encore de sécurité. Ces solutions conduisent à la définition d'algorithmes et de protocoles efficaces.

L'activité "Optimisation combinatoire et stochastique" utilise le paradigme de l'optimisation comme composante fondamentale de la méthodologie de recherche, reposant sur la conception, la modélisation et l'évaluation de performances des solutions optimisées proposées. Cette recherche est liée à l'optimisation combinatoire déterministe (fortement non linéaire et non convexe) et à l'optimisation stochastique (incertitude via les probabillités et approche par sénarii).

L'activité "Optimisation dans les réseaux" est fortement développée depuis cinq. Elle consiste à traiter un problème réel issu de l'activité "Réseaux" en s'appuyant sur la méthodologie de la recherche opérationnelle dont l'une des modélisations puissantes est la programmation mathématique (en univers certain ou incertain) en variables mixtes.

L'objectif principal de ROCS est de traiter de sujets cruciaux et de développements futurs, en particulier dans le domaine des réseaux mobiles et sans fil, et plus particulièrement issus du domaine de l'Internet des Objets (IoT), en développant des collaborations fortes pour résoudre des problèmes complexes d'optimisation dans les réseaux.



Networking and Stochastic Combinatorial Optimization

Head: Steven Martin, Dominique Quadri

ROCS team gathers researchers working in the Networking and Stochastic Combinatorial Optimization fields. The ultimate aim of the Networking part is to deal with research related to quality of service mainly over wireless communication networks regardless their types, i.e. with or without infrastructure. New solutions are investigated for enhancing performance in terms of capacity, throughput, robustness, energy consumption, security, etc. These solutions lead to the definition of efficient algorithms and protocols.

The Deterministic and Stochastic Combinatorial Optimization part is using optimization paradigm as a fundamental component of research methodology which is mainly built on the combined design, modeling, and performance evaluation of the proposed optimized solutions.

The Optimization for Networks part grown up during the last five years. It deals with real-world networking problems based on mathematical programming paradigm and solution methods.

The core objective of ROCS is to deal with crucial topics and future developments especially in Internet of Things (IoT) by developing strong collaborations to solve complex network optimization problems.

Synthetic presentation

Head of ROCS team
Steven Martin and Dominique Quadri (co-director) from 2013 to 2017
Dominique Quadri and Lila Boukhatem (co-director) from 2018

Effectifs de l'équipe
The ROCS team includes 7 permanent university members (3 PR, 4 MC), 8 Ph.D. students, 6 post-doctoral students and 4 research engineers (compared to January, 2013 : 2 PR, 5 MC, 7 Ph.D. students, 6 post-doctoral students and 2 research engineers).

Personnels ayant quitté l'équipe pendant le contrat en cours
Tara ALI-YAHIYA (MC) is on leave (détachement) since September 2014. Khaldoun AL AGHA (PR) was on leave from September 2013 to August 2017.

Nombre de recrutements réalisés au cours de la période considérée et origine des personnels
Steven Martin got the full professor position in September 2014, he was before associate professor at the university Paris-Sud.

Production scientifique au cours de la période écoulée
The ROCS team conducts research organized around three complementary activities:

1. **Networking.** In this activity, the team members address problems related to several types of networks (with or without infrastructure, operated or not) such as 4G, 5G, heterogeneous networks, vehicular ad hoc networks or multi-hops wireless networks. Hence, there is an increasing challenge in the operation of 5G networks: huge amount of data are becoming an overwhelming part of the traffic, while the associated income is shrinking.

2. **Deterministic and stochastic combinatorial optimization.** In this activity, the team members address problems related to non linear programming from theoretical and practical point of view. Indeed, considering deterministic or stochastic program, the models considered are strongly non linear and usually non convex (quadratic, fractional, logarithmic). The originality of our work consists in reformulating the initial difficult problem into an equivalent one, simpler to be solved in practice. In addition, the ROCS team working with industrial partners, an effective implementation of our theoretical approaches is usually performed.

3. **Optimization for networks** In this activity, the team members address problems related to networking area, such as energy savings in multi-hop wireless networks for instance. The originality of our approach is the use of mathematical programming to provide a tight model of networking application. We consequently propose as a first step an optimal solution for the centralized problem. Then we develop an adapted heuristic algorithm in order to allow the scaling and to take into account a decentralized environment. Note that it is a very rewarding work since mathematical programming provides new tools for networking applications but networking area provides new theoretical challenges to mathematical programming community.

The third activity grown from the fusion of two former LRI teams named Networks and GraphComb five years ago. It was a great opportunity to join Networking and Mathematical Programming expertises in order to develop the activity Optimization for networks. Such collaboration allowed us to investigate many networks-specific problems by taking advantage of the mathematical programming methodology such as: energy-efficient downlink resource allocation in heterogeneous OFDMA (Orthogonal Frequency Division Multiple Access) networks, energy savings in multi-hop wireless networks, smart charging for long trip of electrical vehicles on highways, and mobile multimedia services. It is worth noting that our main objective is to develop novel theoretical and practical research results which follow the new technologies' evolutions and revolutions. A prime example consists in the development of several research activities whose applications are directly related to the Internet of Things (IoT) paradigm.

The originality and the distinctive feature of our research works resides in systematically aiming to optimize performances for each activity. Those performances can be formulated by different metrics which can be considered separately or simultaneously (that implies an additional difficulty in using or adapting the optimization methods). Among the metrics considered, we can mention the cost (in terms of energy, deployment, etc.), the radio resources, the quality of service, the robustness, or even the security. In addition, concerning the performance evaluation, we usually implement models using mathematical programming tools. Those models are more or less complex (classical linear program, non

linear and non convex mixed integer program, bi-level program) and provide optimal solutions (exact solutions) which are usually non tractable in practice. Nevertheless, such solutions enable to develop effective (in terms of CPU time and very close to the theoretical optimum) low-complexity heuristics. They are especially designed for each application scenario and adapted for practical and large scale system deployments. Moreover, since real-world applications usually imply that the input parameters are not fully or perfectly known at the time the decisions have to be made, we also consider uncertainty in our models by the use of stochastic programming or robust programming.

Finally, besides the theoretical studies we usually analyse the solutions performance through extensive simulations. The ROCS team has developed a solid expertise in developing specialized software (in particular using Network Simulator, Matlab or OPNET) including advanced network, MAC (Medium Access Control) and physical layers features of 4G/5G and ad hoc systems. Some of our developments are also implemented in real-world testbed experiments (such as the drones platform developed by the team).

Bilan quantitatif des publications de l'équipe

- Articles de revues internationale: 36, autres: 23
- Article de conférences internationales: 40, autres: 48
- Édition de livres: 1
- Chapitres de livres: 3

5 publications majeures

- Kai Yang, Steven Martin, Dominique Quadri, Jinsong Wu, Gang Feng: Energy-Efficient Downlink Resource Allocation in Heterogeneous OFDMA Networks. IEEE Trans. Vehicular Technology 66(6): 5086-5098 (2017)
- Guangyu Li, Lila Boukhatem, Jinsong Wu: Adaptive Quality-of-Service-Based Routing for Vehicular Ad Hoc Networks With Ant Colony Optimization. IEEE Trans. Vehicular Technology 66(4): 3249-3264 (2017)
- Abdel Lisser, Immanuel Bomze, Jianqiang Cheng and Peter J. C. Dickinson: A fresh CP look at mixed-binary QPs: new formulations and relaxations. Mathematical Programming Serie A 166(1-2): 159-184 (2017)
- Dominique Quadri, Eric Soutil: Reformulation and solution approach for non-separable integer quadratic programs. JORS 66(8): 1270-1280 (2015)
- Céline Gicquel, Jianqiang Cheng: A joint chance-constrained programming approach for the single-item capacitated lot-sizing problem with stochastic demand. Annals OR 264(1-2): 123-155 (2018)

5 (max) documents majeurs (autres que publications)

- Khaldoun Al Agha and Daniel Etiemble: Introduction to Internet of Things. Techniques de l'ingénieur (2018)
- Khaldoun Al Agha, Guy Pujolle and Tara Yahiya: Mobile and Wireless Networks, Wiley - ISTE (2016)
- Khaldoun Al Agha: Déglobaliser Internet, Journal Le Monde (2015)

5 (max) faits illustrant le rayonnement ou l'attractivité académique

- Lila BOUKATHEM has very strong results on her Vehicular Ad Hoc Networks expertise leading up to the publication in the prestigious review IEEE Trans. Vehicular Technology (2017)
- Steven MARTIN and Dominique QUADRI have theoretical and practical results in OFDMA networks joining networking and mathematical programming expertises leading up to the publication in the prestigious review IEEE Trans. Vehicular Technology (2017)
- The research leaded by Dominique QUADRI in non convex non linear programming have involved publications in JORS revues (2015) after SIAM revue on the prolongation of the subject
- Quan VU received the ROADEF master student prize, under the direction of Céline GICQUEL (2016)
- Lila BOUKATHEM received the Canon Foundation Fellowship, 2015

5 (max) faits illustrant les interactions de l'équipe avec son environnement socio-économique ou culturel

- K. Al Agha has created Green Communications
- S. MARTIN : maturation project SATT LUTECH
- 2 licences (brevets) are ongoing deposited by S. Martin, A. Laube, D. Quadri, K. Al Agha and G. Pujolle. The first one is named "Procédé de routage énergétique dans les réseaux sans fil " and the second one "Traffic unification in wild networks"
- Steven MARTIN has co-funded the Master "en apprentissage" ISD (Informatique pour la Science des Données)
- Steven MARTIN and Dominique QUADRI collaborate with EDF and Sodetrel since 2016 on electrical vehicles issue (an ANR project has been submitted and is now in Phase 2)

Principales contributions de l'équipe à des actions de formation

- Vice-Présidence enseignement du département informatique de la faculté des sciences d'Orsay, université Paris-Sud

- Co-création du Master en apprentissage ISD (Informatique pour la Science des Données), université Paris-Saclay
- Co-création de la double licence sélective Info-Maths, université Paris-Sud
- Co-création du magistère d'informatique, université Paris-Sud
- Responsabilité du Master I Informatique (site d'Orsay), université Paris-Saclay

Research Group Members and evolution since 2013

The team ROCS is directed by Steven Martin (from June 2013 to January 2018), aside with Dominique Quadri as co-director (from June 2013 to January 2018). From January 2018 ROCS is directed by Dominique Quadri, aside with Lila Boukhatem as co-director.

Permanent Members (June, 2018)				
Name	*First name*	*Position*	*Institution*	*Remarks*
AL AGHA	Khaldoun	PR	Univ. Paris-Sud	On leave from 2014 to 2017
ALI-YAHIYA	Tara	MCF	IUT d'Orsay	On leave at the Irankian University since Sept. 2014
BOUKHATEM	Lila	MCF HDR	Univ. Paris-Sud	
GICQUEL	Céline	MCF	IUT d'Orsay	
LISSER	Abdel	PR	Univ. Paris-Sud	
MARTIN	Steven	PR	Univ. Paris-Sud	
QUADRI	Dominique	MCF HDR	Univ. Paris-Sud	

PhD Students (June, 2018)				
Name	*First name*	*Funding*	*Institution*	*Remarks*
BOULOS	Karen	ETR	Co-tutelle Univ. Paris Saclay and USJB Liban	
DIRATIE	Eyassu Dilla	CIFRE	Univ. Paris Saclay	
HA	Duc Thang	Alloc. Ministérielle	Univ. Paris Saclay	
LAHAD	Bachir	ETR	Co-tutelle Univ. Paris Saclay and USJB Liban	
NIZARD	David	CIFRE	Univ. Paris-Sud	
PENG	Shen	CIFRE	Univ. Paris-Sud	
QUEZADA	Franco	Alloc. Ministérielle	Paris 6	
SHRIT	Omar	Alloc. Ministérielle	Univ. Paris-Saclay	

Post-Doc & Engineers (June, 2018)				
Name	*First name*	*Position*	*Institution*	*Remarks*
ADOUANE	Amine	Post-doc	Univ. Paris-Sud	
KADRI	Ahmed	Post-doc	Univ. Paris-Sud	
LAUBE	Alexandre	Post-doc	Univ. Paris-Sud	
NGUEYEN-THANH	Nhan	Post-doc	Univ. Paris-Sud	
NOURA	Hassan	Post-doc	Univ. Paris-Sud	
ZEMA	Nicola Roberto	Post-doc	Univ. Paris-Sud	

Associate members (June, 2018)				
Name	*First name*	*Position*	*Institution*	*Remarks*
AIT SAADI	Nadjib	Researcher	ESIEE Paris	
CAVALLARI	Nicolas	Research Engineer	Green Comm.	
CLAVEIROLE	Thomas	Research Engineer	Green Comm.	
GAWEDZKI	Ignacy	Research Engineer	Green Comm.	
GORGE	Agnès	Researcher	EDF	
KHAWAM	Kinda	Associate Professor	UVSQ	
LAOUITI	Anis	Associate Professor	Telecom SudParis	
LETOURNEL	Marc	Associate Professor of Mathematics	Orsay	
MARINCA	Dana	Associate Professor	UVSQ	

Group evolution

Steven MARTIN got the full professor position at the Paris Sud university. He was before assistant professor at the same university. Dominique Quadri obtained the Habilitation à Diriger des Recherches (HDR). Tara ALI-YAHIYA is on leave ("détachement") at the Irakian university since September 2014 and Khaldoun AL AGHA has came back (he was on leave at Green Communication up to September 2017) to LRI.
We did not get assistant professor position from 2013 to 2017.

9/ ROCS

Research Description

ROCS team members conduct research on the following activities: (1) **Networking**, (2) **Deterministic and stochastic combinatorial optimization**, (3) **Optimization for networks**. The third activity grown from the fusion of two former LRI teams named Networks and GraphComb five years ago. It was a great opportunity to join Network and Mathematical Programming expertise in order to develop the activity Optimization for networks. Such opportunity allowed us to address many networking problems by leveraging mathematical programming methodology such as: energy-efficient downlink resource allocation in heterogeneous orthogonal frequency division multiple access (OFDMA) networks, energy savings in multi-hop wireless networks, smart charging for long trip of electrical vehicles on highways, and mobile multimedia services.

Our key objective is to develop novel theoretical and practical research results which follow the new technologies' evolutions and revolutions. A prime example consists in the development of several research activities which applications are directly related to **Internet of Things** (**IoT**) paradigm.

The originality and the distinctive feature of our research is that we systematically aim to optimize the performance for each activity. This performance can be formulated by different metrics which can be considered separately or simultaneously (that implies an additional difficulty in using or adapting the optimization methods). Among those metrics, we can mention the cost (in terms of energy, complexity, signaling, deployment), the radio resources, the quality of service, the robustness, the security, etc. In addition, concerning the performance evaluation, we usually implement models using mathematical programming tools. Those models are more or less complex (classical linear program, non linear and non convex mixed integer program, bi-level program) and provide optimal solutions (exact solutions) which are usually non tractable in practice. Nevertheless, such solutions guide us to develop effective (in terms of CPU time and very close to the theoretical optimum) low-complexity heuristics especially designed for each application scenario and adapted for practical and large scale system deployments. Moreover, since real-world applications usually imply that some of the input parameters are not perfectly known at the time the decisions have to be made, we also consider uncertainty in our models by the use of stochastic programming or robust programming.

Finally, besides the theoretical studies we usually analyse the solutions performance through extensive simulations. Several researchers of ROCS team have developed a solid expertise in developing specialized softwares (in particular using NS, Matlab or OPNET simulators) including advanced network, MAC (Medium Access Control) and physical layers features of 4G and 5G systems. Some of our developments are also implemented in real-world testbed experiments such as the drones platform developed by some team researchers.

In the following, we give a detailed description of our research works organized in three complementary activities.

Networks

In this activity, the team members address problems related to several types of networks (operated or multi-hop wireless networks) such as 4G, 5G, heterogeneous networks or vehicular adhoc networks. More specifically, we developed new solutions for optimizing several networking features such as routing, energy, resource allocation and interference. These solutions lead to the definition of original algorithms that achieve high performance while being aware of practical system implementation constraints. We adopted a systematic approach based on both theoretical proofs (performance evaluation, convergence, mathematical bounds, etc.) for simplified models and scenarios, and extensive simulations to capture the effect of the numerous performance parameters (scalability, system dynamics, mobility behaviors, etc.) in the case of more complex scenarios.

5G - Fifth generation communications system. An important aspect of our research works in this activity concerns the new developments in the fifth generation (5G) communications system. 5G system is expected to support the ever-increasing demands for mobile data traffic thanks to the combination of several breakthroughs and technological advances such as small-cell deployments, intelligent multi-antenna, and cloud computing abilities. More specifically, the team addressed several resource allocation issues in Cloud Radio Access Networks (CRANs). In CRAN, all Baseband Units (BBUs) are shifted into the cloud to constitute a centralized processing pool. The radiofrequency signals from geographically distributed antennas are collected by Remote Radio Heads (RRHs) and transmitted to the cloud platform through fronthaul links. This centralized architecture enables a global optimization of joint baseband signal processing and radio resource management functions for all RRHs and users. However, such benefits come at the expense of large bandwidth demands on fronthaul links, as well as significant computational complexity burden at the BBUs side. In this context, the team investigated the joint beamforming and clustering (user-to-RRH association) issue for downlink CRAN to solve the sum-rate maximization problem under fronthaul link capacity and per-RRH power constraints. The main objective is to examine and analyze the trade-off between system throughput and the incurred costs in terms of complexity and signaling overhead, including the impact of imperfect Channel State Information (CSI). Almost many research works addressed the beamforming and clustering issues, very few have analyzed and dealt with the induced signaling burden. For this purpose, we developed a class of hybrid algorithms which periodically activate dynamic and static clustering strategies to manage the allocation process over time. The proposed algorithms are proven to be able to balance between the optimality of the beamforming and association solutions while being aware of practical system constraints (complexity and signaling overhead as well as the mobility behavior of users). Furthermore, we present an analytical analysis of major cost metrics for the proposed and reference dynamic algorithms. The proposed algorithms are proven to reduce significantly the complexity and signaling costs while approaching the performance of the optimal solution. In more recent works, we extend the user clustering and beamforming problem to cloud Edge Computing (EC) such as Mobile Edge Computing (MEC) and Fog Computing (FogRANs). Edge Computing is the new trend in 5G system that pushes mobile computing, system control and storage to the network edges. Toward this end, Edge Nodes (Edge Base Stations) are equipped with more functionalities compared to RRHs, e.g., computing and caching capabilities. Such architecture helps in alleviating the burden on fronthaul links and meeting the stringent delay requirements of edge users, but at the cost of lower network-wide optimality. In this context, we investigate hybrid solutions that provide an optimized tradeoff between the centralized feature of the cloud for globally-optimized functions (such as user clustering) and the distributed nature of Edge Nodes for local physical layer functions (such as beamforming requiring high quality CSIs).

Heterogeneous Networks. Modern cellular networks have drastically changed with the emergence of Long Term Evolution Advanced (LTE-A) technology. Homogeneous networks which were initially designed for voice-centric and low data rates face unprecedented challenges for meeting the increasing traffic demands of high data-driven applications and their important quality of service requirements. Therefore, these networks moved towards the so called Heterogeneous Networks (HetNets). HetNets represent a new

paradigm for cellular networks as their nodes have different characteristics such as transmission power and radio frequency coverage area. Consequently, a HetNet shows completely different interference characteristics compared to homogeneous deployment mostly due to the potential spectrum frequency reuse by the involved tiers. Hence, developing efficient inter-cell interference coordination (ICIC) and mitigation solutions in co-channel deployments of HetNets is a challenging issue. The research works developed by the team members focused on LTE-A OFDMA-based HetNets.

A first set of works aimed at investigating the inter-tier interference issue in two deployment cases, namely Macro-Femtocells and Macro-Picocells. We proposed new practical an dynamic power adjustment solutions for managing the inter-cell interference for both cases. The originality of the adopted approach mainly resides in the awareness of mobility of users and the low implementation complexity suitable for practical systems. In the first part dedicated to Femtocells and Macrocell (MBS) coexistence, we proposed new cooperative and context-aware interference mitigation methods which are derived for realistic scenarios involving mobility of users and their varying locations. In the second part of the studies dedicated to Macro-Picocells coexistence, we paid a special attention to the interference management in the situation where Picocells are configured to set up a cell range expansion. We suggested a MBS-assisted collaborative scheme powered by an analytical model to predict the mobility of Macrocell users passing through the cell range expansion area of the picocell. Simulation results obtained for both HetNets scenarios illustrated significant gain in the cell-edge throughput, a better guaranteed quality of service for the different ongoing applications in the different adjacent tiers, and finally a gain in the capacity of the whole system.

In a second set of works, we stressed on two techniques considered as key methods for ICIC, namely resource block (RB) allocations and power control in the downlink. We pushed further our study by considering both scheduling and power control while focusing on energy efficient methods. Concerning RB allocation, a fully decentralized algorithm based on replicator dynamics was put forward to attain the pure Nash Equilibrium of the ICIC potential game. We also portrayed the RB allocation problem as a congestion game where a fully distributed algorithm is tailored to reach the pure Nash equilibriums of the modeled game. Finally we had recourse to reinforcement learning through the EXP3 algorithm to propose efficient RB allocation. Concerning power control, we proposed centralized and decentralized methods for our devised power control schemes: centralized methods through convex optimization, and decentralized methods based on non-cooperative game theory. Furthermore, we proposed many heuristics that have the advantage of being fast, stable, and based on signaling messages already existing in the system. When we joint RB allocation and Power Allocation, the power control and RB allocation problems have a notable impact on the association of mobile users with their servicing Base Station. Therefore we formulated a global problem encompassing power control, radio resources allocation, and control of users' association to a base station. These three sub-problems are treated iteratively until the convergence to an overall stable solution. The proof of convergence for the various algorithms is established and the in-depth simulations allow us to evaluate and compare quantitatively the performance, the energy efficiency, and convergence time of the proposed algorithms.

Vehicular Networks in Smart Cities. Vehicular ad hoc networks (VANETs) are able to supply scalable and cost-effective solutions for various applications in smart cities environments such as road safety, traffic efficiency and entertainments. However, developing multi-hop communications in VANET environments is a very challenging problem due to the rapid topology changes and frequent network disconnections, which lead to routing failure or inefficiency in traditional mobile ad hoc routing protocols. In this context, the team developed a novel class of routing protocols which can account for specific characteristics of VANETs by using real-time QoS of road segments (namely connectivity probability, packet delivery ratio and delay) and relying on dynamic intersection-based best QoS route selection to cope with the scalability challenge in large-scale urban scenarios. The QoS routing is regarded as optimization problem which is solved using an ACO-based (Ant Colony Optimization) algorithm. Besides, by taking benefit from traffic information, such as vehicle density, vehicle speed and road length, we designed mathematical models to estimate real-time QoS (for 1-lane and 2-lane road scenarios) which provide accurate estimations of road segments QoS metrics used by the routing protocols. Other optimization mechanisms have been developed to decrease signaling overhead and reduce transmission delay. The team developed a simulation platform suitable for VANETs and evaluated the performance of the proposed protocols. The obtained results proved the effectiveness of the proposed solutions and the accuracy of the derived mathematical QoS models. A thorough analysis showed the better performance of our routing protocols in terms of overhead, delay and packet delivery ratio compared with reference routing protocols.

Deterministic and stochastic combinatorial optimization

Mathematical Programming (MP) is the use of mathematical models, particularly optimizing models, to assist in taking decisions. It is a very powerful tool in formulating, solving and analyzing real-world problems involving networks or production planning for instance. More precisely, the real-world applications imply the use of non-linear and non-convex programs with known parameters or unknown input. We face then deterministic or mathematical programs under uncertainty. It is well-known that such programs are very difficult to be solved in practice. In addition, traditional solvers (e.g. CPLEX) do not propose a solution method since many algorithms are based on the evaluation of the LP-relaxation of the integer initial program. We then have to implement ourselves tailored solution methods (exact solution methods or heuristics) in order to provide a solution (exact or approximated) for the considered problem.

ROCS team works focusing on theoretical researches needed to provide efficient solution methods for non-linear and non-convex programs which model real-world applications such as energy saving in multi-hop networks, logistic, electrical vehicles, etc. Note that after the theoretical step, we implement our proposed algorithms with the ambition that they have to be tractable for real-world instances. In this way, we usually provide decision aiding tools adapted to the specific industrial problem.

Deterministic combinatorial optimization. We have studied non convex quadratic 0-1 programs, non convex quadratic mixed integer programs and fractional non convex mixed integer programs. For each case the LP-relaxation of the initial problem can not be calculated by a solver since the problem is not convex. Our particularity consists in proposing to reformulate each initial non convex program into an equivalent convex one. The reformulations are based on a study of the structure of the initial problem (feasible solution set, nature of the variables) in order to compute a tight upper bound at a first step and convex hull when it is possible. Our reformulations utilize piecewise linearization, tangent linearization for instance. In addition our objective is to suggest a solution method tractable in practice. For example, concerning integer quadratic programming we are able to exactly solve instances up to 200 variables and constraints. We outperforms state of art techniques since our approach is based on the computation of very tight upper bounds and feasible solution before reformulating the initial problem which implies a branch-and-bound algorithm which develops very few nodes.

Stochastic combinatorial optimization. In many real-world optimization problems, some of the input parameters are not perfectly known at the time the decisions have to be made. Part of the work carried out in the team was devoted to develop stochastic programming approaches to model and solve combinatorial optimization problems involving uncertainty. Stochastic programming relies on the fact that even if the exact value of the problem parameters cannot be perfectly known at the time the decision has to be made, some knowledge about their possible values is available in the form of a probability distribution. The basic idea is thus to take advantage of this knowledge to somehow identify the best possible decision to be made.
We first focused on single-stage stochastic models where all decisions have to be made before the actual realization of the random events. In this case, we cannot ensure that our decision will result in a solution complying with all the constraints of the problem. One possibility to deal with this difficulty is to introduce in the problem formulation chance constraints which will ensure that the possible violated constraints will hold with a certain probability. We investigated joint chance-constrained formulations for two applied optimization problems: a call center workforce scheduling problem under uncertain call arrival rates and a lot-sizing problem under stochastic demand. For both problems, we exploited specific features of the probability distributions of the random parameters to reformulate the problem as a large-size mixed-integer linear program and solved it efficiently with a mathematical programming solver.
Our ongoing work is related to multi-stage stochastic models in which the possibility of using some recourse actions after the realization of the random events is explicitly exploited. In this case, first-stage decisions consist of all decisions that have to be made before any further information on the random parameters is revealed whereas further (second-stage, third-stage, etc.) decisions are allowed to be taken as a function of this information. This type of model usually relies on scenario trees to represent the uncertainty and leads to the formulation of very large size mathematical programs. We are currently seeking to develop multi-stage stochastic programming approaches for two optimization problems arising from industrial engineering applications: a production planning problem for remanufacturing end-of-life industrial products and a facility location problem for deploying electric vehicle recharging stations.

Optimization for Networks

We present in this part some specific networking problems solved by the use of a mathematical programming methodology.

Fractional mixed integer programming for OFDMA networks. We investigate energy-efficient downlink resource allocation in heterogeneous OFDMA networks, and formulate the energy efficiency (EE) maximization problem as a mixed-integer nonlinear fractional programming (MINLFP) problem with a nonconcave nonlinear objective function and nonlinear constraints. By means of fractional programming and changing of variables, we transform the original MINLFP problem into an equivalent optimization problem in a parametric subtractive form, which is proved to be a concave mixed-integer nonlinear programing (MINLP) problem and is optimally solved by using Dinkelbach and branch-and-bound (BB) methods. In BB method, the concave MINLP problem is relaxed to a series of concave nonlinear programming problems and solved by the use of Powell-Hestenes-Rockafellar augmented Lagrangian (PHR-AL) method. The optimal solution can be used to benchmark the performance of suboptimal solutions. As the computational complexity of BB method increases exponentially with problem size, we further develop a suboptimal two-step scheme, which first allocates the resource blocks and then performs the transmit power control to give suboptimal solution with much lower complexity. Simulation results demonstrate the effectiveness of the proposed schemes and show that the proposed suboptimal two-step scheme is promising for practical applications as it makes a good tradeoff between EE performance and computational complexity.

Optimal Flow Aggregation for Global Energy Savings in Multi-hop Wireless Networks. Today, regardless of economic or environmental incentives, reducing energy consumption is of great importance when designing IT systems. In a multi-hop wireless network, taking into account energy usually consists in maximizing the lifetime of the network by uniformly distributing the traffic all over the nodes. In this work, we propose a new routing paradigm which aggregates flows on a minimum number of nodes to maximize the number of nodes that can be turned off in the network. In this way, we intend to significantly reduce global energy consumption. To maintain the same quality of service while keeping the same network capacity, we combine flow aggregation with network coding. Our approach is particularly effective, in part because aggregation increases coding opportunities, as proven by simulation in terms of global energy savings and network load compared to conventional routing algorithms.

Smart charging for electrical vehicles on highways. Electric vehicles (EVs) can contribute to reduce carbon emissions and facilitate renewable integration. However, EVs are not competitive with fuel-based vehicles, particularly for long distances, because of their limited range and long charging times. More specifically, we aim to build a decision aiding tool addressed both to the electrical provider and the users. This tool has to control the power required by the charging stations. A key step of our work consists in taking into account both the energy provider and the numerous user of VEs. We then propose the use of mathematical programming with equilibrium constraints (MPEC) which is to the best of our knowledge the only mathematical tool which can consider two different types of decision agents. MPEC are strongly non linear and non convex programs. It is well-known that they are very difficult to be solved in practice even if decision variables are real. In our context, decision variables are mixed integer variables. Classical reformulations (as complementary constraints can not be used). We have then proposed as a first step to solve the bi-level program by evaluating the solution of the lower level which is then injected at the upper level. For sure, it is very time consuming method but it is an interesting starting point providing a benchmark for future solution methods we develop. Those future techniques will be based on the mathematical study of the structure of the solution area which should help us to reformulate the initial bi-level program into a one level program.

Team Organisation

Team Organisation

The full team (permanent researchers, associate researchers, PhD students, post-doctorant, engineers and master research) meets four times per year for a whole day. A significant part of the weekly meetings is focused on scientific presentations and discussions. The other part is devoted to organizational issues and team-specific decisions: budget, conferences, project submissions, proposal for internships, PhD positions, etc. In addition, team members hold regular meetings for each activity. There are many collaborations between team members and doctoral students are usually co-directed or co-supervised.

Self Assessment

Strengths: The ROCS team tackles a number of current research issues by forging links and interactions among its members, and offering original theoretical and practical solutions tailored to real-world applications for its industry partners. A wide range of topics is covered in the Networking and Mathematical Programming fields. Thanks to all the achievements and collaborations between the former members of the networking and optimization groups, the creation of ROCS team was a real successful initiative. In addition, the topics actually developed by the team attract a growing number of doctoral and master's students, which is one of the main ways to link research to education. Finally, all members of the team actively publish their research results in leading international conferences and journals and maintain strong and ongoing national and international collaborations. They also develop and maintain strong and fruitful contacts with industrial partners.

Building on its results over the past period, the ROCS team would like to extend and enrich its work by collaborating with LAHDAK team expert in Data & Knowledge in order to respond more broadly to the entire IoT value chain, incorporating expertise in massive and heterogeneous data. Indeed, the ROCS members have been developing for several years now many activities related to the IoT paradigm and are willing to increase and strengthen these activities for the next years. We would then propose an innovative scientific project bringing together, the expertise of researchers in networks, optimization and data & knowledge.

Although the Communication activity is present in the Saclay area (Telecom ParisTech, INRIA Saclay, L2S Laboratory) and at a wider region (e.g. UVSQ, UPMC), our distinctive features in terms of methodology, innovation and IoT-oriented research are unique.

Lastly, the Applications activity has expertise in non-linear and non-convex optimization, particularly applied to network problems, which are only found in France at ENSTA (Saclay) and at the University of Bordeaux.

Weaknesses: Considering all the recent changes and reorganizations operated at Paris-Saclay University as well as at a larger national level, it is important for us to restructure our activities to maintain and sustain our attractivity and visibility. This is why we are highly motivated in leading the IoT project.

Opportunities: We strongly collaborate with Saclay researchers such as INRIA Saclay, UVSQ, Telecom Sud-Paris. The future reorganization is a great opportunity for the team to significantly develop research on IoT, building on the results obtained in recent years. The ROCS team presents a strong expertise in Communications (Networks) and Applications (Mathematical Programming and Combinatorial Optimization) but we miss expertise on Data & Knowledge, which constitutes a component in the IoT value chain. These skills are within an other LRI team and a future collaboration would provide a great opportunity to offer innovative and effective solutions, in connection with our various academic and industrial partners.

Threats: Several team members have strong administrative responsibilities (e.g. head of the computer science department). Apart from the promotion of the team leader (Steven Martin) in 2014, there has been no recruitment for 5 years. An associate professor has been on leave since 2014. A full professor was on leave for four years as part of a start-up project.The team needs more support to reinforce the team's efforts over the past five years to develop strong lines in promising areas.

9/ ROCS

Strategy and five-year project

As previously mentioned in the presentation of ROCS team's research activities, we have particularly developed, the last 5 years, the activity Optimization for networks while maintaining our efforts to be innovative in both Networking and Optimization activities. More precisely, we have focused on Optimization Networks addressing Internet of Things (IoT) derived applications (for instance, smart charging of electrical vehicles, revers logistics, fleet of drones for industry 4.0 (surveillance video), data analysis for video platforms). **IoT**, as 5G systems before, has been recognized to be a strategic driving force of mobile telecommunications toward 2020.

IoT transforms every "thing" into a smart thing. Nowadays, we often speak of smart buildings, smart firms, smart cities, smart grids. Indeed, a lot of things are connected through sensors which provide many

informations and data about the things, via connection to Internet. More precisely, the revolution of IoT consists in possible communication thing to thing, because, the things are connected and smart. They are able to communicate via networks to data analysis platform based on technologies such as Cloud. This revolution is often followed by Big Data area which provides the main source of expected massive data.The last market studies indicate the deployment of approximately 50 billion things connected to Internet by 2020. These things will generate a very large quantity of heterogeneous data which will be exchanged between the things themselves and worms of the processing centers lodged in Cloud. The data and their use are in the core of IoT, the system having to be able to generate, starting from the multitude of heterogeneous and incomplete data, of interpretable information and knowledge which will make it possible to enrich the uses and to consider new ones.

Many applications, in various fields, are planned right now to exploit the possibilities fully that offers IoT to react in real time with the environment, in particular the smart cities, (transport, energy, water, etc), the autonomous vehicles, industry 4.0 (in particular systems of type control), e-health, logistics, or the house automation. The world of IoT thus generates a large number of complex problems of optimization, in particular in terms of use of the resources and improvement of the performance of the tools and the techniques. This concept of optimization (combinatorics, mathematical programming, problem of satisfaction of constraints, programming by constraints) is crucial and transverse with the chain of value of IoT, integrating the aspects of communication, application, storage and data processing.

Several scientific challenges are to be raised to answer the whole of the needs and constraints imposed in this complex environment. First of all, the data, once collected, must be communicated efficiently via various technologies of communication available. In the processing centers, these massive data resulting from various sources are difficult to manage because of their heterogeneity, then posing problems of representation, treatment, exploration, analysis and storage. The scaling up and the distributed point of view constitute another challenge of size which it will be necessary to record by various faces (communication, processing data, optimization, etc). The fact of passing to distributed poses algorithmic problems, embarked solutions, of real time or of compression of the models.

We then aim working in the five years on **IoT** through three activities namely, **communication**, **optimization** and **applications**. It is important to mention that we would like to pursue our working methodology which is the following. Our objective is still to optimize the performances on the whole of the value's chain of IoT. These performances can be declined according to different metric, which can be taken in a separate or cumulated way (what make more difficult the methods of optimization to be set up). Among these metric, we can cite the cost (energy, deployment...), the quality of service, the robustness, the quality of the data and knowledge, the security, ethic... These metric is transverse of the futur project team Internet of Things, just as the methods of optimization. Let us now briefly describe those three activities.

Communication. From the communication point of view, several scientific challenges are to be raised. Optimized mechanisms of communication must be developed in order to offer a connectivity targeted and adapted to different specificities and constraints from the applications IoT (intermittent or uninterrupted transmissions with periodic deactivations of the equipment, for example). These mechanisms must take account of the multiple often antagonistic constraints: real time, energy efficiency, mobility, reliability, security. Several technological tracks are already considered such as the systems with low energy consumption and long range (Sigfox, LoRaWAN, Nb-IoT, LTE-M, 5G). Our objective, in this context, is to develop new solutions and protocols which will make it possible efficiently to meet the need for heterogeneity of IoT connectivity. With this intention, we plan to adopt an approach of centralized and omniscient, allowing in certain cases to derive the global optimum and of the theoretical bounds, but so decentralized optimization when the scaling up and the complexity of the system impose it.

The infrastructure which must be made to support the data processing must be able to fund the resources (of storage, communication, energy, treatment, analyzes, etc) in a flexible and effective way. To face to the problem of latency and to increase the reactivity necessary to the applications IoT real time, the last architectural trends recommend the decentralization of the cloud by integrating the concepts of the Mobile Edge Computing (MEC) or Fog Computing which propose to push back the functions of storage and calculation of the data centers cloud towards the ends of the network. Thus, nodes of access (access point, intelligent footbridges) to strong capacities of computation and treatment are found closest to the information sources (IoT equipment). This proximity will give to the IoT equipment the opportunity of discharging their tasks from calculation and treatment accelerating the computing process thus and reducing their energy consumptions. We will be interested for example in the problem of optimal

placement of contents multimedia (caching) by using predictive approaches exploiting of the tools the such machine learning.

Optimization. We will pursue research on Optimization area required to solve efficiently combinatorial optimization problems involved by IoT. More precisely, we will work on two main axis: non linear integer optimization and combinatorial optimization under uncertainty. Indeed, in communication networks as in IoT, the objective functions of the models are non linear (logarithmic, fractional, exponential, cubic). In addition, a lot of data of the problems studied are not known which implies considering uncertainty of input of the models. That is why, we propose still develop algorithm especially designed for this type of problem, based on our knowledge on stochastic programming.

Applications. Among the applications aimed in the context of IoT, we can cite the inverse supply chain. It is a question for example of deciding quantity of used products to disassemble, components used to repair, new components to buy, or new products to reassemble. One of the major difficulties to make these decisions comes from the high degree of uncertainty on the data input of the problem. Indeed, the companies have only one weak control on the used quantity and product quality reported by the customers, for example. This thus makes particularly difficult the optimization of the production planning. IoT technology makes it possible to simplify the problem of optimization of planning thanks to the collect of information via sensors placed on containers which take delivery of the objects to be recycled. Another more and more developed service relates to the fast charging of the Electric Vehicles (EV). The objective consists in here developing a tool of decision-making aid for the operators of charging point, aiming at controlling the power called in the stations of charging in order to respect the power of connection or to answer specific instructions of crest lowering in the event of constraint on the network by taking account of the behavior and quality of service suggested with the users of VEs. A central point of this kind of study is the taking into explicit account of the interactions between the individual choices of EV in rolling/load (quality of service users) and the metric ones of the operators of the site of load (and of the electric distribution network). As for the inverse logistics problem, one of the difficulties to make these decisions also comes from the degree of uncertainty related to the data input of the problem. Difficulties which can be raised when charging station are IoT equipment, intelligent and connected. It will be very also interesting to treat these data, certainly dubious but which upstream will require to draw some from the knowledge adapted to with the dealt problem.

To realize our objectives, we plan to participate actively in the rich research and development programs, networks and initiatives with both academic and industrial partners at the national, European and international levels to promote research and technology transfer. We will strengthen our active actions and collaborations we already initiated within several programs such as EIT ICT-Labs, competitiveness clusters, ANR, IRT SystemX, Labex, Idex, etc. Finally, to participate to the effort of bringing scientific research to the service of education, we are actively investing the Paris-Saclay university project which integrates several higher education establishments. We aim to pursue our commitment in defining attractive and high-quality Master's offers. To realize our projects in IoT, and referring to our weak point in terms of researchers' number, we would need support from all concerned institutions for hiring new researchers, assistant/associate and full professors.

Annex 4

Collaborations

Participation to national and international collaborative research projects

International projects

- WIZARD (WIreless solutions for haZARD monitoring) : FEDER project with ADWAVE, INRIA, SIP, Telcom ParisTech
- Approxim@ction : EIT Digital project with Trento university, Torino university
- Citizen safety: EIT ICT Labs project with EADS, Siemens, Trento university, Twente university
- RENA : CNRS PICS international collaborative project with National Institue of Informatics (Tokyo)
- Eco-HetNet: PHC Sakura program with Kyoto university
- NEWCOM: European network of excellence with CNRS, CNIT, AAU, IASA, ACAM, OULU
- Secure VANETs for intelligent transportation syts.: CONICYT-IRD with Chili and Brasil

National projects

- Performance Evaluation of LPWAN in IoT: Digicosme project with INRIA Saclay
- Learning and prediction for content popularity in 5G MEC: Digicosme project with UVSQ
- CMN : Systematic FUI21 project with AIRBUS, Green, Page Up, SAGEM
- RESPET: ANR with INRIA Lille-Nord Europe, Univ. Avignon, DHL
- LotRelax: ANR Jeune Chercheur
- E-bison futé de la recharge : PGMO project
- Stochastic programming approaches for call center shift scheduling: Digiteo project
- Lot-sizing under energy and environmental constraints: Région de Lorraine funding
- Stochastic programming approaches for planning remanufacturing activities under uncertain demand and returns forecast : PGMO project
- Location of recharging stations for electric vehicles under uncertainty: United Arab Emirates University funding
- Energy-efficient production planning: models and algorithms: PGMO project

Collaborations with other laboratories leading to joint publications

International collaborations

- Kyoto University, Japon
- National Institue of Informatics (Tokyo), Japon
- Arizona University, USA
- United Arab Emirates University, UAE
- Beijing Institute of Technology, Beijing, China

National collaborations

- INRIA Saclay
- LGI, Central Supelec
- CEDRIC, Cnam Paris
- LIP6, Univ. Sorbonne
- LIA, Univ. Avignon
- LORIA, Univ. Lorraine
- LIMOS-CMP Ecole des Mines de Saint Etienne
- Polytechnique de Grenoble
- Telecom Sud Paris
- Telecom ParisTech

Visiting professors and students (more than one week)

- Megumi KANEKO (Kyoto University, Japon)
- Nilay NOYAN (SABANCI University, Turkey)
- Samer LAHOUD (USJ, Liban)
- Lawrence YEUNG (Hoing Kong University)
- Jinsing WU (Santiago University, Chile)
- Gang FENG (Chengdu University, China)
- Walter GROTE (Valparaiso University, Chile)

Other Collaborations

- SABANCI University, Turkey

Group seminar

Member of the executif comitee Labex Digicosme, Seminar PGMO

Participation to national and international networks

- EIT ICT Labs, Steven MARTIN, coordinateur européen 2010-2014
- NEWCOM , European Network of Excellence, Lila BOUKATHEM 2013-2015
- Réseau d'excellence européen, Steven MARTIN 2012-2015
- HYCON 2 , European Network of Excellence, Lila BOUKATHEM 2010-2014
- ROADEF, Céline GICQUEL, responsable communication 2018-2021

Volunteer Professional Service

Management Positions in Scientific Organisations

- Membre du réseau d'excellence europén NEWCOM, Lila BOUKATHEM, Steven MARTIN, (2012-2015)
- Coordinateur européen de 'activité "citizen safety" au sein de l'EIT ICT Labs, Steven MARTIN, (2011-2014)
- Co-responsable de l'un des trois axes de recherche prioritaire Digicosme, Steven MARTIN (depuis 2015)
- Membre du comité exécutif du Labex Digicosme, Steven MARTIN (depuis 2015)
- Membre du comité du pôle 2 de l'Ecole Doctorale STIC de l'Université Paris-Saclay, Lila BOUKATHEM (depuis 2014)
- Responsable de la communication pour la ROADEF, Céline GICQUEL (depuis 2017)

Organisation of Conferences and Scientific Events

- Spring School Digicosme, Gif Sur Yvette, 2017, Steven MARTIN, Organization
- IFIP NTMS, Paris, 2015, Steven MARTIN, president of the steering committee
- ROADEF, Marseille, 2015, Dominique QUADRI, steering committee
- IEEE VTC, Boston, 2015, Lila BOUKHATEM, steering committee
- CARI, Afrique du Sud, 2014, Lila BOUKHATEM, steering committee
- IEEE WCNC, Istanbul, 2014, Lila BOUKHATEM, steering committee
- IEEE Med-hoc-Net, Corsica, 2013, Steven MARTIN, president of the steering committee
- ODYSSEUS, Corsica,2015, Dominique QUADRI, organization
- EUROCSP, Paris, 2014, Dominique QUADRI, organization
- Summer school "Citizen safety", Trento, 2013, Steven MARTIN, organization

Honors

Awards

- Kinda Khawam, *Best Paper Awards IEEE conference on communication* (2015)
- Lila BOUKATHEM, *Prix Canon Foundation Fellowship* (2015)
- Céline GICQUEL, *Prix de la ROADEF du meilleur mémoire de Master pour son étudiant* (2017)

Keynote Addresses and invited talks

International

- Dominique QUADRI, *ISMP*, 2018 : Non linear and non convex programming
- Lila BOUKATHEM, *National Institute of Informatics, Tokyo*, 2017: Joint beamforming and user-to-cell clustering optimization for 5G C-RANs
- Steven MARTIN, *Beijing University Seminar*, 2017: Energy optimization in IoT
- Steven MARTIN, *UCLA seminar*, 2016: Drones networks: from theory to practice
- Steven MARTIN, *Stanford seminar*, 2015: Energy-aware routing protocols in wireless networks
- Lila BOUKATHEM, *Graduate School of Informatics in informatics, university of Kyoto*, 2014: Interference Mitigation in heterogeneous networks
- Steven MARTIN, *Valparaiso university seminar*, 2013: Mobility models for public safety

France

- Dominique QUADRI, *LIPN seminar*, 2017: Reformulation en programmation quadratique en variables mixtes
- Dominique QUADRI, *COSMOS day*, 2016: Un programme mathématique sous contrainte d'équilibre pour le e-commerce

Evaluation of Research

Editorial Boards

- Réseaux de drones revue, ISTE OpenScience, Steven MARTIN, 2017
- EURASIP Journal, Journal on Wireless Communications and Networks, Lila BOUKATHEM, 2015

Program Committees

Chair

- IFIP NTMS 2015: program committee chair (Steven MARTIN)
- MajecSTIC 2013 : program committee chair (Dominique QUADRI)
- IEE Med-hoc-Net 2013 : program committee chair (Steven MARTIN)

Member (international events)

- IEEE MedHocNet 2018 : Lila BOUKATHEM
- IFIP PEMWN 2016 : Steven MARTIN
- IEEE VTC 2015 : Lila BOUKATHEM
- IEEE WCNC 2014 : Steven MARTIN
- IEEE SaCoNet 2014: Steven MARTIN
- CARI 2014 : Lila BOUKATHEM
- IEEE WCNC 2014 : Lila BOUKATHEM
- IEEE MedHocNet 2013 : Lila BOUKATHEM
- IFIP WOCN 2013 : Lila BOUKATHEM
-

Member (national events)

- ROADEF 2015: Dominique QUADRI
- MajecSTIC 2013 : Dominique QUADRI

Evaluation Committees and Invited Expertise

- Appel à projet PRC CNRS 2017: Lila BOUKATHEM
- ANR 2017: Steven MARTIN
- Région Ile de France 2014: Dominique QUADRI
- Appel Post-doc de l'institu Mines-Telecom 2014: Lila BOUKATHEM
- Digicosme 2015, 2016, 2017 : Steven MARTIN

Other evaluation activities

- Reviewer for 15 PhD defenses: Steven MARTIN
- Reviewer for 10 PhD defenses: Lila BOUKATHEM
- Reviewer for 2 PhD defenses: Dominique QUADRI
- Examiner in the committee of 12 PhD defenses: Steven MARTIN (7 presidences of the committee)
- Examiner in the committee of 6 PhD defenses: Lila BOUKATHEM
- Examiner in the committee of 4 PhD defenses: Dominique QUADRI
- Hiring committees of assistant professor positions: Steven MARTIN (2013-2017)
- Hiring committees of assistant professor positions: Dominique QUADRI (2013-2017)

Interactions with the social, economic and cultural environment

Interaction with the economic environment

- 5 CIFRE PhD with Thales, EDF, AEMYS, Cityway, GreenCommunication
- Research projects with industrial (EDF, Sodetrel, SAGEM, ALTRAN, EADS, THALES, SIEMENS, AIRBUS)

Dissemination

- Khaldoun Al Agha and Daniel Etiemble: Introduction to Internet of Things. Techniques de l'ingénieur (2018)
- Khaldoun Al Agha, Guy Pujolle and Tara Yahiya: Mobile and Wireless Networks, Wiley - ISTE (2016)

Popularisation of Research Results

- Participation à la fête de la science depuis 2013
- Khaldoun Al Agha: Déglobaliser Internet, Journal Le Monde (2015)

Contracts and grants

Public contracts and grants (jan 2013 - jun 2018)							
Type	*Scientific director*	*Name*	*Managing Institution*		*Start / Duration*		*Amount*
FEDER	Steven Martin	WiZARD	Université Sud	Paris	01.2018	36	156
EIT Digital	Steven Martin	Approxim@ction	Université Sud	Paris	01.2018	12	120
Digicosme	Steven Martin	Perf. Eval. of LP-WAN in IoT	Université Sud	Paris	01.2018	12	50
CNRS PICS	Lila Boukhatem	RENA	Université Sud	Paris	10.2017	36	21
PGMO	Dominique Quadri	LMH-IROE	Université Sud	Paris	10.2017	24	7
PGMO	Céline Gicquel	LMH-PRMO1	Université Sud	Paris	10.2017	24	6
Digicosme	Steven Martin	Learning and Prediction in 5G MEC	Université Sud	Paris	09.2017	12	50
Systematic FUI	Steven Martin	CMN	Université Sud	Paris	10.2016	36	161
PGMO	Céline Gicquel	LMH-PRMO2	Université Sud	Paris	10.2016	24	4
PGMO	Dominique Quadri	LMH-PRMO	Université Sud	Paris	10.2015	24	6
SATT LUTECH	Steven Martin	SQUAD	Université Sud	Paris	01.2015	24	180
Digiteo	Abdel Lisser	SUN	Université Sud	Paris	10.2014	36	102.6
PHC Sakura program	Lila Boukhatem	Eco-HetNet	Université Sud	Paris	10.2013	24	16
European network of excellence	Lila Boukhatem	NEWCOM	Université Sud	Paris	10.2013	24	8
Digicosme	Céline Gicquel	SPACE	Université Sud	Paris	10.2012	36	102
EIT ICT Labs	Steven Martin	Citizen safety	Université Sud	Paris	10.2011	36	263
Systematic FUI	Steven Martin	SOAPS	Université Sud	Paris	10.2011	42	185
ANR	Céline Gicquel	LotRelax	Université Sud	Paris	10.2011	36	65
ANR	Dominique Quadri	RESPET	Université Sud	Paris	10.2011	48	35
CONICYT-IRD	Steven Martin	Secure VANETs for intelligent transp. syst.	Université Sud	Paris	09.2010	36	156
Digiteo	Steven Martin	COREPHY	Université Sud	Paris	09.2010	36	53

Private contracts and grants (jan 2013 - jun 2018)						
Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*		*Amount*
Industriel	Steven Martin	Thalès	CIFRE	05.2018	36	60
Industriel	Dominique Quadri	AEMYS	CIFRE	10.2017	36	25
Industriel	Steven Martin	EDF	CIFRE	12.2011	36	25
Industriel	Khaldoun Al Agha	TELECOM	CRE	10.2011	36	102
Industriel	Abdel Lisser	EDF	Contrat Rche	07.2010	36	4

Training and Education

Management of teaching programmes

- Président du département Informatique de l'UFR Sciences Univ. Paris-Sud, Steven MARTIN (depuis 2018)

- Vice-président enseignement du département Informatique de l'UFR Sciences Univ. Paris-Sud, Steven MARTIN (2014-2017)
- Responsable du M1 Informatique Paris Saclay (site d'Orsay), Dominique QUADRI (depuis 2014)
- Co-création du Master ISD (Informatique pour la science des données) en apprentissage, Steven MARTIN (2017)
- Co-création de la double licence sélective Info-Maths, université Paris-Sud, Steven MARTIN (2016)
- Co-création de du magistère d'informatique, université Paris-Sud, Steven MARTIN (2015)

Master Internships

- 2018 (3 mois): Mirwaisse DJANBAZ, Programme par contraintes pour stabiliser un vol de drones en triangle (Steven MARTIN et Dominique QUADRI)
- 2018 (3 mois): Anthony WOZNICA, Programme mathématique avec contrainte d'équilibre pour la recharge efficace de véhicules électriques (Dominique QUADRI)
- 2017 (4 mois) : Franco QUEZADA, Stochastic lot-sizing for planning remanufacturing activities (Céline GICQUEL)
- 2017 (4 mois): He GAO, Développement d'un module de simulation pour réseaux véhiculaires (Lila BOUKATHEM)
- 2017 (3 mois) : Romain PERROUAULT, Location of recharging stations for electric vehicles (Céline GICQUEL)
- 2017 (6 mois) : Omar SHRIT , Algorithmique distribuée pour vol de drones en formation (Steven MARTIN)
- 2016 (4 mois): Thibault FERET, Problème dual pour l'optimisation énergétique dans les réseaux sans fil (Steven MARTIN, Dominique QUADRI)
- 2016 (4 mois) : Quan VU, Stochastic lot-sizing for planning remanufacturing activitities (Céline GICQUEL)
- 2016 (4 mois): Hadjer TOUATI, Fedback overhead analysis in H-CRAN (Lila BOUKATHEM)
- 2016 (4 mois): Isaline FRANIATTE, Mise en place d'une plateforme de simulation réseaux Wi-Fi (Lila BOUKATHEM)
- 2016 (3 mois) : Félicien MUSHAMUKA, Stochastic international logistics network design (Céline GICQUEL)
- 2015 (6 mois): Duc Thang HA, Efficacité énergétique dans le contexte D2D (Lila BOUKATHEM, Steven MARTIN)
- 2015 (4 mois): Julen OLAZCUAGA, Développement d'un drone open source (Steven MARTIN)
- 2015 (4 mois): Alexandre PECHEREAU, Intégration d'un logiciel de contrôle/commande (Steven MARTIN)
- 2015 (3 mois): Gilles TADEI, Développement d'une solution de suivi de cible avec QR codes (Steven MARTIN)
- 2014 (6 mois): Alexandre LAUBE, Optimisation de la consommation énergétique dans les réseaux sans fil (Steven MARTIN, Dominique QUADRI)
- 2014 (3 mois) : Manel OUAJA, Stochastic production planning in reverse supply chains (Céline GICQUEL)
- 2013 (6 mois) : Valentin RIVIERE , Agrégation de trafic et codage réseau dans les réseaux sans fil (Steven MARTIN)
- 2013 (6 mois) : Florent FORTAT, Procédures d'évacuation dans les réseaux ad hoc (Steven MARTIN)
- 2013 (6 mois) : Bo WANG, Contrôle de puissance dans les réseaux LTE (Steven MARTIN)

Graduate Courses

- Master FIIL, Université Paris-Saclay, *Networks*: Steven MARTIN
- Master ACN, Université Paris-Saclay, *Autonomous Networks*: Lila BOUKATHEM
- Master CCN, Université Paris-Saclay, *C-RAN Networks*: Lila BOUKATHEM
- Master Optimization, Université Paris-Saclay, *Optimization non linéaire non convexe en variables mixtes*: Dominique QUADRI
- Master Optimization, Université Paris-Saclay, *Programmation linéaire en nombres entiers*: Céline GICQUEL
- M1 Informatique, Université Paris-Saclay, *Networks*: Steven MARTIN
- M1 Informatique, Université Paris-Saclay, *Réseaux sans fil et IoT*: Lila BOUKATHEM and Kaldhoun AL AGHA
- Master ISD, Université Paris-Saclay, *Modèles mathématiques*: Dominique QUADRI
- Master ISD, Université Paris-Saclay, *Réseaux sans fil*: Steven MARTIN
- M1 MIAGE, Université Paris-Saclay, *Réseaux et systèmes*: Lila BOUKATHEM

Schools

- Spring school Digicosme, Gif sur Yvette France 2017
- Summer school "Citizen safety", Trento Italy 2013

Other

- Membre du conseil de l'UFR Science de Paris-Sud, Steven MARTIN (2010-2014)
- Membre du conseil scientifique du LRI, Steven MARTIN, Dominique QUADRI (depuis 2013)
- Membre de la CCSU, Lila BOUKATHEM, Steven MARTIN (depuis 2010), Dominique QUADRI (depuis 2013)
- Membre du conseil doctoral de l'université Paris-Sud, Lila BOUKATHEM (2012-2014)
- Membre de la commission Locaux du LRI, Lila BOUKATHEM (depuis 2008)

Honors

- Quan VUL, *Prix de la ROADEF du meilleur mémoire de Master* directed by Céline GICQUEL (2017)

Thesis

Habilitation à Diriger des Recherches	
Name	*Defense*
Dominique QUADRI	07.2015
Kinda KHAWAM	09.2015
Megumi KANEKO	05.2017

Defended thesis				
Name	*Start*	*Defense*	*Funding*	*Advisor*
Jianqiang CHEN	01.10.2010	01.12.2013	ETR	Abdel LISSER
Mathilde EXCOFFIER	01.10.2013	01.10.2016	ANR	Steven MARTIN, Céline GICQUEL
Alexandre LAUBE	01.10.2014	01.10.2017	Alloc. Ministère	Steven MARTIN, Dominique QUADRI
Soran HUSSEIN	01.10.2011	08.12.2014	ETR	Steven MARTIN, Lila BOUKATHEM
Mouna KCHAOU-BELJEBEN	01.10.2011	08.12.2014	CIFRE	Céline GICQUEL, M. MINOUX
Guangyu LI	01.10.2010	01.10.2013	ETR	Lila BOUKATHEM
Reben KURDA	01.10.2012	01.12.2015	ETR	Lila BOUKATHEM

Position after the thesis	
Name	*Position*
Prenom NOM	Post-doc, où

Thesis in progress			
Name	*Start*	*Funding*	*Advisor*
Karen BOULOS	01.10.2017	ETR Co-tutelle	Steven MARTIN, Kinda khawam
Eyassu Dilla DIRATIE	01.02.2018	ETR	Khaldoun AL AGHA
Duc Thang HA	01.10.2015	Allocation ministérielle	Lila BOUKHATEM, Steven MARTIN
David NIZARD	01.04.2018	CIFRE	Steven MARTIN, Dominique QUADRI
Bachir LAHAD	01.10.2018	ETR Co-tutelle	Steven MARTIN, Kinda khawam
Shen PENG	01.10.2016	CIFRE	Abdel LISSER
Franco QUEZADA	01.10.2017	Allocation ministrérielle	Céline GICQUEL
Omar SHRIT	01.10.2017	Allocation ministérielle	Steven MARTIN

ROCS team publications (20 %)

Journal articles

Major international journals

(1) P. ADASME and A. Lisser. A Computational Study for Bilevel Quadratic Programs using Semidefinite Relaxations. *European Journal of Operational Research (EJOR)*, 254(1), 2016.

(2) Y. Benfattoum, S. Martin, and K. Al Agha. QoS for real-time reliable multicasting in wireless multi-hop networks using a Generation-Based Network Coding. *Computer Networks*, Apr. 2013.

(3) D. Feillet, T. Garaix, F. Lehuédé, O. Péton, and D. Quadri. A new consistent vehicle routing problem for the transportation of people with disabilities. *Networks*, 63(3):211–224, May 2014.

(4) S. Lahoud, K. Khawam, S. Martin, G. Feng, L. Zhewen, and J. Nasreddine. Energy-Efficient Joint Scheduling and Power Control in Multi-Cell Wireless Networks. *IEEE Journal on Selected Areas in Communications*, Sept. 2016.

(5) G. Li, L. Boukhatem, and W. Jinsong. Adaptive Quality of Service based Routing for Vehicular Ad hoc Networks with Ant Colony Optimization. *IEEE Transactions on Vehicular Technology*, 66(4):3249 – 3264, Apr. 2017.

(6) A. Lisser, I. Bomze, J. Cheng, P. J. C. Dickinson, and A. Lisser. A fresh CP look at mixed-binary QPs: new formulations and relaxations. *Mathematical Programming*, 166(1-2):159 – 184, Nov. 2017.

(7) A. Lisser, J. Cheng, E. Delage, and A. Lisser. Distributionally Robust Stochastic Knapsack Problem. *SIAM Journal on Optimization*, 24(3):1485 – 1506, Jan. 2014.

(8) D. Quadri and E. SOUTIL. Reformulation and solution approach for non-separable integer quadratic programs. *Journal of the Operational Research Society*, 66:1270–128, Jan. 2015.

(9) K. Yang, S. Martin, D. Quadri, W. Jinsong, and G. Feng. Energy-Efficient Downlink Resource Allocation in Heterogeneous OFDMA Networks. *IEEE Transactions on Vehicular Technology*, 66(6), June 2017.

Other journals

(10) M. Excoffier, C. Gicquel, and O. Jouini. A joint chance-constrained programming approach for call center workforce scheduling under uncertain call arrival forecasts. *Computers and Industrial Engineering*, 96:16–30, Mar. 2016.

(11) C. Gicquel and J. Cheng. A joint chance-constrained programming approach for the single-item capacitated lot-sizing problem with stochastic demand. *Annals of Operations Research*, 264(1-2):123 – 155, May 2018.

Conference articles

Major international conferences and workshops

(12) D. Quadri, A. Laube, S. Martin, K. Al Agha, and G. Pujolle. FAME: A Flow Aggregation MEtric for Shortest Path Routing Algorithms in Multi-Hop Wireless Networks. In *Wireless Communications and Networking Conference 2017* , San Francisco, United States, Mar. 2017. IEEE.

(13) O. Shrit, S. Martin, K. Al Agha, and G. Pujolle. A new approach to realize drone swarm using ad-hoc network. In *2017 16th Annual Mediterranean Ad Hoc Networking Workshop (Med-Hoc-Net)*, Budva, Montenegro, June 2017. IEEE.

(14) H. T.D., L. Boukhatem, M. Kaneko, and S. Martin. Performance-Cost Trade-off of Joint Beamforming and User Clustering in Cloud Radio Access Networks. In *IEEE PIMRC'17 - IEEE International Symposium on Personal, Indoor and Mobile Radio Communications* , Montreal, Canada, Oct. 2017. IEEE.

Other conferences and workshops

(15) A. Laube, S. Martin, and D. Quadri. Optimal Flow Aggregation for Global Energy Savings in Multi-hop Wireless Networks. In Springer, editor, *Ad-hoc, Mobile, and Wireless Networks*, volume 9724 of *Lecture Notes in Computer Science*, pages 124–137, Lille, France, July 2016. Springer.

Theses and habilitations

(16) M. Excoffier. *Chance-Constrained Programming Approaches for Staffing and Shift-Scheduling Problems with Uncertain Forecasts : application to Call Centers*. Theses, Université Paris Sud - Paris XI, Sept. 2015.

(17) S. Hussein. *Lightweight Security Solutions for LTE/LTE-A Networks*. Theses, Université Paris Sud - Paris XI, Dec. 2014.

(18) R. Kurda. *Les stratégies de coopération inter-cellules pour l'atténuation des interférences dans les systèmes OFDMA*. Theses, Université Paris Sud - Paris XI, Mar. 2015.

(19) A. Laube. *Traffic aggregation for global energy savings in multi-hop wireless networks*. Theses, Université Paris-Saclay, Sept. 2017.

(20) G. Y. Li. *Adaptive and Opportunistic QoS-based Routing Protocol in VANETs*. Theses, Université Paris Sud - Paris XI, July 2015.

(21) S. Medlej. *Scalable Trajectory Approach for ensuring deterministic guarantees in large networks*. Theses, Université Paris Sud - Paris XI, Sept. 2013.

(22) D. Quadri. *Programmation Mathématique en variables entières: théorie et applications*. Habilitation à diriger des recherches, Université Paris Sud (Paris 11), July 2015.

(23) C. Wang. *Variants of Deterministic and Stochastic Nonlinear Optimization Problems*. Theses, Université Paris Sud - Paris XI, Oct. 2014.

ROCS team publications (all)

Journal articles

Major international journals

(A1) P. ADASME, R. Castro De Andrade, M. Letournel, and A. Lisser. Stochastic maximum weight forest problem. *Networks*, 65(4):289–305, 2015.

(A2) P. ADASME and A. Lisser. Stochastic and semidefinite optimization for scheduling in orthogonal frequency division multiple access networks. *Journal of Scheduling*, 17(5):445 – 469, Oct. 2014.

(A3) P. ADASME and A. Lisser. A Computational Study for Bilevel Quadratic Programs using Semidefinite Relaxations. *European Journal of Operational Research (EJOR)*, 254(1), 2016.

(A4) P. ADASME and A. Lisser. Uplink scheduling for joint wireless orthogonal frequency and time division multiple access networks. *Journal of Scheduling*, 19(3):349–366, 2016.

(A5) K. Avrachenkov and V. V. Singh. Stochastic Coalitional Better-response Dynamics and Stable Equilibrium. *Mathematical Game Theory and Applications*, Feb. 2016.

(A6) Y. Benfattoum, S. Martin, and K. Al Agha. QoS for real-time reliable multicasting in wireless multi-hop networks using a Generation-Based Network Coding. *Computer Networks*, Apr. 2013.

(A7) J. Cheng, J. Leung, and A. Lisser. New reformulations of distributionally robust shortest path problem. *Computers and Operations Research*, 74:196–204, 2016.

(A8) J. Cheng, J. Leung, and A. Lisser. Random-payoff two-person zero-sum game with joint chance constraints. *European Journal of Operational Research (EJOR)*, 252(1):213–219, 2016.

(A9) J. Cheng and A. Lisser. A completely positive representation of 0-1 linear programs with joint probabilistic constraints. *Operations Research Letters*, (41):597–601, 2013.

(A10) J. Cheng and A. Lisser. Maximum probability shortest path problem. *Discrete Applied Mathematics*, 192:40–48, 2015.

(A11) J. Cheng, A. Lisser, and M. Houda. Chance constrained 0-1 quadratic programs using copulas. *Optimization Letters*, 9(7):1283–1295, 2015.

(A12) D. Feillet, T. Garaix, F. Lehuédé, O. Péton, and D. Quadri. A new consistent vehicle routing problem for the transportation of people with disabilities. *Networks*, 63(3):211–224, May 2014.

(A13) C. Gicquel, A. Lisser, and M. Minoux. An evaluation of semidefinite programming based approaches for discrete lot-sizing problems. *European Journal of Operational Research*, 237(2):498–507, Sept. 2014.

(A14) C. Gicquel and M. Minoux. Multi-product valid inequalities for the discrete lot-sizing and scheduling problem. *Computers and Operations Research*, 54:12–20, Feb. 2015.

(A15) A. Gorge, A. Lisser, and R. Zorgati. Generating cutting planes for the semidefinite relaxation of quadratic programs. *Computers and Operations Research*, 55:65–75, 2015.

(A16) M. Iturralde, T. Ali-Yahiya, A. Wei, and A.-L. Beylot. Resource Allocation for Real Time Services in LTE Networks: Resource Allocation Using Cooperative Game Theory and Virtual Token Mechanism. *Wireless Personal Communications*, vol. 72(n° 2):pp. 1415–1435, Sept. 2013.

(A17) I. jia, A. Lisser, and Z. Chen. Stochastic geometric optimization with joint probabilistic constraints. *Operations Research Letters*, 44(5):687–691, 2016.

(A18) M. Kchaou Boujelben, C. Gicquel, and M. Minoux. A distribution network design problem in the automotive industry: MIP formulation and heuristics. *Computers and Operations Research*, 52:16–28, Dec. 2014.

(A19) S. Lahoud, K. Khawam, S. Martin, G. Feng, L. Zhewen, and J. Nasreddine. Energy-Efficient Joint Scheduling and Power Control in Multi-Cell Wireless Networks. *IEEE Journal on Selected Areas in Communications*, Sept. 2016.

(A20) G. Li, L. Boukhatem, and W. Jinsong. Adaptive Quality of Service based Routing for Vehicular Ad hoc Networks with Ant Colony Optimization. *IEEE Transactions on Vehicular Technology*, 66(4):3249 – 3264, Apr. 2017.

(A21) G. Li, L. Boukhatem, and S. Martin. An Intersection-based QoS Routing in Vehicular Ad Hoc Networks. *Mobile Networks and Applications*, 20(2):268–284, Apr. 2015.

(A22) A. Lisser, P. ADASME, R. Andrade, and A. Lisser. Minimum cost dominating tree sensor networks under probabilistic constraints. *Computer Networks*, 112:208 – 222, Jan. 2017.

(A23) A. Lisser, I. Bomze, J. Cheng, P. J. C. Dickinson, and A. Lisser. A fresh CP look at mixed-binary QPs: new formulations and relaxations. *Mathematical Programming*, 166(1-2):159 – 184, Nov. 2017.

(A24) A. Lisser, J. Cheng, E. Delage, and A. Lisser. Distributionally Robust Stochastic Knapsack Problem. *SIAM Journal on Optimization*, 24(3):1485 – 1506, Jan. 2014.

(A25) A. Lisser and C. Cordero. Jamming Attacks Reliable Prevention in a Clustered Wireless Sensor Network. *Wireless Personal Communications Journal-Springer Publisher*, 85(3):925–936, 2015.

(A26) A. Lisser, J. Liu, Z. Chen, A. Lisser, and Z. Xu. Closed-Form Optimal Portfolios of Distributionally Robust Mean-CVaR Problems with Unknown Mean and Variance. *Applied Mathematics and Optimization*, Oct. 2017.

(A27) H. Noura, S. Martin, K. Al Agha, and K. Chahine. ERSS-RLNC: Efficient and robust secure scheme for random linear network coding. *Computer Networks*, 75(Part A):99–112, Dec. 2014.

(A28) J. Perez-Romero, A. Zalonis, L. Boukhatem, A. Kliks, K. Koutlia, N. Dimitriou, and R. Kurda. On the use of radio environment maps for interference management in heterogeneous networks. *IEEE Communications Magazine*, 53(8):184 – 191, Aug. 2015.

(A29) D. Quadri and E. SOUTIL. Reformulation and solution approach for non-separable integer quadratic programs. *Journal of the Operational Research Society*, page 11, Oct. 2014.

(A30) D. Quadri and E. SOUTIL. Reformulation and solution approach for non-separable integer quadratic programs. *Journal of the Operational Research Society*, 66:1270–128, Jan. 2015.

(A31) V. V. Singh, O. Jouini, and A. Lisser. Existence of Nash equilibrium for chance-constrained games. *Operations Research Letters*, 44(5):640–644, 2016.

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(A154) A. Laube. *Traffic aggregation for global energy savings in multi-hop wireless networks*. Theses, Université Paris-Saclay, Sept. 2017.

(A155) M. Letournel. *Dual approaches in stochastic programming*. Theses, Université Paris Sud - Paris XI, Sept. 2013.

(A156) G. Y. Li. *Adaptive and Opportunistic QoS-based Routing Protocol in VANETs*. Theses, Université Paris Sud - Paris XI, July 2015.

(A157) S. Medlej. *Scalable Trajectory Approach for ensuring deterministic guarantees in large networks*. Theses, Université Paris Sud - Paris XI, Sept. 2013.

(A158) D. Quadri. *Programmation Mathématique en variables entières: théorie et applications*. Habilitation à diriger des recherches, Université Paris Sud (Paris 11), July 2015.

(A159) C. Wang. *Variants of Deterministic and Stochastic Nonlinear Optimization Problems*. Theses, Université Paris Sud - Paris XI, Oct. 2014.

10/ VALS

Verification of Algorithms, Languages and Systems

équipe Vérification d' Algorithmes, de Languages et de Systèmes

Responsable: Évelyne Contejean, Burkhart Wolff

L'équipe VALS travaille dans le domaine scientifique des *Méthodes Formelles*. L'objectif général de l'équipe est de promouvoir les techniques de vérification formelle en les rendant plus facile à utiliser. Notre programme de recherche est structuré en six activités interagissant entre elles:

La démonstration automatique inclut des techniques de satisfiabilité modulo théories (SMT), la résolution de contraintes numériques, et des applications comme le *Model-Checking* à base de SMT.

Les langages et systèmes centrés-données visent à la conception et au développement de langages de programmation et de systèmes manipulant de grandes masses de données.

La formalisation de langages au sens large est une activité commune à une grande partie de l'équipe, en particulier à l'aide des assistants de preuve Coq et Isabelle, et permet la formalisation de la sémantique des langages de programmation, de la concurrence, des calculs numériques, etc.

Le test formel à base de modèles promeut les approches formelles dans les processus de test en génie logiciel, en utilisant des représentations logiques et des techniques de preuve, ainsi que les méthodes d'exploration aléatoires, et les modèles de comportement.

L'arithmétique des ordinateurs certifiée vise à la fois à formaliser l'arithmétique des ordinateurs, en particulier les calculs en virgule flottante, et les applications à la vérification de systèmes basés sur l'analyse numérique.

La vérification déductive de programmes vise le développement de techniques pour prouver formellement qu'un programme respecte une spécification formelle. Elle s'appuie sur plusieurs des activités précédentes.

Verification of **A**lgorithms, **L**anguages and **S**ystems

Head: Évelyne Contejean, Burkhart Wolff

The VALS team works in the scientific field called *Formal Methods*. The general objective of the team is to develop, to promote and to publicize formal methods, in particular by making formal verification an easier to use, more wide-spread technology. Our research program is structured into six activities, interacting with one another:

Automated Deduction includes research around satisfiability modulo theories, numerical constraint solving, and applications like SMT-based model-checking.

Data-Centric Languages and Systems aim at designing and developing programming languages as well as systems that seriously take into account massive data. This includes improving existing languages and systems.

Formal Model-based Testing promotes formal approaches into the testing process in software engineering, using logical representations and proof techniques, random exploration methods, and behavioural models.

Formalization of Languages in a broad sense is an activity shared by many members of the team, in particular using proof assistants Coq and Isabelle, which serve at formalizing semantics of languages, concurrency, mathematical/numerical theories, etc.

Verified Computer Arithmetic aims at both the formalization of computer arithmetic, including floating-point computations, and applications to the verification of systems based on numerical analysis.

Deductive Program Verification aims at developing techniques to formally prove that a program respects a formal specification. It builds upon several of the activities above.

Synthetic presentation

Head of Vals : **Évelyne CONTEJEAN**, Deputy : **Burkhart WOLFF**

Members of the group
As of January, 2013, the Vals team had 17 permanent members, 11 university faculty (4 PR, 1 emeritus PR, 6 MC, one of them on secondment at Collège de France), 2 CNRS researchers (2 CR), and 4 Inria researchers (1 DR, 3 CR).

As of June 30, 2018, the Vals team is made up of 19 permanent members, 13 university faculty (4 PR, 1 emeritus PR, 8 MC, one of them on secondment at IBM Watson, USA), 3 CNRS researchers (1 DR, 2 CR), and 3 Inria researchers (2 DR, 1 CR). 11 PhD students, 1 Post-doc, and 1 invited professor, are also member of the team.

Permanent members who left the group
Arthur Charguéraud (CR Inria) left in 2016 to join iCube lab. Xavier Urbain (MCF ENSIIE, previously associated member) joined Vals as a full member in 2015, and left in 2016 to join University Lyon 1 as a professor.

Permanent members who joined the group
Thibaut Balabonski (PhD University Paris 7, Post-doc Inria Rocquencourt) joined Vals as an assistant professor in 2014. Chantal Keller (PhD École Polytechnique, Post-doc Aarhus Danemark then MSR-Inria) joined as an assistant professor in 2015. Jacques-Henri Jourdan (PhD Inria Rocquencourt, Post-doc MPI-SWS) joined in 2017 as a CNRS researcher (CR).

Highlights of the scientific activity

1. A major characteristic of the Vals group is it strong development effort (more than twenty software packages, some of them used in the industry, some widely used in the academic field).
2. Due to the group's concern with research's application and valorisation, Vals has many contracts with industry (Adacore, Alstom, Airbus, Intel, Oracle Labs, Thalès, *etc*).
3. Vals is recognized at the highest international level with many prices and invited presentations in the top conferences in its research's field.
4. Vals also contributes to undergraduate studies through several textbooks on programming.
5. Vals is strongly involved in Paris-Sud university governance.

Number of publications

- Articles in major international journals: 24 – Other journals: 20
- Articles in major international conferences: 48 – Other conferences: 82
- Edited books: 6
- Books and chapters: 9

Top five publications

- C. Dross, S. Conchon, J. Kanig, and A. Paskevich. Adding Decision Procedures to SMT Solvers using Axioms with Triggers. Journal of Automated Reasoning, 56(4):387–457, 2016.
- V. Benzaken, E. Contejean, C. Keller, and E. Martins. A Coq formalisation of SQL's execution engines. In International Conference on Interactive Theorem Proving (ITP), Oxford, United Kingdom, July 2018.
- S. Boldo and G. Melquiond. Computer Arithmetic and Formal Proofs. ISTE Press - Elsevier, December 2017.
- J.-C. Filliâtre, L. Gondelman, and A. Paskevich. The Spirit of Ghost Code. In CAV 2014, Computer Aided Verification - 26th International Conference, Vienna Summer Logic 2014, Austria, July 2014.
- A. Feliachi, M-C. Gaudel, and Burkhart Wolff: Symbolic Test-Generation in HOL-TestGen/Cirta: A Case Study. In: Int. J. Software Informatics. Volume 9, Issue 1, pages 177-203, September 2015.

Major Softwares

- Alt-Ergo **http://alt-ergo.lri.fr/** is a little engine of proof dedicated to program verification, whose development started in 2006. It solves goals that are directly written in Why's annotation language; this means that Alt-Ergo fully supports first-order polymorphic logic with quantifiers. It also supports the SMT standard defined by the SMT-lib initiative.
- The BOLDR project **https://gitlri.lri.fr/jlopez/qir** is an implementation of the Query Intermediate Representation (QIR). QIR is a language that aims to be able to encode any query from any language or database.
- Coccinelle **https://www.lri.fr/~contejea/Coccinelle/coccinelle.html** is a Coq library for term rewriting. Besides the usual definitions and theorems of term algebras, term rewriting and term ordering, it also models some of the algorithms implemented in the CiME toolbox, such a matching, matching modulo associativity-commutativity, computation of the one-step reducts of a term, RPO comparison between two terms, etc.

- Coq.Interval **http://coq-interval.gforge.inria.fr/** is a library that provides Coq tactics for automatically proving bounds of real-valued expressions.
- Coquelicot **http://coquelicot.saclay.inria.fr/** is a user-friendly Coq library for real analysis. An easier way of writing formulas and theorem statements is achieved by relying on total functions in place of dependent types for limits, derivatives, integrals, power series, and so on. To help with the proof process, the library comes with a comprehensive set of theorems that cover not only these notions, but also some extensions such as parametric integrals, two-dimensional differentiability, asymptotic behaviors. It also offers some automation for performing differentiability proofs.
- Cubicle **http://cubicle.lri.fr/** is an open source model checker for verifying safety properties of array-based systems. This is a syntactically restricted class of parametrized transition systems with states represented as arrays indexed by an arbitrary number of processes. Cache coherence protocols and mutual exclusion algorithms are typical examples of such systems.
- Datacert **http://datacert.lri.fr** is a Coq library for formalising data-centric models and languages.
- Flocq (Floats for Coq) **http://flocq.gforge.inria.fr/** is a floating-point formalization for the Coq system. It provides a comprehensive library of theorems on a multi-radix multi-precision arithmetic. It also supports efficient numerical computations inside Coq.
- Frama-C **http://frama-c.cea.fr/** is a suite of tools dedicated to the analysis of the source code of software written in C. Frama-C gathers several static analysis techniques in a single collaborative framework. The approach of Frama-C allows static analyzers to build upon the results already computed by other analyzers in the framework. Thanks to this approach, Frama-C already provides sophisticated tools such as a slicer and dependency analysis.
- Gappa **http://gappa.gforge.inria.fr/** is a tool intended to help verifying and formally proving properties on numerical programs dealing with floating-point or fixed-point arithmetic. It has been used to write robust floating-point filters for CGAL and it is used to certify elementary functions in CRlibm. While Gappa is intended to be used directly, it can also act as a backend prover for the Why3 software verification plateform or as an automatic tactic for the Coq proof assistant.
- HOL-OCL **http://www.brucker.ch/projects/hol-ocl/** is an interactive proof environment for the Object Constraint Language (OCL). It is implemented as a shallow embedding of OCL into the Higher-order Logic (HOL) instance of the interactive theorem prover Isabelle.
- HOL TestGen **http://www.brucker.ch/projects/hol-testgen/index.en.html** allows one to write test specifications in Higher-order logics (HOL), to (semi-) automatically partition the input space, resulting in abstract test cases, to automatically select concrete test data, to automatically generate test scripts (in SML), and to test implementations in arbitrary languages (e.g. C).
- Iris **http://iris-project.org/** is a Higher-Order Concurrent Separation Logic Framework implemented and verified in the proof assistant Coq. It can be used for reasoning about safety of concurrent programs, as the logic in logical relations, to reason about type systems, etc.
- SMTCoq **https://smtcoq.github.io/** is a Coq plugin that checks proof witnesses coming from external SAT and SMT solvers. It provides a certified checker for proof witnesses coming from the SAT solver ZChaff and the SMT solvers veriT and CVC4. This checker increases the confidence in these tools by checking their answers a posteriori and allows to import new theroems proved by these solvers in Coq. SMTCoq also provides decision procedures through new tactics that discharge some Coq goals to ZChaff, veriT, and CVC4.
- Why3 **http://why3.lri.fr/** is a software verification platform. It provides a set of tools for deductive verification of Java and C source code. Requirements are specified as annotations in the source, in a special style of comments. It differs from other systems in that it outputs conditions for several existing provers: interactives ones (Coq, Isabelle/HOL, PVS, HOL-light, Mizar) and automatic ones (Simplify, Alt-Ergo, and SMT provers Yices, CVC3, Z3, haRVey, etc.).

Major facts illustrating the scientific visibility

- The ACM Software System Award 2013 was given, during a ceremony in June 2014 in San Francisco, to the Coq proof assistant (**http://awards.acm.org/software_system/**). The prestigious ACM price was previously awarded to the LLVM compiler infrastructure (2012) and to the Eclipse IDE (2011). Among the 9 recipients of the 2013 award are C. Paulin and J.-C. Filliâtre, from the Vals team.
- C. Paulin-Mohring received the award "Michel Monpetit – Institut National de Recherche en Informatique et en Automatique" of the French Academy of Sciences (**http://www.academie-sciences.fr/fr/Laureats/laureats-2015-prix-thematiques.html**).
- S. Conchon (local chair) and K. Nguyen (student competition chair) for the 44th ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages (POPL 2017), held in Paris, France in January 2017 (**http://conf.researchr.org/home/POPL-2017**).
- Several members of the team (J.-C. Filliâtre, G. Melquiond, M. Clochard, L. Gondelman, M. Pereira, R. Rieu-Helf) received several times (2015, 2016, 2017, 2018) an award from the VerifyThis verification competition.
- V. Blot was awarded a Marie Skłodowska-Curie fellowship for his project "PolyBar: A new approach to polymorphism through bar recursion".

Major facts illustrating the interactions with the socio-economic and cultural environment

- C. Paulin-Mohring is dean of the "Faculté des Sciences" of Université Paris-Sud since 2016.

- V. Benzaken was vice dean in charge of human ressources of the "Faculté des Sciences" of Université Paris-Sud (2014-2016)
- C. Marché is the scientific director for LRI of "ProofInUse Joint Lab", an ANR LabCom together with AdaCore (Paris). See **http://www.spark-2014.org/proofinuse**. This LabCom was selected and funded by the ANR programme "Laboratoires communs", starting from April 2014, for 3 years. AdaCore is a software publisher specializing in providing software development tools for critical systems.
- C. Marché co-organized with M. Sighireanu, Y. Moy, F. Kirchner, N. Kosmatov, the first joint Frama-C/SPARK day (May 2017, Paris, **http://frama-c.com/FCSD17.html**), in the context of the Open Source Innovation Spring (**http://www.open-source-innovation-spring.org/**). Around 130 participants.
- B. Wolff participated in from Sept. 2016 to Aug. 2017 via a delegation in the Project PST (directed by C. Pichot) co-funded by the IRT SystemX and Alstom.

Major contributions to teaching and training

- S. Conchon is vice-president for teaching of the department of Computer Science of "faculté des sciences d'Orsay, université Paris-Sud" since 2017.
- S. Conchon is jointly responsible of M2 "Fondements de l'Informatique et Ingénierie du Logiciel - Foundations of Computer Science and Software Engineering" (FIIL).
- J.-C. Filliâtre is the organizer of EJCP (École Jeunes Chercheurs en Programmation du GDR GPL) since 2016.
- S. Conchon and J.-C. Filliâtre are co-authors of the book "Apprendre à programmer avec Ocaml : Algorithmes et structures de données" and were involved in the writing of a new book supporting the new teaching program for the "Classes préparatoires aux grandes écoles"

Research Group Members and evolution since 2013

As of June 30, 2018, the team includes:

- 19 permanent members: 13 university faculty (4 PR, 1 emeritus PR, 8 MC), 3 CNRS researchers (2 CR, 1 DR), 3 Inria researchers (2 DR, 1 CR);
- an invited professor (Inria) on secondment from Paris 6 since sept 2017;
- 12 Ph.D. students and 1 post-doctoral student.

Permanent Members				
Name	*First name*	*Position*	*Institution*	*Remarks*
BALABONSKI	Thibaut	MCF	Paris-Sud	since 1st sept 2014
BENZAKEN	Véronique	PR	Paris-Sud	
BOLDO*	Sylvie	DR	Inria	CR until 1st oct 2017, DR since then
CHARGUÉRAUD*	Arthur	CR2	Inria	until 30 sept 206
CONCHON*	Sylvain	PR	Paris-Sud	MCF until 1st sept 2015, PR since then
CONTEJEAN*	Évelyne	CR	CNRS	
FILLIÂTRE*	Jean-Christophe	DR	CNRS	CR until 1st oct 2016, DR since then
GAUDEL	Marie-Claude	PR émérite	Paris-Sud	
JOURDAN	Jacques-Henri	CR	CNRS	since 1st oct 2017
KELLER	Chantal	MCF	Paris-Sud	since 1st sept 2015
LONGUET	Delphine	MCF	Paris-Sud	
MANDEL**	Louis	MCF	Paris-Sud	
MARCHÉ*	Claude	DR	Inria	
MELQUIOND*	Guillaume	CR	Inria	
NGUYEN	Kim	MCF	Paris-Sud	
PASKEVICH*	Andrei	MCF	Paris-Sud	
PAULIN-MOHRING*	Christine	PR	Paris-Sud	
URBAIN	Xavier	MCF	ENSIIE	from 1st sept 2015 until 31 aug 2016
VOISIN	Frédéric	MCF	Paris-Sud	
WOLFF	Burkhart	PR	Paris-Sud	
ZAÏDI	Fatiha	MCF	Paris-Sud	

* member of the LRI-Inria joint team Toccata, directed by C. Marché.
** currently on leave ("détachement") at IBM Watson (USA).

PhD students				
Name	*First name*	*Funding*	*Institution*	*Remarks*
AÏSSAT	Romain	Doc.	Paris-Sud AM (+ P7 ATER)	01-10-2012 - 30-01-2017
CLOCHARD	Martin	Doc.	ENS Paris	01-10-2013 - 30-03-2018
COQUEREAU	Albin	Doc.	Digicosme	01-10-2015 -
DECLERCK	David	Doc	Paris-Sud AM	01-10-2014 -
DROSS	Claire	Doc.	AdaCore (CIFRE)	01-01-2011 - 01-04-2014
DUMBRAVA	Stefania	Doc.	Paris-Sud AM + ATER	01-10-2012 - 02-12-2016
FAISSOLE	Florian	Doc.	Digicosme	01-10-2016 -
GALLOIS-WONG	Diane	Doc.	Fondation CFM pour la Recherche	01-10-2017 -
GONDELMAN	Léon	Doc.	Paris-Sud, ANR BWare grant	- 13-12-2016
HACHMAOUI	Houssem	Doc.	Paris-Sud, ANR Datacert grant	01-10-2016 -
HAI	Nguyen-Van	Doc.	Paris-Sud AM + ATER	01-01-2014 -
LELAY	Catherine	Doc.	Inria, Digiteo PhD grant	
LOPEZ	Julien	Doc.	Paris-Sud AM	01-10-2015 -
MEBSOUT	Alain	Doc.	Paris-Sud AM	
NEMOUCHI	Yakoub	Doc.	Paris-Sud (CDD)	
NGUYEN	Huu Nghia	Doc.	Paris-Sud (AM)	
OUFFOUÉ	George	Doc	Paris-Sud AM	01-10-2015 -
PELLE	Robin	Doc.	Paris-Sud AM	01-10-2016 -
PEREIRA	Mario	Doc.	bourse Portugal	2014 -
RIEU-HELFT	Raphaël	CIFRE	TrustInSoft	01-10-2017 -
ROUX	Mattias	Doc	Paris-Sud AM	01-10-2015 -
TUONG	Frédéric	Doc.	IRT SystemX (CDD)	
TAFAT BOUZID	Asma	bourse ministérielle		2009-2013

Temporary Personnel				
Name	*First name*	*Position*	*Institution*	*Remarks*
FELIACHI	Abderrahmane	Post-doc	EURO-MILS	2013
HILAIRE	Thibault	Invited Prof.	Délég. Paris 6	2017-2019
IM	Hyeonseung	Post-doc	Paris-Sud (ANR Typex grant)	2013-2104
MARCOZZI	Michaël	Post-Doc	INRIA (ERCIM Grant)	2014-215
MARTIN-DOREL	Erik	Post-doc.	Inria (ANR Verasco grant)	2013-2014
TOLMACH	Andrew	Invited Prof.	Digiteo Chair	2014-2015
BLOT	Valentin	Post-Doc	Digicosme	2017-2018
WENZEL	Markus	Post-doc	ANR Paral-ITP	2013-2014

Group evolution

The main evolution is that Vals is built from two distinct former teams, ForTesSe and Toccata who merged in July 2013. Toccata's life continues as an Inria project-team, associated to VALS.

Permanent members who left the group
Arthur Charguéraud (CR Inria) left in 2016 to join iCube lab. Xavier Urbain (MCF ENSIIE, previously associated member) join Vals as a full member in 2015, and left in 2016 to join University Lyon 1 as a professor.

Permanent members who joined the group
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10/ VALS

Research Description

The Vals team is built from former teams ForTesSE and Toccata who merged in 2013.

The research of the ForTesSE group was dedicated to formal methods and their applications to soft- and hardware systems. Particular emphasis is put on combinations of *Test* and *Proof* techniques. The general objective of Toccata was to promote formal specification and computer-assisted proof in the development of software that requires a high assurance of its safety and its correctness with respect to its intended behavior.

Test and proof, originally perceived as adversaries, have a lot in common in leading edge approaches: as "formal methods" (FM), they have both their roots in logic and discrete mathematics. The goal of the Vals team is to join complementary skills and expertise of its members, to address some challenging issues in the domain of programming and specification languages, in modeling-approaches for programs and systems, as well as constraint-solving technologies and theorem provers.

Automated Deduction

- **Decision Procedures via Axiomatizations with Triggers.** C. Dross, A. Paskevich, J. Kanig and S. Conchon published a paper in the *Journal of Automated Reasoning* (1) about integration of first-order axiomatizations with triggers as decision procedures in an SMT solver. This work extends a part of C. Dross PhD thesis (14). A formal semantics of the notion of trigger is presented, with a general setting to show how a first-order axiomatization with triggers can be proved correct, complete, and terminating. An extended DPLL(T) algorithm can then integrate such an axiomatization with triggers, as a decision procedure for the theory it defines.
- **Lightweight Approach for Declarative Proofs.** M. Clochard designed an extension of first-order logic, for describing reasoning steps needed to discharge a proof obligation. The extension is under the form of two new connectives, called proof indications, that allow the user to encode reasoning steps inside a logic formula. This extension makes possible to use the syntax of formulas as a proof language. The approach was presented at the JFLA conference and implemented in Why3. It brings a lightweight mechanism for declarative proofs in an environment like Why3 where provers are used as black boxes. Moreover, this mechanism restricts the scope of auxiliary lemmas, reducing the size of proof obligations sent to external provers.

Verified Computer Arithmetic

Computer arithmetic is the study of how computers handle numbers. This includes in particular floating-point arithmetic, described by the IEEE-754 standard. The VALS team worked on several aspects of the formal verification of properties, algorithms, and programs related to computer arithmetic. We discovered and proved several properties, e.g., about the double rounding phenomenon, and we created and/or verified several algorithms, e.g., a correctly-rounded average, as well as several programs, e.g., an industrial program about quaternions. Linked with the "Formalization of Languages" axis, we formally proved results about numerical analysis, with the collaboration of applied mathematicians, e.g., a finite-difference scheme and the Lax–Milgram theorem. We also contributed to the CompCert C compiler to

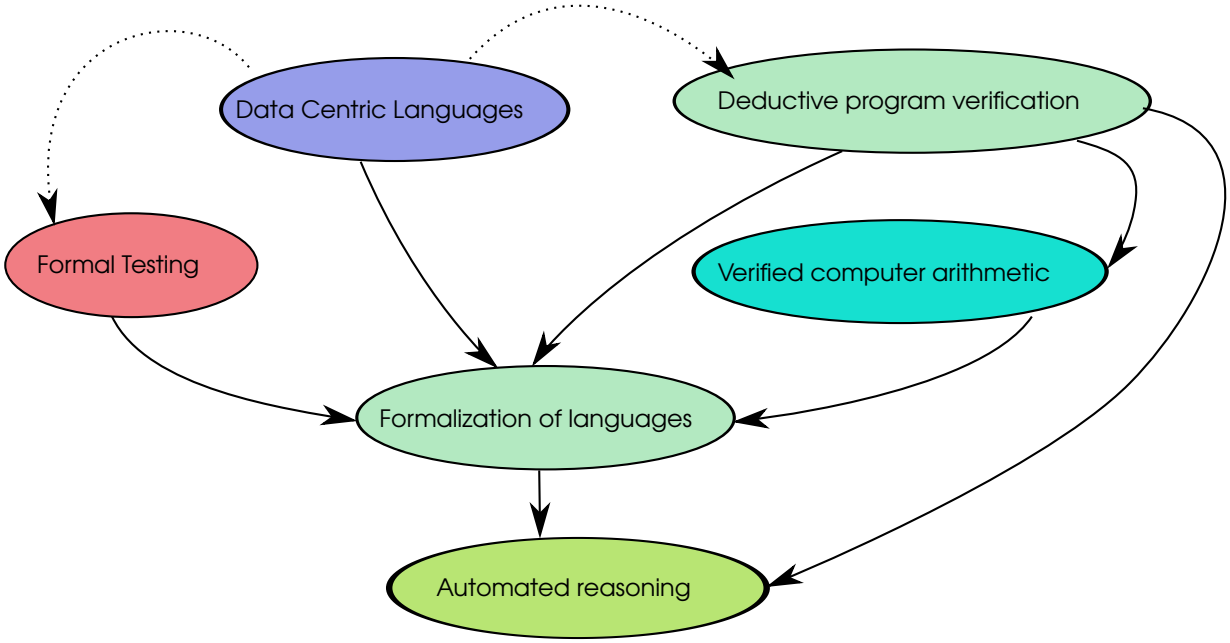

Figure 10.1: Vals Activities.

ensure it preserves the semantics of floating-point programs and to verify the various conversion between integers and floating-point numbers. Finally, we worked on disseminating a correct and thoughtful usage of floating-point arithmetic through the publication of books and formal libraries.

Formalisation of Languages

The activity "Formalization of Languages" is a transverse activity in VALS. As a prerequisite of verification activities (be it by deductive techniques or be it by testing), a formal semantics of data-structures and languages built over them is crucial. The VALS team developed over the years substantial know-how to represent formal semantics for them in systems like Why3, Coq and Isabelle, to develop formal theories over them, and to derive rules for optimised code-generation, symbolic evaluation, and constraint solving.

On the side of computational structures, the team produced libraries and proof-support for fixed- and floating-point arithmetics, linked with the "Verified Computer Arithmetic" axis. The team also developed libraries and tactics in Coq for real analysis, for bounding integrals, and for nonlinear inequalities involving elementary functions. Further, the team developed theories for the modeling of low-level infrastructures: OS-system routines based on shared-memory models and processor models, as well as security mechanisms such as firewalls and specific access-control mechanism used in data-bases. On the side of programming languages, the team developed semantics for the formal analysis of shell-scripts, a widely used language for various system administration tasks on UNIX machines. A further achievement in the same line is the development of a complete formalisation of the JavaScript language. (The work of formalising relational data-base models together with corresponding query languages is described in an own activity "data-centric Languages and Systems".) As for specification languages, the semantics of Hoare's "Unifying Theories of Programs" has been undertaken (which has been generalised to a theory of lenses leading to kind own verification-condition generators), which lead in collaboration with the team of John Woodcock to the development of a semantics for a CSP-like process algebra called Circus. As for (extended) compiler-correctness, several works have been undertaken to verify compilers and verification condition generators.

All these activities lead not only to publications in conferences and journals, but also to verified theories (distributed in archives such as the AFP) and a number of tool-specific web-sites that represent an important means for dissemination of our research activity. In parts, the activity was documented in a more or less regularly organised "Isabelle club" accessible at **https://modhel.lri.fr/IsabelleClub/**.

Data-Centric Languages and Systems

The data-centric languages and systems thematic aims at designing and developing programming languages as well as systems that seriously take into account massive data. The purpose is to build robust and efficient platforms on well founded theoretical grounds.

Internet explosion and the ever growing importance of data in applications as well as the recent emergence of cloud computing, has given birth to a whirlwind of new data models (XML, JSON) and languages (XPath, XQuery, Pig, Jaql, etc). Whether they are developed under the banner of NoSQL (which stands for Not Only SQL), for BigData Analytics, for Cloud computing or as domain specific languages (DSL) embedded in a host language, most of them share a common subset of SQL and/or the ability to handle semi-structured data.

Such languages can greatly benefit from formal uniform foundations, and we argue that such foundations should account for novel features critical to various application domains. Also, most of those languages provide limited type checking, or ignore it altogether. We believe type checking is essential for many applications, with usage ranging from error detection to optimization.

The data-centric languages and systems thematic follows three related research directions. At a foundational level, the design and implementation of ever more sophisticated type systems, with data-oriented features. Such type systems, initially developed within the scope of the CDuce programming language, push the boundaries of data properties that can be enforced statically, while remaining completely decidable and amenable to efficient implementations. The second feature, is a principled conception of efficient systems based on formal tools (automata, lambda-calculi, etc). The third research direction which is shared with the "Formalisation of Languages" thematic is the formal specification and certification of data intensive systems with the Coq proof assistant.

Formal Model-based Testing

The activity Formal Model-based Testing promotes formal approaches in the testing process in software engineering using logical representations, proof techniques and also random exploration methods and behavioral models.

There are three strongly related fundamental research activities underlying our approaches to system validation and verification. We categorize them as follows:

1. testing using logical representations and proof techniques,
2. random exploration methods, and
3. behavioural models for testing, composition and attack-tolerance.

The fundamental research of the group relies on theoretical activities around the formalisms used for specification and modelisation, transition systems and process algebras and their associated verification methods (theorem proving, symbolic evaluation, model-checking or exploration methods).

On the side of formalisms of specifications, the team has produced languages (ChorD, TESL) to address the formalization of choreographies (collaborations of components) and associated verification techniques (bi-simulation, deductive verification).

On the side of testing, we developed theories, methods and tools in different directions. To address the testing of distributed systems, the team proposed active and passive testing approaches. A work based on Petri nets defined new testing relations for distributed and concurrent systems. The team has a strong know-how in testing methods based on proof techniques, and has worked on extending the HOL-TestGen tool in both theory and implementations. We are also involved in testing methods targetting Circus process algebra specifications in cooperation with the authors of Circus. Concerning the application of random exploration methods to program testing, a new approach allows to reduce the number of unfeasible paths, based on symbolic execution and graphs transformations (all formally proved in Isabelle).

Regular Activity: Test Club

The test group decided at the beginning of the academic year 2017-18 to follow the scheme of "Isabelle club"-discussion group for internal meetings. The documentation can be seen here: **https://vals.lri.fr/mbt/TestClub**.

Deductive Program Verification

- **Automated Verification of B Proof Obligations**(A144, A143)
- **Safety of hybrid automata.** D. Ishii and G. Melquiond applied methods of deductive program verification to ensure the safety of hybrid automata (A157).
- **Proof sessions.** F. Bobot, J.-C. Filliâtre, C. Marché, G. Melquiond, and A. Paskevich have presented the proof session mechanism of Why3 at VSTTE 2013 (A118). It is a technique to maintain a proof session against modification of verification conditions. It was successfully used in developing more than a hundred verified programs and in keeping them up to date along the evolution of Why3 and its standard library. It also helps out with changes in the environment, *e.g.* prover upgrades.
- **Ghost Code.** J.-C. Filliâtre, L. Gondelman, and A. Paskevich published a paper on a general approach to the concept of ghost code in a paper *The Spirit of Ghost Code* (A79) presented at CAV 2014 and in the journal of *Formal Methods in System Design* (A16). Ghost code is a subset of program code that serves the purposes of specification and verification: it can be erased from the program without affecting its result. This work forms the basis of the support for ghost code in Why3. This work is an extended version of the paper presented at the 26th International Conference on Computer Aided Verification (CAV) in 2014.
- **VerifyThis.** J.-C. Filliâtre, C. Marché, and A. Paskevich, together with F. Bobot (CEA LIST), took part in the VerifyThis program verification competition, held at the 18th FM symposium in August 2012. They used Why3 to solve three challenges (which can be found at **http://fm2012.verifythis.org/challenges/**), and their solutions have been published in a special issue of the journal *Software Tools for Technology Transfer* (A5).
- **Bounded integers.** M. Clochard, J.-C. Filliâtre, and A. Paskevich proposed a novel method to prove the relative safety of operations over bounded integers in a large class of programs. Their approach consists of introducing dedicated abstract types for the bounded integers and restricting the set of allowed operations over these types in such a way that it is impossible to reach the bound during a realistic execution of the program: for example, it would take several hundred years to overflow a 64-bit integer. This technique is aimed at integer variables that serve essentially as counters or size measures. It can be used alongside the traditional methods of proving the absence of overflows for other integer values in the same program. The proposed approach is implemented in Why3 and was presented at VSTTE 2015 (A136).
- **Cursor data structures** J.-C. Filliâtre and M. Pereira proposed a new way to specify the behavior of a cursor data structure, with the objective of being able to verify both the implementation of a cursor and its use by client code. The approach is modular, which means that a program using a cursor can be verified independently of the way the cursor is implemented. An experimental evaluation has been conducted with Why3, with several implementations and client codes being verified. This work will be presented at JFLA 2016 (A101).
- **A bit-vector library for deductive verification.** C. Fumex and C. Marché developed a new library for bit-vectors, in Why3 and SPARK. This library is rich enough for the formal specification of functional behavior of programs that operate at the level of bits. It is also designed to exploit efficiently the support for bit-vectors built-in in some SMT solvers. This work is done in the context of the ProofInUse joint laboratory. The SPARK front-end of Why3, for the verification of Ada programs, is extended to exploit this new bit-vector theory. Several cases studies are conducted: efficient search for rightmost bit of a bit-vector, efficient computation of the number of bits set to 1, efficient solving of the n-queens problem. At the level of SPARK, a program inspired from some industrial code (originally developed in C par J. Gerlach, Fraunhofer FOKUS Institute, Germany and partially proved with Frama-C and Coq) is specified in SPARK and proved with automatic solvers only. A paper on that library together with the way it is connected with the built-in support for bitvectors in SMT solver was presented at the NASA Formal methods Conference (A152). The support for bit-vectors is distributed with SPARK since 2015, and SPARK users already reported that several verification conditions, that couldn't be proved earlier, are now proved automatically.
- **Counterexamples from proof failures.** D. Hauzar and C. Marché worked on counterexample generation from failed proof attempts. They designed a new approach for generating potential counterexamples in the deductive verification setting, and implemented in Why3. When the logic goal generated for a given verification condition is not shown unsatisfiable by an SMT solvers, some solver can propose a model. By carefully reverting the transformation chain (from an input program through the VC generator and the various translation steps to solvers), this model is turned into a potential counterexample that the user can exploit to analyze why its original code is not proved. The approach is implemented in the chain from Ada programs through SPARK, Why3, and SMT solvers CVC4 and Z3. This work is described in a research report (A209) and a paper was presented at the SEFM Conference (A156). It was considered robust enough to be distributed in the release Pro 16 of SPARK. The work was extended together with

S. Dailler and extended approach was published in a journal (A35).

- **Static versus dynamic verification.** C. Marché, together with Y. Moy from AdaCore, J. Signoles and N. Kosmatov from CEA-LIST, wrote a survey paper about the design of the specification languages of Why3 and its front-ends Frama-C and SPARK. The choices made when designing these specification languages differ significantly, in particular with respect to the executability of specifications. The paper reviews these differences and the issues that result from these choices. The paper also emphasizes two aspects where static and dynamic aspects of the specifications play an important role: the specific feature of *ghost code*, and the techniques that help users understand why static verification fails. This paper was presented at the Isola Symposium (A159).
- **Extracting Why3 programs to C programs.** R. Rieu-Helft, C. Marché, and G. Melquiond devised a simple memory model for representing C-like pointers in the Why3 system. This makes it possible to translate a small fragment of Why3 verified programs into idiomatic C code (A106). This extraction mechanism was used to turn a verified Why3 library of arbitrary-precision integer arithmetic into a C library that can be substituted to part of the GNU Multi-Precision (GMP) library (A173).
- **Reflection-based proofs.** G. Melquiond and R. Rieu-Helft proposed a framework for performing computational reflection inside Why3, which means that the user can write and verify a solver using Why3 and then apply it to the proof obligations generated by Why3. One novelty of this framework is that the decision procedures defined that way are effectful, as they can raise exceptions, manipulate mutable arrays, and so on. This framework was used to considerably reduce the size of the proofs for a reimplementation of GMP's algorithms, by defining an adhoc procedure for proving systems of linear equalities using symbolic coefficients (A83).
- **Automating the Verification of Floating-Point Programs.** The level of proof success and proof automation highly depends on the way the floating-point operations are interpreted in the logic supported by back-end provers. C. Fumex, C. Marché and Y. Moy addressed this challenge by combining multiple techniques to separately prove different parts of the desired properties. They use abstract interpretation to compute numerical bounds of expressions, and use multiple automated provers, relying on different strategies for representing floating-point computations. One of these strategies is based on the native support for floating-point arithmetic recently added in the SMT-LIB standard. The approach is implemented in the Why3 environment and its front-end SPARK 2014. It is validated experimentally on several examples originating from industrial use of SPARK 2014 (A208, A153).
- **Isabelle Kernel development and parallelization.** The ANR Paral-ITP project **http://paral-itp.lri.fr** joining the partners Inria/Saclay, Inria/Roquencourt et LRI/Paris-Sud (Lead) developed new versions of Kernels of two major theorem proving systems, namely Coq and Isabelle. The objective was to overcome the traditional sequential execution model both for Coq and Isabelle, and to make the resources of moodern multi-core hardware available for even larger proof developments in interactive proof environments. The main contributions were the releases of Coq version 8.5 and Isabelle14-1, but a number of accompanying papers and workshops. Parallelizing modern high-end interactive theorem proving systems is a *pervasive* business that ranges from modifications in the kernel, the tactic and proof procedure layer, over to front-end technologies that have to be asynchronous in order to support the underlying parallel execution model. An overview paper about the overall activity by B. Barras, L. Gonzalez Huesca, H. Herbelin, Y. Régis-Gianas, E. Tassi, M. Wenzel and B. Wolff (project leader) is (A114). Specific contributions from the LRI/Paris-Sud concerning the Isabelle system were done by M. Wenzel, who was member of the VALS team since 2012. This concerns the parallel execution model of the kernel based on global shared memory as well as the asynchronous infrastructure of the Isabelle/PIDE framework.
- **AVL trees.** M. Clochard developed, using Why3, verified implementations of several data structures, including random-access lists and ordered maps. These are derived from a common parametric implementation of self-balancing binary trees in the style of Adelson-Velskii and Landis trees (so-called AVLs). This work appeared at the VSTTE conference (A134). Its originality relies on the genericity of the specifications and the code, and the very high level of proof automation. Such a case study is aimed at illustrating the capabilities of Why3 for designing certified libraries. Development is available from our gallery at **http://toccata.lri.fr/gallery/avl.fr.html**.
- **Algorithms for matrix multiplication.** M. Clochard, L. Gondelman and M. Pereira worked on a case study about matrix multiplication. Two variants for the multiplication of matrices are proved: a naive version using three nested loops and Strassen's algorithm. To formally specify the two multiplication algorithms, they developed a new Why3 theory of matrices, and they applied a reflection methodology to conduct some of the proofs. A first version of this work was presented at the VSTTE Conference in 2016 (A137). An extended version that considers arbitrary rectangular matrices instead of square ones is published in the Journal of Automated Reasoning (A14). The development is available in Toccata's gallery **http://toccata.lri.fr/gallery/verifythis_2016_matrix_multiplication.en.html**.
- **Koda-Ruskey's algorithm for generating ideals of a forest.** J.-C. Filliâtre and M. Pereira presented the

first formal proof of an implementation of Koda and Ruskey's algorithm (an algorithm for generating all ideals of a forest poset as a Gray code) at VSTTE 2016 (A151). The proof is conducted within the Why3 system and is mostly automatic.

- **Strongly Connected Components in Directed Graphs.** As part of a larger set of case studies on algorithms on graphs **http://pauillac.inria.fr/~levy/why3/**, R. Chen and J.-J. Lévy work on formal verification of algorithms for computing strongly connected components of directed graphs. The formal proofs are conducted using Why3. The formal proof of Tarjan's algorithm was presented at the French-speaking symposium JFLA 2017 (A93) and then at the VSTTE 2017 international conference (A133)
- **A Formally Proved, Complete Algorithm for Path Resolution with Symbolic Links.** In the context of file systems like those of Unix, path resolution is the operation that given a character string denoting an access path, determines the target object (a file, a directory, etc.) designated by this path. This operation is not trivial because of the presence of symbolic links. Indeed, the presence of such links may induce infinite loops in the resolution process. R. Chen, M. Clochard and C. Marché consider a path resolution algorithm that always terminates, detecting if it enters an infinite loop and reports a resolution failure in such a case. They propose a formal specification of path resolution and they formally prove that their algorithm terminates on any input, and is correct and complete with respect to this formal specification. (A33). The development is available in Toccata's gallery **http://toccata.lri.fr/gallery/path_resolution.en.html**.

Team Organisation

Vals is a group built from two former groups, ForTesSE and Toccata which merged in 2013. Toccata LRI team members were also members of Toccata as an Inria project-team, whereas no one in ForTesSE was. We decided that Toccata shall remain as a project-team, hence, some members of Vals belong to Toccata, the other do not. The permanent members recruited since 2013 (except when they are Inria researchers) are *not* member of Toccata.

The team is quite large, hence it is structured into several activities: an activity has a focused research domain, a leader, a web page, some participants[1], and sometimes some regular meetings, such as the "Isabelle Club", or the "Test Club". This flexibility allowed a nice operating mode during the evaluation period, since cooperation between both former groups seems now natural and simple. In particular, the whole group decided to hire new MCF people to strengthen the activity of formal testing which needed some human resources.

As a whole, the Vals teams has a regular (one per week) seminar **https://vals.lri.fr/agenda.html**, and some team meetings, one every year in October, and when needed in order to make important decisions (PhD funding, permanent member's recruiting, integration of new groups such as 5 people from the ModHel team, discussion with LSV Lab).

Self Assessment

Strengths:

- The Vals group enjoys a high international recognition.
- The team members are involved in and/or leader of many contracts, either academic or with industry.
- We have some strong links with our local environment (CEA, labex).
- We publish our work in top journals and venues of our field, and our software production is widely used.

Weaknesses:

[1] a Vals member may be present in several activities.

- It is quite difficult to hire good local PhD students, due to the (former) structure of Paris-Sud University masters in computer science. The situation should evolve with Paris-Saclay.
- We lack engineers to develop and maintain our numerous pieces of software (they also could ease our relationship with the Paris-Saclay SATT).
- We also lack some time to make our theoretical research.

Opportunities:

- Paris-Saclay, and the arrival of LSV, a large group of colleagues working the field of formal methods.
- Paris-Saclay, and the new FILL master, where our research themes are present.
- In our digital world, strong guaranties are needed in more and more critical domains (railways, planes, space, autonomous vehicle, data privacy, etc) and formal methods are able to provide some.

Threats:

- Difficulty to maintain a good balance between theoretical research and software and tools development.
- Good students in our domain are often attracted by top US universities (in Princeton, our colleagues know MPRI very well!).
- Paris-Saclay, the living environment (no more roads, current landscaping projects started since our arrival in the new LRI building, and not finished yet).
- Difficulty to access the "Plateau de Saclay".

10/ VALS

Strategy and five-year project

Positioning in the local, national and international context

The domain of formal methods for software engineering is historically a major axis of research in the LRI. This domain of research is important in the context of the institutional evolutions of the "Plateau de Saclay", in the recent past, the present and for the future. In the past years, the RTRA Digiteo played an important role for the development of collaborative research on the Plateau, and Software Engineering was one of its seven themes of its research programme. In the present, software was also important in the "investissements d'avenir": SciLex is one of the three action lines of the Labex DigiCosme, centered on the reliability of software; the IRT SystemX, which is more focused on industrial applications, has one theme around embedded systems, where the same problematic appears. We are strongly involved in all these actions.

The near future is the creation of the Université Paris-Saclay, and the creation of a large computer science department. The interest in formal software engineering methods will be shared by several institutions: Inria Saclay, CEA, LSV, ENSTA ParisTech, etc. The new VALS team aims at playing a central role is this future join of forces on the Plateau. Also, we are strongly involved in the new Master programme of the future STIC department. This would be a new mean to attract students, e.g., from engineering schools, to do a PhD thesis.

Our strategy also fits in the national context. We are members of both GDR of CNRS "Génie de la Programmation et du Logiciel" and "Informatique Mathématique". We will continue collaborations with many teams in France. At the international level, we want to develop our contacts with major institutions and sites of our domain, such as Microsoft Research, ETH Zürich, Imperial College London, etc. Our involvement in the IFIP WG 1.9/2.5 is also representative of our involvement in world-wide trends.

We plan to continue and improve our collaborations with industrial partners, in particular the companies that promote formal methods. These collaborations are not only a precious source of concrete challenges and real case studies: they are a key for the spreading and the transfer of our methods and tools in the industry.

Research Project

Vals, a part of the ModHel team (Frédéric Boulanger's group) and LSV (ENS Paris-Saclay) shall form a new laboratory for formal methods in 2020, when ENS Paris-Saclay arrives on the "Plateau". The research project of this laboratory will be sent to the HCERES by LSV.

Annex 4

Collaborations

Participation to national and international collaborative research projects

International projects

- MoBasT project, CNRS-Royal Society (2012-2013), Coordinators: M.-C. Gaudel and A. Cavalcanti, Partners: LRI and University of York. We addressed in this project the issue of selecting tests when using an abstract specification for testing that a system behaves like one of the refinements of this specification. Some results were published in the conference ETAPS/FASE 2014 (A131) (those on data flow selection criteria). Other results on testing concurrent systems, were published in TCS (A11).
- Special Visiting Researcher Fellowship - PVE (Pesquisador Visitante Especial), Brazilian Scientific Mobility Program "Ciências sem Fronteiras", 2015-2017, M.-C. Gaudel, Partner: Adenilso da Silva Simão, Universidade de São Paulo. This project was devoted to the study of mutation testing methods when using abstract specifications written in the *Circus* language. It was led via three long visits of M.-C. Gaudel at USP and a Sandwich PhD scholarship: the student Alex D. B. Alberto spent eight months in LRI. The results were published in the Journal of Information & Software Technology (A26), and in a technical report (A195).
- DATE, Stic-Amsud, Partners LRI (F. Zaïdi, D. Longuet, P. Dague, L; Yé) Universidad Nacional de Cordoba (FaMAF), University Austral de Chile (UACH) (jan. 2013 - dec 2014)

- Semantics and implementation of functional programming, ECOS-Sud, Partners LRI (T. Balabonski), Univ. Paris Diderot, Universidad de Buenos Aires (UBA), CONICET.

National projects

- Digicosme DisMonTest – co-leader, Digicosme project, Partners: LRI (F. Zaïdi, Télécom Sud Paris (oct. 2015 - oct. 2018)
- ANR DataCert – leader. Partners: LRI, Université Paris-Sud (É. Contejean (leader), V. Benzaken, C. Keller, H. Hacmaoui); CRIStAL, Université de Lille; LIRIS, Université Claude Bernard Lyon 1 (jan. 2016 – déc. 2019)
- ANR SoftQPro. Partners: LRI, Université Paris-Sud (B. Valiron (leader), M. Baboulin, T. Balabonski, C. Keller); BULL SAS; CEA Saclay; LORIA (oct. 2017 – sep. 2021)
- DigiCosme UPSCaLe – leader. Partners: LRI, Université Paris-Sud (C. Keller (leader), É. Contejean); LIX, École polytechnique; LSV, ÉNS Cachan; Samovar, Télécom SudParis; U2IS, ENSTA; Inria Saclay–Île-de-France (oct. 2017 – sep. 2019)

Collaborations with other laboratories leading to joint publications

International collaborations

- Imperial College London (UK): Certification of JavaScript, AJACS project
- Carnegie Mellon University: Parallel dynamic computations, ERC Deepsea
- S. Conchon, A. Mebsout and F. Zaïdi (VALS group, LRI) collaborate with S. Krstic and A. Goel (Intel Strategic Cad Labs in Hillsboro, OR, USA), in particular around the development of the SMT-based model checker Cubicle (see above). This collaboration is partly supported by an academic grant by Intel.
- V. Blot collaborates with Jim Laird (University of Bath, UK): denotational semantics.
- C. Keller collaborates with the University of Iowa (Cesare Tinelli *et al.*) and Stanford University (Clark Barrett *et al.*): improving automation in the Coq proof assistant.
- B. Wollf and C. Keller collaborate with University of Sheffield (Achim D. Brucker): formal test generation
- J.-H. Jourdan collaborates with Derek Dreyer and Ralf Jung (Max Planck Institute for Software Systems, Saarbrücken, Germany), Robbert Krebbers (Delft University of Technology, Netherlands) and Lars Birkedal and Aleš Bizjak (Aarhus University): Iris higher-order separation logic.

National collaborations

- Collaboration with Télécom Sud Paris (Stephane Maag)
- C. Keller collaborates with École polytechnique (Stéphane Graham-Lengrand, co-advisor of Valentin Blot): correct-by-construction automated provers.
- T. Balabonski collaborates with Université Claude Bernard Lyon 1 (Xavier Urbain): formalisation of mobile sensors networks models and protocols.

Visiting professors and students (more than one week)

- Cláudio Belo Da Silva Lourenço, PhD student, Universidade do Minho, Portugal, visiting from Jun. to Dec. 2016
- Ran Chen, PhD student, Institute of Software, Chinese Academy of Sciences, Beijing, China, May 2016-Feb. 2017. Under the supervision of C. Marché and J.-J. Lévy (PiR2 team, Inria Paris), she worked on the formal verification of graphs algorithms (A210, A93, A133), and also in the context of the CoLiS project on verification of some aspects of the Unix file system and shell scripts (A202, A33).
- Giogio Ghelli, Professore ordinario, Università degli studi di Pisa, May-June 2014, Working on NoSQL programming languages with a special focus on SparQL/RDF with V. Benzaken, É. Contejen and K. Nguyen. Digitéo grant.
- Thibault Hilaire, Associate Professor Univ Pierre et Marie Curie, from Sep 2017, "en délégation". Co-supervises PhD of D. Gallois-Wong. Development of a formalization in the Coq proof assistant of numerical filters. It includes equivalences between several expressions and the formal proof of the Worst-Case Peak Gain Theorem to bound the magnitude of the outputs (and every intern variable) of stable filters.
- Andrew Tolmach, visiting professor Portland State University, USA, Sep 2014-Aug 2015, Digiteo Chair. The project is to initiate a new research effort to develop principles, techniques, and tools for large-scale proof engineering. It is focused on the Coq proof assistant and is designed to take advantage of the deep pool of expertise available in the Paris area concerning both the use and the development of Coq. Initial results include: a precise description of requirements for large proof management; sample prototype tools addressing one or more of these requirements; and a technical survey of relevant proof representation options.
- Pierre Roux (ISAE, Onera) visited for 7 months in order to collaborate with S. Boldo and G. Melquiond on the topic of formal verification of numerical algorithms (A42, A24).
- V. Sassone, Professor, University of Southampton, UK, May-June 2014, Working on NoSQL programming languages with a special focus on SparQL/RDF with V. Benzaken, É. Contejen and K. Nguyen. Digitéo grant.
- Bas Spitters visited for 3 months from April to June funded by a Digiteo grant. He worked with C. Paulin on the extension of the ALEA library to continuous structures and the use of "lower reals" (monotonic sequences of rationals). He also worked on adapting the Corn and Math-classes libraries to the new Coq release.
- F. Faissole has spent two months visiting B. Spitters at Aarhus University (Denmark). They proposed an extension of ALEA library to continuous datatypes.(A147).
- F. Faissole visited G. Constantinides and D. Thomas at Imperial College (London, UK) for 3 months (June to August 2018) to work on the formalization of pragmas for high-level synthesis code for FPGAs.
- Simaõ Melo de Sousa

Other Collaborations

- V. Benzaken, É. Contejean, C. Keller and K. Nguyen collaborate with L. Mandel et J. Siméon (IBM Watson Research).

Participation to national and international networks

IFIP Working Group 1.9/2.15 (Verified Software)

- J.-C. Filliâtre, permanent member

European research network on types for programming and verification (EUTypes)

- Program COST (European Cooperation in Science and Technology), action CA15123, **https://eutypes.cs.ru.nl/**, 2015-2019
- Coordinator: Herman Geuvers, Radboud University Nijmegen, The Netherlands
- Other partners: 36 members countries, see **http://www.cost.eu/COST_Actions/ca/CA15123?parties**

Volunteer Professional Service

Management Positions in Scientific Organisations

Research management

- V. Benzaken, co-responsible of the research and innovation commission of the "Labex Digicosme" since 2017.
- V. Benzaken, President of the *"commission consultative de spécialistes de l'université"*, Section 27 (informatique), Commission in charge of recruiting and professors and assistant professor careers' management. Since june 2016.

- V. Benzaken, elected Vice President in charge of research of the computer science department (2012-2015).
- V. Benzaken, member of the research council of the Faculty of sciences (2012-2015).
- S. Boldo, elected member of the Inria Evaluation Committee until August 2014. She was in the committee in charge of selecting the Inria permanent researchers (CR2) in Bordeaux and Nancy and in the national committee for first-class Inria permanent researchers (CR1) (2013-2014).
- S. Boldo, member of the national Inria admission committee (2013, 2014).
- S. Boldo was in the committee in charge of upgrading an Inria support staff at the IR level (*ingénieur de recherche*), which is the highest level for support staff (2013)
- S. Boldo, member of the CCD, *commission consultative des doctorants* (2015-2016)
- S. Boldo, member of the committee for the monitoring of PhD students (*commission de suivi des doctorants*) (2013–2018)
- S. Boldo, member of the national popularization committee, *comité de médiation scientifique*, of Inria (2013-2014).
- S. Boldo, member of the CLFP, *comité local de formation permanente* (2013-2018).
- S. Boldo, scientific head for Saclay for the MECSI group for networking about computer science popularization inside Inria (2013-2018).
- S. Boldo has been elected in 2017 chair of the ARITH working group of the GDR-IM (a CNRS subgroup of computer science) with J. Detrey (Inria Nancy).
- A. Charguéraud is vice-president of *France-ioi*, a non-profit organization in charge of the selection and the training of the French team to the International Olympiads in Informatics (IOI). France-ioi also provides online exercises in programming and algorithmics—in average, over 100,000 such exercises are solved every month on the website (2013-2016)
- A. Charguéraud is a board member of the non-profit organization *Animath*, which aims at developing interest in mathematics among young students (2013-2016).
- A. Charguéraud, member of the committee for the monitoring of PhD students (*"commission de suivi des doctorants"*) (2013-2016).
- S. Conchon, member of the *"commission consultative de spécialistes de l'université"*, Section 27, University Paris-Sud since December 2014.
- É. Contejean, leader of the VALS team since February 2014.
- É. Contejean, nominated member of the *"conseil du laboratoire"* of LRI since April 2010 till June 2014.
- É. Contejean, elected member of the *"section 6 du Comité National de la Recherche Scientifique"* (2012-2016). 2012.
- É. Contejean, elected member of the *"Conseil d'Administration de la CoMUE Paris-Saclay"* (2015-).
- É. Contejean, elected member of the *"Conseil d'Administration de l'Université-Paris"* (2016-)
- S. Dumbrava, elected member of the *"conseil du laboratoire"* of LRI (June 2014-2016)
- J.-C. Filliâtre is *correcteur au concours d'entrée à l'École Polytechnique et aux ENS* (computer science examiner for the entrance exam at École Polytechnique and Écoles Normales Supérieures) since 2008 (2014-2016).
- J.-C. Filliâtre, member of the board of GDR GPL, since January 2016.
- M.-C. Gaudel, chair of the *Program Committee of Digiteo* (2005-2015), and therefore member of the *Steering Committee* all that time.
- M.-C. Gaudel, *Digiteo seminar* (2011-2015).
- M.-C. Gaudel, *Scientific Committee of the GDR GPL* (Génie de la Programmation et du Logiciel) since its foundation and member of the thesis award committee several times.
- M.-C. Gaudel, chair of the *Scientific Committee of the Fédération ICVL*, Informatique Centre Val de Loire (2018-)
- C. Keller is a nominated member of the *conseil du laboratoire* of LRI since 2017.
- C. Lelay, elected representative of the students at the Doctoral School in Computer Science at University Paris-Sud from November 2011 to November 2013.
- C. Lelay, elected member of the *"conseil du laboratoire"* of LRI from November 2011 to June 2014.
- D. Longuet, nominated member of the *"conseil de laboratoire"* of LRI from September 2012 to June 2014.
- D. Longuet and K. Nguyen, elected members of the commitee of the computer science department of University Paris-Sud (*"conseil de département"*) from February 2012 to December 2017.
- D. Longuet, nominated member of the *"conseil de laboratoire"* of LRI from September 2012 to June 2014.
- C. Marché, scientific and executive leader of Inria project-team Toccata, **http://toccata.lri.fr/** (2012-2018)
- G. Melquiond, member of the committee for the monitoring of PhD students (*"commission de suivi doctoral"*) (2014-2017).
- G. Melquiond, elected officer of the IEEE-1788 standardization committee on interval arithmetic since 2008 (-2015?)
- G. Melquiond, member of the *"commission consultative de spécialistes de l'université"*, Section 27, University Paris-Sud from April 2010 to December 2014.
- A. Paskevich was in charge (together with C. Bastoul in 2012–2013 and B. Cautis in 2013–2014) of Licence professionnelle PER (L3) at IUT d'Orsay, Paris-Sud University since September 2012 till August 2014.
- A. Paskevich, member of the *"commission consultative de spécialistes de l'université"*, Section 27, University Paris-Sud since December 2014.
- C. Paulin, member of the *"commission consultative de spécialistes de l'université"*, Section 27, University Paris-Sud from April 2010 to December 2014.

- C. Paulin, president of the *"commission consultative de spécialistes de l'université"*, Section 27, University Paris-Sud from December 2014 till 2016.
- C. Paulin, member of the program committee of Digiteo Labs (2010-2014).
- C. Paulin, scientific leader of Labex DigiCosme **http://labex-digicosme.fr** (Digital Worlds: distributed data, programs and architectures), a project launched by the French Ministry of research and higher education as part of the program "Investissements d'avenir", it involves the 14 research units in computer science and communications from the "Paris-Saclay" cluster (2013-2015).
- F. Voisin was in charge of "monitorat et missions enseignement en Informatique" for doctorants at Université Paris-Sud (Until 09.2014). Currently, he represents Polytech Paris-Sud in the hiring comitte of doctorants for "missions enseignement en Informatique".
- F. Zaïdi member of *"commission consultative de spécialistes de l'université"*, Section 27 (informatique) (since 2010)
- F. Zaïdi, member of the research council of the Faculty of sciences (since 2013).

Administration managment

- V. Benzaken, vice dean in charge of human ressources of the Faculty of Science (2014-2016).
- V. Benzaken, member of the *"Comité Technique" de l'Université de Paris-Sud 11.* till 2014.
- V. Benzaken,, responsible of *Service Informatique de la division des Formations*, till 2014.
- V. Benzaken, elected member of " *CNESER (Conseil National de l'Enseignement Supérieur et de la Recherche)"*, in charge of examining legal texts regarding higher education till 2015.
- C. Keller is in charge (together with Nathalie Roy Brown-Brulant) of Licence professionnelle SRSI (L3) at IUT d'Orsay, Paris-Sud University since September 2016.
- C. Marché, member of the executive team of the LRI (as "chargé de mission") 2014-2015.
- C. Paulin, president of the Computer Science Department of the University Paris-Sud **https://www.dep-informatique.u-psud.fr/** (2012-2014).
- C. Paulin, president of the assembly of directors of graduate schools at the Université Paris-Sud (2012-2014).
- C. Paulin, dean of the Faculty of Sciences of Université Paris-Sud, since July 2016.
- F. Zaïdi, Head of the educational computer science service at Paris-Sud (2014-2016).

Organisation of Conferences and Scientific Events

- S. Boldo, organizer of the 29th "Journées Francophones des Langages Applicatifs" (JFLA 2018)
- S. Boldo, vice-organizer of the 28th "Journées Francophones des Langages Applicatifs" (JFLA 2017)
- S. Boldo and G. Melquiond are members of the organizing committee for the 22nd IEEE Symposium on Computer Arithmetic (ARITH 2015), held in Lyon in June 2015.
- A. Charguéraud is the organizer of the 2nd International Workshop on Coq for Programming Languages, co-located with POPL, January 23rd 2016. **http://conf.researchr.org/home/CoqPL-2016**.
- S. Conchon is the program committee co-Chair of ICFEM 2015 (CNAM, Paris, 3-6 November 2015). **http://icfem2015.lri.fr**.
- S. Conchon, local chair and co-organizer for the 44th ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages (POPL 2017), held in Paris, France in January 2017. **http://conf.researchr.org/home/POPL-2017**).
- J.-C. Filliâtre organized the sixth meeting of the IFIP Working Group 1.9/2.15 (Verified Software) in Paris, France, December 2014.
- J.-C. Filliâtre, organizer of EJCP (École Jeunes Chercheurs en Programmation du GDR GPL) at Lille on June 27–July 1, 2016. 42 participants. **http://ejcp2016.univ-lille1.fr/**
- J.-C. Filliâtre, scientific chair and co-organizer of EJCP (École Jeunes Chercheurs en Programmation du GDR GPL) at Toulouse on June 26–30, 2017. **http://ejcp2017.enseeiht.fr/**
- C. Marché, organizer of the first DigiCosme Spring School (**https://www.lri.fr/~marche/DigiCosmeSchool/**) at Supélec, Gif-sur-Yvette, from 22 to 26 april, 2013. 65 participants from France and abroad.
- C. Marché, co-organizer with Y. Moy (AdaCore): public kick-off meeting of the ProofInUse joint lab (Feb. 2, 2015, Paris, **http://www.spark-2014.org/proofinuse/kickoff**).
- C. Marché, co-organizer with M. Sighireanu, Y. Moy, F. Kirchner, N. Kosmatov: first joint Frama-C/SPARK day (May 2017, Paris, **http://frama-c.com/FCSD17.html**), in the context of the Open Source Innovation Spring (**http://www.open-source-innovation-spring.org/**). Around 130 participants.
- G. Melquiond, web chair for the 23rd IEEE Symposium on Computer Arithmetic (Arith 23), held in Silicon Valley, USA in July 2016.
- K. Nguyen, proceedings chair of the European Conference on Object-Oriented Programming (ECOOP 2013), held in Montpellier, France in July 2013 (**http://www.lirmm.fr/ecoop13/**).
- K. Nguyen, student competition chair for the 44th ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages (POPL 2017), held in Paris, France in January 2017 (**http://conf.researchr.org/home/POPL-2017**).
- C. Paulin, organizer with D. Pichardie and S. Blazy of the 4th Conference on Interactive Theorem Proving (**http://itp2013.inria.fr/**) in July 2013.
- C. Paulin, organizer with Zhong Shao (Yale Univ.) of the workshop "Certification of high-level and low-level programs" July 7-11, 2014, as part of the Institut Henri Poincaré thematic trimester on Semantics of proofs and certified mathe-

matics **https://ihp2014.pps.univ-paris-diderot.fr**.

- A. Paskevich is the co-organizer of the 4th international workshop on Proof eXchange for Theorem Proving (PxTP 2015), affiliated with CADE-25 (August 2-3, 2015, Berlin, Germany).
- F. Zaïdi, Steering Comittee member of the 26th IFIP International Conference on Testing Software and Systems (ICTSS 2014).
- F. Zaïdi, Steering Comittee member of the 25th IFIP International Conference on Testing Software and Systems (ICTSS 2013).
- F. Zaïdi, Organizing Committee of CSDM 2013 (Cité Universitaire, Paris, 4-6 December 2013). **http://www.csdm2013.csdm.fr/**

Honors

Awards

- The Coq proof assistant received the ACM SIGPLAN *Programming Languages Software Award* in 2013 **http://www.sigplan.org/Awards/Software/Main**. The development of Coq was initiated by Thierry Coquand and Gérard Huet in 1984. The current environment is the result of the work of more than 40 direct contributors, including major contributions by C. Paulin-Mohring and J.-C. Filliâtre from our team.
  The ACM Software System Award 2013 was given, during a ceremony in June 2014 in San Francisco, to the Coq proof assistant (**http://awards.acm.org/software_system/**). The prestigious ACM price was previously awarded to the LLVM compiler infrastructure (2012) and to the Eclipse IDE (2011). Among the 9 recipients of the 2013 award are C. Paulin and J.-C. Filliâtre, from our team.
- C. Paulin was elected member of the Informatics Section of Academia Europaea **http://www.ae-info.org/**, 2014.
- C. Paulin-Mohring received the award "Michel Monpetit – Institut National de Recherche en Informatique et en Automatique" of the French Academy of Sciences (**http://www.academie-sciences.fr/fr/Laureats/laureats-2015-prix-thematiques.html**).
- C. Paulin-Mohring was nominated for "chevalier de la Légion d'Honneur" (2015).
- M.-C. Gaudel, *Doctor Honoris Causa of the University of York* (2013).
- M.-C. Gaudel, *Visiting Professor at the University of York* (2015).
- J.-C. Filliâtre and G. Melquiond received the "Best team" award of the VerifyThis@ETAPS2015 verification competition (**http://verifythis2015.cost-ic0701.org/results**). The Why3 tool also received the "Distinguished user-assistance tool feature" award.
- (April 2016) Martin Clochard, Léon Gondelman, Mário Pereira: jointly receive the "Best student team" award of the *VerifyThis@ETAPS2016 verification competition*
- J.-C. Filliâtre received the "Best overall team" award of the VerifyThis 2017 verification competition.
- M. Pereira and R. Rieu-Helf received the "Best student team" award of the VerifyThis 2017 verification competition.
- R. Rieu-Helf received the "Student team gold medal" award of the VerifyThis 2018 verification competition.
- (July 2016) S. Boldo: Best Talk Award at workshop NSV *Computing a correct and tight rounding error bound using rounding-to-nearest*.
- V. Benzaken nominated as "Chevalier des Palmes Académiques", 2018.
- V. Blot was awarded a Marie Skłodowska-Curie fellowship for his project "PolyBar: A new approach to polymorphism through bar recursion".

Keynote Addresses and invited talks

International

- V. Benzaken and É. Contejean were invited speaker ("A Coq formal semntics for real-life SQL queries") at the international Coq Workshop, (CoqWS@Floc 18)
- J.-C. Filliâtre was invited as keynote speaker ("One Logic To Use Them All" (A78)) at the International Conference on Automated Deduction in 2013. It is the main conference of the year in the domain of Automated Reasoning. In this talk he presented the Why3 approach for interacting with dozens of provers on the same theories and goals. This invited talk is a recognition by the community of this unique feature of Why3.
- J.-C. Filliâtre was invited speaker ("Deductive Program Verification") at the International Conference on Interactive Theorem Proving (ITP) in 2018, Oxford, UK.
- M.-C. Gaudel, keynote speaker, 11th International Symposium on Theoretical Aspects of Software Engineering (TASE 2017), Sep 2017, Sophia Antipolis, France.
- S. Boldo was invited speaker at the 16th GAMM-IMACS International Symposium on Scientific Computing, Computer Arithmetic and Validated Numerics conference (SCAN 2014) (A119) about her methodology for the formal verification of floating-point programs.
- S. Boldo and G. Melquiond were invited speakers at an international workshop in Lyon, France called Mathematical Structures of Computation during the week 4: Formal Proof, Symbolic Computation and Computer Arithmetic (2014). **http://smc2014.univ-lyon1.fr/doku.php?id=week4**.
- C. Marché, "Beyond SPARK2014: the ProofInUse project", invited talk at the annual meeting of the IFIP Working Group 1.9/2.15, Vienna, Jul. 15, 2014.

- G. Melquiond was invited speaker at the 12th International Workshop on Satisfiability Modulo Theories (SMT 2014).
- G. Melquiond, "Formal verification of a floating-point elementary function", ARITH 22 tutorials, June 25th, 2015, **http://www.ens-lyon.fr/LIP/AriC/tutorials-june-25-2015**.
- S. Boldo gave an invited lecture at Effective Analysis: Foundations, Implementations, Certification in January 2016 at Marseille, France.
- S. Boldo gave a keynote talk in Cambridge at a local workshop about Testing and Verification in Computational Science. 2016
- C. Keller was invited to give a talk at the EUTypes 2018 Working Meeting in Nijmegen: "Mixing type-based proof techniques for the verification of the SQL compilation chain"
- C. Keller was invited to participate in the Dagstuhl (Germany) seminars "Universality of Proofs" (Oct. 2016 16-21) and "Deduction Beyond First-Order Logic" (Sep. 2017 10-15).
- B. Wolff was invited to give a talk at the Departments Colloquim Virginia Tech, Blacksburg, USA: "Towards Verified and Certifiable Subsystems". (Oct 27, 2017).
- B. Wolff was invited to give a tutorial at the 11th International Conference on Tests and Proofs: "Theorem Prover-based Testing: Combining Verification and Testing." (July 19, 2017).
- B. Wolff was invited to give a talk at the Departments Colloquim at University of Sheffield, GB "Monadic Program-based Tests - An Exercise in Test and Proof." (Feb 17, 2017)
- B. Wolff was invited to give a talk at the Departments Colloquim University of York: "Can Testing Be Liberated from the Automata Style ???" (July 2015).

France

- S. Boldo, "Formal verification of numerical programs", long talk at the Journées du GDR IM, Lyon, January 21st.
- C. Lelay was invited speaker at the 25th JFLA (Journées Francophones des Langages Applicatifs), Fréjus, France, Jan 10th, 2014 about "Coq passe le bac": she tried the 2013 mathematics test of the scientific Baccalaureate in Coq at the same time as the students.
- C. Marché, "SMT solvers in Deductive Program Verification", journée "solveurs SMT dans le contexte des systèmes embarqués critiques" de l'AFSEC **http://afsec.asr.cnrs.fr/**, Mar. 29, 2016.
- C. Keller was invited to give a talk at *Journées FAC (Formalisation des Activités Concurrentes)* in March 2017 in Toulouse: "Les prouveurs automatiques pour la preuve et le test formel".
- J.-H. Jourdan was invited to give a talk at *Journées annuelles du GT-Verif* in May 2018 in Grenoble: "RustBelt et Iris – Sûreté du système de types de Rust et logique de séparation concurrente extensible d'ordre supérieur".

Miscellaneous Highlights

- The *Castor informatique* **http://castor-informatique.fr/**, is an international competition to present computer science to pupils (from *6ème* to *terminale*). Two members of the Toccata team (S. Boldo and A. Charguéraud) belong to the organization committee (5 people). More than 170,000 teenagers played on more than 30 proposed exercises in November 2013. In November 2014, more than 228,000 teenagers from over 1500 schools participated. In November 2015, more than 345,000 teenagers from over 2280 schools participated.
- The full formalization of the JavaScript language specification (ECMAScript 5) was completed by the *JsCert* team (A58), which includes A. Charguéraud and 7 collaborators from Imperial College and Inria Rennes (**http://jscert.org**). The formalization, which involves more than 10,000 lines of code and an inductive semantics with over 600 reduction rules, is the result of 2 years of effort. It lead to the discovery of bugs in the official standard, in the official test suites, and in all major browsers. In particular, it has raised the interest of several members of the ECMAScript standardization committee, and that of the developers of secure subsets for JavaScript.
- Most 18-year old French students pass an exam called Baccalaureate which ends the high school and is required for attending the university. The idea was to try our Coq library Coquelicot on the 2013 mathematics test of the scientific Baccalaureate. C. Lelay went to the "Parc de Vilgénis" high school in Massy, France and took the 2013 test at the same time as the students, but had to formally prove the answers (A29) (see also **https://www.lri.fr/~lelay/**).

Evaluation of Research

Editorial Boards

- S. Boldo, member of the editorial committee of the popular science web site *interstices*, **http://interstices.info/** (2008-2016).
- S. Boldo, member of the editorial board of Binaire **http://binaire.blog.lemonde.fr**, the blog of the French Computer Science Society (2014-2018).
- J.-C. Filliâtre, member of the editorial board of the *Journal of Functional Programming*.
- 1024, *1024-Bulletin de la Société Informatique de France*, SIF, M.-C. Gaudel (2013-present)
- SCP, *Science of Computer Programming*, Elsevier, M.-C. Gaudel (1981-present)
- FAoC, *Formal Aspect of Computing*, Springer, M.-C. Gaudel (1989-present)
- *Formal Method subline of LNCS series*, Springer, M.-C. Gaudel, co-chair (2016-present)
- G. Melquiond, member of the editorial board of *Reliable Computing*.

- C. Paulin, member of the editorial board of the *Journal of Formalized Reasoning*.

Program Committees

Chair

- S. Boldo, program chair, 10th International Workshop on Numerical Software Verification (NSV 2017) in collaboration with Alessandro Abate (Oxford) (A186).
- S. Boldo, program vice-chair, 28th "Journées Francophones des Langages Applicatifs" (JFLA 2017) (A189).
- S. Boldo, program chair, 29th "Journées Francophones des Langages Applicatifs" (JFLA 2018) (A188).
- A. Charguéraud, program chair, 2nd International Workshop on Coq for Programming Languages, co-located with POPL, January 23rd 2016. **http://conf.researchr.org/home/CoqPL-2016**.
- A. Charguéraud, program chair, 2nd International Workshop on Coq for Programming Languages, co-located with POPL, January 23rd 2016. **http://conf.researchr.org/home/CoqPL-2016**.
- S. Conchon, program co-Chair, ICFEM 2015 (CNAM, Paris, 3-6 November 2015). **http://icfem2015.lri.fr**.
- J.-C. Filliâtre, program chair, EJCP (École Jeunes Chercheurs en Programmation du GDR GPL) at Lille on June 27–July 1, 2016. **http://ejcp2016.univ-lille1.fr/**
- J.-C. Filliâtre, program chair, EJCP (École Jeunes Chercheurs en Programmation du GDR GPL) at Toulouse on June 26–30, 2017. **http://ejcp2017.enseeiht.fr/**
- J.-C. Filliâtre, program chair, EJCP (École Jeunes Chercheurs en Programmation du GDR GPL) at Lyon on June 25–29, 2018. **https://ejcp2018.sciencesconf.org/**
- C. Marché, *Tool Chair* of the program committee of the 19th International Conference on Tools and Algorithms for the Construction and Analysis of Systems (TACAS 2013, Rome, Italy, **http://www.etaps.org/index.php/2013/tacas**), part of the ETAPS joint Conference. The tool chair is responsible for the evaluation and selection of tool papers and tool demonstrations, following precise guidelines given in the call for papers. This initiative of TACAS aims at making the selection of such submissions more accurate (**http://www.etaps.org/index.php/2013/tacas/tacas13-tool-papers-menu**).
- A. Paskevich, programm co-chair, 4th international workshop on Proof eXchange for Theorem Proving (PxTP 2015), affiliated with CADE-25 (August 2-3, 2015, Berlin, Germany).
- A. Paskevich, program chair of the 9th Working Conference on Verified Software: Theories, Tools, and Experiments (VSTTE 2017), in collaboration with Thomas Wies (NYU) (A191). https://inception.universite-paris-saclay.fr/fr/
- F. Zaïdi, co-chair, Formal Methods Doctorial Symposium (Oxford, 14 July 2018). **http://www.fm2018.org/doctoral-symposium/**
- F. Zaïdi, General Chair, ICFEM 2015 (CNAM, Paris, 3-6 November 2015). **http://icfem2015.lri.fr**.

Member (international events)

- T. Balabonski, 44th ACM SIGPLAN Symposium on Principles of Programming Languages (POPL 2017), Artifact Evaluation.
- T. Balabonski, 30th International Conference on Computer Aided Verification (CAV 2018), Artifact Evaluation.
- V. Benzaken, 22nd European Symposium on Programming (ESOP 2013)
- V. Benzaken, 28th European Symposium on Programming (ESOP 2013)
- S. Boldo, 22nd IEEE Symposium on Computer Arithmetic (ARITH 2015).
- S. Boldo, 23rd IEEE Symposium on Computer Arithmetic (ARITH 2016).
- S. Boldo, 24th IEEE Symposium on Computer Arithmetic (ARITH 2017)
- S. Boldo, 25th IEEE Symposium on Computer Arithmetic (ARITH 2018)
- S. Boldo, 6th ACM SIGPLAN Conference on Certified Programs and Proofs (CPP 2017)
- S. Boldo, 7th ACM SIGPLAN Conference on Certified Programs and Proofs (CPP 2018)
- S. Boldo, 8th International Conference on Interactive Theorem Proving (ITP 2017)
- S. Boldo, Tenth NASA Formal Methods Symposium (NFM 2018)
- S. Boldo, 1st Workshop on High-Consequence Control Verification (HCCV 2016).
- S. Boldo, 7th International Workshop on Numerical Software Verification (NSV 2014).
- S. Boldo, 8th International Workshop on Numerical Software Verification (NSV 2015).
- S. Boldo, 9th International Workshop on Numerical Software Verification (NSV 2016).
- S. Boldo, 7th Coq Workshop (2015).
- A. Charguéraud, 25th European Symposium on Programming (ESOP), April 2016, **http://www.etaps.org/index.php/2016/esop**.
- A. Charguéraud, International Workshop on Hammers for Type Theories (HaTT 2016).
- A. Charguéraud, Workshop on ML (ML 2016).
- A. Charguéraud, external review commitee for POPL 2015.
- É. Contejean, 24th International Conference on Automated Deduction (CADE 24, **http://www.cade-24.info/**)
- É. Contejean, ACM SIGPLAN 2014 Workshop on Partial Evaluation and Program Manipulation (PEPM 2014, **http://www.program-transformation.org/PEPM14**) affiliated with the POPL 2014 conference.

- É. Contejean, 13th International Workshop on Termination (WST 2013, **http://www.imn.htwk-leipzig.de/WST2013/**).
- J.-C. Filliâtre, 5th NASA Formal Methods Symposium (NFM 2013)
- J.-C. Filliâtre, Certified Programs and Proofs (CPP 2013)
- J.-C. Filliâtre, Symposium on Languages, Applications and Technologies (SLATE 2013)
- J.-C. Filliâtre, VeriSure: Verification and Assurance (2013)
- J.-C. Filliâtre, 5th Working Conference on Verified Software: Theories, Tools and Experiments (VSTTE 2013)
- J.-C. Filliâtre, Symposium on Languages, Applications and Technologies (SLATE 2014)
- J.-C. Filliâtre, Symposium on Languages, Applications and Technologies (SLATE 2015)
- J.-C. Filliâtre, NASA Formal Methods (NFM 2015)
- J.-C. Filliâtre, 15th International Workshop on Automated Verification of Critical Systems (AVoCS 2015)
- J.-C. Filliâtre, Symposium on Trends in Functional Programming (TFP 2015)
- J.-C. Filliâtre, 8th Working Conference on Verified Software: Theories, Tools and Experiments (VSTTE 2016)
- J.-C. Filliâtre, First International Workshop on Hammers for Type Theories (HaTT 2016)
- J.-C. Filliâtre, Symposium on Languages, Applications and Technologies (SLATE 2017)
- J.-C. Filliâtre, 18th International Workshop on Automated Verification of Critical Systems (AVOCS 2018)
- J.-C. Filliâtre, Symposium on Languages, Applications and Technologies (SLATE 2018)
- J.-H. Jourdan 9th International Conference on Interactive Theorem Proving (ITP 2018)
- J.-H. Jourdan Coq Workshop 2018
- C. Keller, 6th Workshop on Mathematically Structured Functional Programming (MSFP 2016)
- C. Keller, 5th Workshop on Practical Aspects of Automated Reasoning (PAAR 2016)
- C. Keller, Logical Frameworks and Meta-Languages: Theory and Practice (LFMTP 2016)
- C. Keller, Hammers for Type Theories (HaTT 2016)
- C. Keller, 44th ACM SIGPLAN Symposium on Principles of Programming Languages (POPL 2017)
- C. Keller, 5th Workshop on Proof eXchange for Theorem Proving (PxTP 2017)
- C. Keller, 9th International Conference on Interactive Theorem Proving (ITP 2018)
- C. Keller, Logical Frameworks and Meta-Languages: Theory and Practice (LFMTP 2018)
- C. Keller, 4th International Workshop on Coq for Programming Languages (CoqPL 2018)
- C. Keller, Off the Beaten Track (OBT 2018)
- C. Keller, 7th Workshop on Practical Aspects of Automated Reasoning (PAAR 2018)
- C. Keller, 12th International Conference on Tests & Proofs (TAP 2018)
- D. Longuet, 23rd International Conference on Testing Software and Systems (ICTSS 2011).
- D. Longuet, 28th Symposium on Applied Computing, Software Verification Track (SAC 13).
- D. Longuet, 1st Usages of Symbolic Execution Workshop (USE 15)
- C. Marché, first international workshop Formal-IDE (F-IDE), held as a satellite workshop of ETAPS 2014
- C. Marché, 2nd international workshop Formal-IDE (F-IDE 2015).
- G. Melquiond, 3rd International Workshop on Coq for Programming Languages (CoqPL 2017).
- G. Melquiond, 1st ACM SIGPLAN Workshop on Machine Learning and Programming Languages (MAPL 2017).
- G. Melquiond, 10th International Workshop on Numerical Software Verification (NSV 2017).
- G. Melquiond, 11th International Workshop on Numerical Software Verification (NSV 2018).
- K. Nguyen, International Conference on Functional Programming 2018 (ICFP 18), external review commitee member.
- A. Paskevich, 3rd International Workshop on Proof Exchange for Theorem Proving (PxTP 2013) affiliated with the CADE-24 conference.
- A. Paskevich, 11th International Workshop on User Interfaces for Theorem Provers (UITP 2014) affiliated with the FLoC 2014 conference.
- A. Paskevich, 20th International Symposium on Formal Methods (FM 2015).
- C. Paulin, 4th conference on Interactive Theorem Proving (ITP 2013, **http://itp2013.inria.fr/**
- C. Paulin, 5th conference on Interactive Theorem Proving (ITP 2014 **http://www.cs.uwyo.edu/~ruben/itp-2014/**).
- C. Paulin, Coq Workshop 2014.
- C. Paulin, 4th ACM-SIGPLAN Conference on Certified Programs and Proofs (CPP 2015, colocated with POPL 2015).
- C. Paulin, conference on Mathematics of Program Construction (MPC 2015).
- C. Paulin, 21st International Conference on Types for Proofs and Programs (Types 2015).
- C. Paulin, 20th International Conferences on Logic for Programming, Artificial Intelligence and Reasoning (LPAR-20).
- C. Paulin, 31st Annual ACM/IEEE Symposium on Logic in Computer Science (LICS 2016).
- C. Paulin, 7th International Conference on Interactive Theorem Proving (ITP 2016).
- F. Zaïdi, 21nd International Symposium on Formal Methods (FM 2018).
- F. Zaïdi, 22st International Symposium on Formal Methods (FM 2016).
- F. Zaïdi 24th International Conference on Web Services (ICWS 2017)
- F. Zaïdi 23rd International Conference on Web Services (CWS 2016)
- F. Zaïdi 22nd International Conference on Web Services (ICWS 2015)
- F. Zaïdi 21th International Conference on Web Services (ICWS 2014)
- F. Zaïdi 20th International Conference on Web Services (ICWS 2013)

- F. Zaïdi 29th IFIP International Conference on Testing Software and Systems (ICTSS 2017)
- F. Zaïdi 28th IFIP International Conference on Testing Software and Systems (ICTSS 2016)
- F. Zaïdi 27th IFIP International Conference on Testing Software and Systems (ICTSS 2015)
- F. Zaïdi 18th International Conference on Formal Engineering Methods (ICFEM 2016)
- F. Zaïdi 33rd ACM Symposium on Applied Computing (SAC, track SVT 2018)
- F. Zaïdi 32nd ACM Symposium on Applied Computing (SAC, track SVT 2017)
- F. Zaïdi 31st ACM Symposium on Applied Computing (SAC, track SVT, 2016)
- F. Zaïdi 30th ACM Symposium on Applied Computing (SAC, track SOAP, 2015)
- F. Zaïdi The 2018 IEEE International Conference on Software Quality, Reliability & Security (QRS 2018)
- F. Zaïdi The 2017 IEEE International Conference on Software Quality, Reliability & Security (QRS 2017)
- F. Zaïdi The 2016 IEEE International Conference on Software Quality, Reliability & Security (QRS 2016)
- F. Zaïdi The 2015 IEEE International Conference on Software Quality, Reliability & Security (QRS 2015, (fusion of SERE and QSIC conferences)
- F. Zaïdi 9th International Conference on Tests and Proofs (TAP 2015)
- F. Zaïd 8th International Conference on Tests and Proofs (TAP 2014)
- F. Zaïdi 7th International Conference on Tests and Proofs (TAP 2015)
- F. Zaïdi 11th International Colloquim on Theoretical Aspects of Computing (ICTAC 2014)
- F. Zaïdi 16th IEEE International Symposium on High Assurance Systems Engineering (HASE 2015)
- F. Zaïdi 15th IEEE International Symposium on High Assurance Systems Engineering (HASE 2014)
- F. Zaïdi 14th International Conference on Quality Software (QSIC 2014)
- F. Zaïdi 13th International Conference on Quality Software (QSIC 2013)
- F. Zaïdi 20th International Workshop on Formal Methods for Industrial Critical Systems (FMICS 2015)
- F. Zaïdi International Workshop on SOFL+MSVL (2014)
- F. Zaïdi The fifth International Workshop on Security Testing (SECTEST 2014)
- F. Zaïdi Second IEEE International Workshop on Security Testing and Monitoring (STAM affiliated to ICDCS 2016)
- F. Zaïdi Formal Methods in Software Engineering (FORMALISE, wokshop affiliated to ICSE 2014)
- F. Zaïdi Workshop on Formal Methods in the Development of Software (WS-FMDS, affiliated to SEFM 2016)

Member (national events)

- T. Balabonski, 27th Journées Francophones des Langages Applicatifs (JFLA 2016).
- S. Boldo, member of the program committee of the Inria Scientific Days in Rennes (June 2016).
- S. Boldo, 26th Journées Francophones des Langages Applicatifs (JFLA 2015)
- S. Boldo, 27th Journées Francophones des Langages Applicatifs (JFLA 2016).
- J.-C. Filliâtre, Journées Francophones des Langages Applicatifs (JFLA 2014).
- D. Longuet, 14th Journées Approches Formelles dans l'Assistance au Développement de Logiciels (AFADL 2015).
- D. Longuet, 15th Journées Approches Formelles dans l'Assistance au Développement de Logiciels (AFADL 2016).
- D. Longuet, 16th Journées Approches Formelles dans l'Assistance au Développement de Logiciels (AFADL 2017).
- D. Longuet, 17th Journées Approches Formelles dans l'Assistance au Développement de Logiciels (AFADL 2018).
- K. Nguyen, 30th Journées des Bases de Données Avancées (BDA 2014).
- K. Nguyen, 26th Journées Francophones des Langages Applicatifs (JFLA 2015).
- K. Nguyen, 29th Journées Francophones des Langages Applicatifs (JFLA 2018).
- C. Marché, member of the program committee of the Inria Scientific Days in Bordeaux (June 2018).
- F. Zaïdi Journées francophones Internationales sur les Approches formelles dans l'assistance du développement de logiciels (AFADL 2018, 2017, 2016, 2015, 2013)

Evaluation Committees and Invited Expertise

- S. Boldo, member of the reviewing board for the ANR (first step in 2016).
- S. Boldo, member of the 2015, 2016, and 2017 committees for the Gilles Kahn PhD award of the French Computer Science Society.
- É. Contejean, member of the committee of experts for the AERES evaluation of the Verimag laboratory (2014).
- É. Contejean, reviewer for the ANR (2014).
- É. Contejean, reviewer for the START program of the Austrian Science Fund (FWF) (2014).
- C. Marché (2012-2015) and S. Boldo (2012-2014), members of the *"jury de l'agrégation externe de mathématiques"* as experts in computer science.
- C. Marché, reviewer for ANR (2014, 2015), Chalmers Institute of Technology (2014, 2018), Dutch Research Council NWO (2018), Dutch Technology Foundation STW (2015)
- C. Marché, member of the program committee of Digiteo Labs, the world-class research park in *Île-de-France* region dedicated to information and communication science and technology, **http://www.digiteo.fr/**. President of this committee from July 2013. (April 2007-2015)
- C. Marché, president of the evaluation committee of the joint Digiteo-DigiCosme calls for projects funding PhDs and

Post-docs (2015,2016)

- C. Marché, member of the scientific commission of Inria-Saclay, in charge of selecting candidates for PhD grants, Post-doc grants, temporary leaves from universities ("délégations") (2016-2017)
- C. Marché, member of the "Bureau du Comité des Projets" of Inria-Saclay, in charge of examining proposals for creation of new Inria project-teams. (2016-2018)
- A. Paskevich, reviewer for the ANR (second step in 2015).
- F. Zaïdi, reviewer for The Region Aquitaine (2015)

Other evaluation activities

- S. Boldo, C. Marché, G. Melquiond, D. Longuet and F. Voisin members of committees in charge of recruiting assistant professors at Université Paris-Sud (2014)
- É. Contejean, member of the hiring committee for an associate professor position (Maître de Conferences) at Université Paris 6 - IRCAM (2013)
- É. Contejean, member of the hiring committee for an associate professor position (Maître de Conferences) at ENS Paris-Saclay (2018)
- C. Marché, president of the hiring committee of one associate professor position (Maître de Conferences), Université Paris-Sud, April-June 2014. Member of another such committee.
- C. Paulin, chaired the hiring committee for a professor position in computer science at Université Paris-Sud (2014)
- C. Paulin, chaired the hiring committee for a professor position in computer science at Université Paris-Sud (2015)
- C. Paulin, chaired the hiring committee for a professor position in computer science at Université Paris-Sud (2016)
- S. Boldo, member of the 2016 committee for the Gilles Kahn PhD award of the French Computer Science Society.
- C. Marché, member of a hiring committee for an associate professor position in computer science at CNAM, Paris, France. (sep-oct 2016)
- S. Boldo, member of the program committee for selecting postdocs of the maths/computer science program of the Labex mathématique Hadamard.
- S. Boldo, member of a hiring committee for an associate professor position in computer science at Université Joseph Fourier, Grenoble, France. (2017)
- S. Boldo, member of hiring committees for junior Inria researchers in Bordeaux and Nancy (CR2) and of the national hiring committee for first-class junior researchers (CR1) (2014)
- S. Boldo, member of hiring committees for junior Inria researchers in Saclay and Sophia-Antipolis (CR2) (2013)
- C. Keller, member of a hiring committee for junior Inria researchers in Saclay–Île-de-France (2018)
- C. Keller, member of several hiring committees for associate professor positions in computer science at Univ. Paris-Sud (2017,2018)
- C. Keller has been an examiner for the entrance exam at École Normale Supérieure de Paris in 2016.
- K. Nguyen, member of a hiring committee for an associate professor position in computer science at Université Paris Diderot, Paris, France. (2018)
- F. Zaïdi, Member of the National Committee of University (CNU), section 27 (computer science) (since sep. 2017)
- F. Zaïdi Member of a hiring committee for an associate professor position in computer science at CNAM, Paris, France (sep-oct 2016)
- F. Zaïdi Member of a hiring committee for an associate professor position in computer science at IUT Bordeaux (2017)

Interactions with the social, economic and cultural environment

Interaction with the economic environment

Critical Software written in Ada SPARK2014 is an environment for the development of safety- and security-critical software written in the Ada programming language. SPARK2014 is developed and distributed by the AdaCore company (Paris) since 2014 (**http://www.spark-2014.org/**). The ProofInUse joint lab aims at transferring the technology of deductive program verification, as implemented in our tool Why3, into SPARK2014. The team's scientific innovations transferred into SPARK2014 concern various topics such as techniques to support bitvectors (A152), floating-point computations (A153), and the generation of counterexamples in case of proof failure (A156).

Transfer to the community of Atelier B In the ANR project BWare, we investigated the use of Why3 and Alt-Ergo as an alternative back-end for checking proof obligations generated by *Atelier B*, whose main applications are railroad-related software[2], a collaboration with Mitsubishi Electric R&D Centre Europe (Rennes) and ClearSy (Aix-en-Provence).

[2] **http://www.methode-b.com/documentation_b/ClearSy-Industrial_Use_of_B.pdf**

Dissemination

- C. Marché, "Deductive Verification in Frama-C and SPARK2014: Past, Present and Future", talk at the joint Frama-C/SPARK day, Open Source Innovation Spring, May 30, 2018
- C. Marché, "Le Laboratoire Commun ProofInUse Inria Toccata - PME AdaCore", comité de direction d'Inria, May 7, 2017
- C. Marché, "Le labCom ProofInUse", visite de l'Inspection Générale de l'Administration de l'Éducation Nationale, Sep. 11, 2017
- C. Marché, "LabCom ProofInUse et logiciels libres", Minute nécessaire du transfert, Inria Saclay, Dec. 6, 2016
- C. Marché, "An History of Frama-C", first Frama-C Day, May 15, 2015

Popularisation of Research Results

During the period:

- From 2008 to 2016, S. Boldo has been member of the editorial committee of the popular science web site)i(: **http://interstices.info/**.
- From 2014 to 2018, S. Boldo has been member of the editorial board of Binaire **http://binaire.blog.lemonde.fr**, the blog of the French Computer Science Society.
- From 2012, S. Boldo is scientific head for Saclay for the MECSI group for networking about computer science popularization inside Inria.

- M.-C. Gaudel, member of the board (2012-present) and since 2015 member of the executive board of the association *Femmes et Sciences*: numerous lectures and panels in secondary schools on women in science, scientific jobs, stereotypes, etc; frequent participations to careers fairs (Savantes Banlieues, Carrousel des Métiers, etc). **http://www.femmesetsciences.fr/**
- M.-C. Gaudel, member of the Scientific Committee of the association *Science Ouverte* (Drancy), (2007-present). **http://scienceouverte.fr/**
  - lectures (with Johanne Cohen) in January 2015, to pupils of the lycée Condorcet, Montreuil on: layers and algorithms in computer networks (seconde), and computability (terminale).
  - one-day visit at LRI (thanks to the whole laboratory) of the pupils above in June 2015.
  - lecture at *Scientific Park* at Bobigny in December 2016: "Alan Turing : vous avez dit Calcul ?" in front of more than 200 persons. This series of conference takes place at the Paris 13 University and targets pupils in secondary schools, teachers, and public audience.
    http://scienceouverte.fr/Programme-Scientific-Park-2017-2018
- M.-C. Gaudel, honorary member of the SIF, *Société Informatique de France*:
  - Organising committee and lecturer at the 2015 annual symposium devoted to "Femmes et Informatiques", Orléans, Feb. 2015
  - Panelist at the SIF meeting on "Femmes et Numérique", May 2016.
- M.-C. Gaudel, member of the Scientific Committee of *Scube* (2009-present): organisation of scientific exhibitions. **http://partageonslessciences.com/**

In 2013,

- S. Conchon and J.-C. Filliâtre were involved in the writing of a new book supporting the new teaching program for the *"Classes préparatoires aux grandes écoles"* (A181).
- S. Boldo and A. Charguéraud belong to the organization committee of the *Castor informatique* **http://castor-informatique.fr/**, an international competition to present computer science to pupils (from *6ème* to *terminale*). More than 170,000 teenagers played on the more than 30 proposed exercises in November 2013.
- S. Boldo, member of the popularization committee, *comité de médiation scientifique*, of Inria.
- S. Boldo was among the authors of a document (A211) that describes the present and future of popularization at Inria.
- S. Boldo is responsible for a *mission doctorale* for popularization. She is in charge of Li Gong of the LIMSI laboratory: he wrote an Interstices article: **http://interstices.info/traduction-automatique-statistique**.
- S. Boldo, talk at the *Fête de la science* 2013 for the laboratory, October 11th.
- S. Boldo, talk for a general audience at the Courbevoie library, February 9th
- S. Boldo, talk for teenagers at the lycée Talma de Brunoy, April 23th
- S. Boldo, talk for mathematics teachers at Rocquencourt, June 5th
- S. Boldo, "speed-dating" with teenagers at the Halle Forum, October 18th, in an event called "Science au carré(e)".
- S. Boldo, article for the French blog celebrating 2013 as the "Mathematics of Planet Earth" year: **http://mpt2013.fr/meme-les-ordinateurs-font-des-erreurs/**.
- C. Lelay tried the 2013 mathematics test of the scientific Baccalaureate in Coq. After the test, a meeting was organized with some teachers and the produced proofs and results were presented.
- C. Paulin organised at the *Fête de la science* 2013 an action of Labex DigiCosme to promote the new course "Informatique and Sciences du Numériques" in high-school, a few selected projects developed by students as part

of their curriculum were exhibited.

In 2014,

- S. Boldo presented the *Concours Castor informatique* to computer sciences teachers (ISN) in Nancy on April 17th, 2014. A video of the talk is available at **http://videos.univ-lorraine.fr/index.php?act=view&id=1369**.
- S. Boldo gave a 2-hour course entitled *Les nombres et l'ordinateur* at the École Normale Supérieure de Cachan, France, on September 9th.
- S. Boldo gave a 2-hour course *Pourquoi mon ordinateur calcule faux?* to a general audience at the Université Inter-Âge in Versailles, France, on March 4th.
- S. Boldo gave a talk for computer sciences teachers (ISN) in Créteil on March 24th
- S. Boldo gave a talk for teenagers at the lycée Maximilien Perretin Alfortville on May 22nd.
- S. Boldo wrote an article with Jean-Michel Muller (ARIC) in the popularization journal La Recherche (A40).
- S. Boldo wrote in 2013 an article for the French blog celebrating 2013 as the "Mathematics of Planet Earth" year: **http://mpt2013.fr/meme-les-ordinateurs-font-des-erreurs/**. This article was selected to be published in a book published in 2014 (A177).
- S. Boldo, G. Melquiond, A. Paskevich, and C. Paulin animated two stands at the *Fête de la science*.
- A. Charguéraud and S. Boldo contributed to the preparation of the exercises of the *Concours Castor informatique* **http://castor-informatique.fr/**. A. Charguéraud is also one of the three organizers of this contest. The purpose of the Concours Castor in to introduce pupils (from *6ème* to *terminale*) to computer sciences. More than 228,000 teenagers played with the interactive exercises in November 2014.
- S. Conchon and J.-C. Filliâtre published a book *"Apprendre à programmer avec OCaml"* for undergraduate students learning computer programming (A180) (Eyrolles, September 2014).

In 2015,

- A. Charguéraud and S. Boldo contributed to the preparation of the exercises of the *Concours Castor informatique* **http://castor-informatique.fr/**. A. Charguéraud is also one of the three organizers of this contest. The purpose of the Concours Castor in to introduce pupils (from *CM1* to *Terminale*) to computer sciences. More than 345,000 teenagers played with the interactive exercises in November 2015.
- C. Marché, together with J. Kanig from AdaCore company, wrote an article in the ERCIM news journal (A38) to advertise on the work done in the ProofInUse joint laboratory for the popularization of formal methods in the development of safety-critical Ada programs.
- S. Boldo, with T. Vieville (Mnemosyne team, Inria Bordeaux - Sud-Ouest), F. Masseglia (Zenith team, Inria Sophia Antipolis - Méditerranée and P. Bernhard (INRA) wrote a text about the TIPE 2016 (personal work before the competitive entrance in engineering schools). The topic was "Structures: organization, complexity, dynamic". This was published on the popularization website **http://pixees.fr** (A213).
- S. Boldo co-organized popularization talks for the administrative staff of Inria Saclay - Île-de-France. She gave a talk on January 29th about a scientific article (A120) and led a coding session (with Scratch) on February 12th with A. Imperiale (M3DISIM team).
- S. Boldo co-organized the coming of teenagers from the collège Flemming in Orsay to the laboratory on May 28th and gave talks to several groups all day long.
- S. Boldo co-organized the Inria Saclay - Île-de-France *Fête de la science*. She created two stands (about programming) and run one on October 9th.
- S. Boldo gave a talk to the winners of the Mathematics Olympiads on June 10th in Rocquencourt.
- S. Boldo gave a talk at the "Girls can code" week on August 27th, in Paris.
- S. Boldo gave a talk to high school teenagers in Angers on October 12th.
- S. Boldo gave a talk to "Classes Préparatoires" at l'Essouriau, Les Ulis on September 24th.
- S. Boldo gave a talk at "Futur en Seine" a popularization festival in Paris and Paris area, in Orsay, on June 18th.
- J.-C. Filliâtre gave a talk at "Mathematic Park" in Institut Henri Poincaré, Paris, on March 7th.
- C. Paulin together with I. Glas from labex DigiCosme is proposing an introduction to computer science (various activities on programming, data representation, algorithms during 6 sessions of 1 hour) as an extracurricular activity in schools for pupils in *CM1-CM2*.
- C. Paulin organised in 2015 the third edition of the Concours ISN of the Labex DigiCosme, supported by the Rectorat de l'Académie de Versailles. Selected projects developed by the high school pupils (Terminale) as part of their curricula in Computer Science are submitted to this contest. The best projects are selected and presented during a general event.
- C. Paulin, I. Glas, and A. Paskevich run a stand (introduction to information technologies and programming) during the "Fête de la science" Île-de-France on October 9 and 10.

In 2016,

- A. Charguéraud is one of the three organizers of the *Concours Castor informatique* **http://castor-informatique.fr/**. The purpose of the Concours Castor in to introduce pupils (from *CM1* to *Terminale*) to computer sciences. 475,000 teenagers played with the interactive exercises in November 2016.

- S. Boldo is a speaker for a MOOC for computer science teachers. She was also invited to Poitiers in November 2016 to discuss with teachers and present this MOOC.
- S. Boldo was invited to a panel about teaching computer science before university in Besançon in June 2016 during the GDR GPL days.
- During the "Fête de la science" on October 14th to 16th, S. Boldo gave several talks about computer arithmetic to teenagers and F. Faissole run a stand about an introduction to programming with robots.
- S. Boldo and F. Voisin did an introduction to computer science with an activity on computer hardware as a 1-hour extracurricular activity in schools for pupils in *CM1-CM2* on October 4th.
- S. Boldo gave a talk during a girls & maths weekend on November 22nd. See **http://www.animath.fr/spip.php?article2897&lang=fr**.

In 2017,

- S. Boldo, scientific head for Saclay for the MECSI group for networking about computer science popularization inside Inria.
- S. Boldo gave a talk at the Inria Saclay about how to popularize programming.
- During the "Fête de la science" on October 13th, S. Boldo demonstrated unplugged computer science to teenagers and F. Faissole run a stand about an introduction to programming with robots. S. Boldo also did this activity to kids from 7 to 17 at the Massy opera on November, 17th.
- S. Boldo gave a talk during at a *Girls can code* weekend on August 23rd in Paris.
- S. Boldo went to the Arpajon high-school for presenting Women in Science on December 19th.
- S. Boldo gave a popularization talk to the administrative staff of Inria at Rocquencourt for the Inria birthday on November 16th.

In 2018,

- J.-C. Filliâtre gave a talk at "Mathematical Summer in Paris" (ENS, Paris), on July 16th.
- C. Keller is invited to write a chapter for the book "Proof Technology in Mathematics Research and Teaching", dedicated to post-grad students and researchers in Mathematics: "SMTCoq: Mixing automatic and interactive proof technologies". To appear in June 2018.

2016-present,

- F. Voisin, Ch. Froidevaux, F. Boulanger and M. Bénard organize "Introduction to programming" sessions as an extracurricular activity for pupils in *CE2-CM2* in schools in Bures-sur-Yvette.

Contracts and grants

Public contracts and grants (jan 2013 - jun 2018)

Type	*Scientific director*	*Name*	*Managing Institution*	*Start*	*Duration*	*Amount*
Digiteo	BOLDO	Coquelicot	Inria	09.2011	36	102.20
ANR	CONCHON	BWARE		09.2012	48	
ANR	BENZAKEN	Typex		01.2012	36	
ANR	MELQUIOND	Verasco	Inria	01.2012	48	158.35
Region IDF	MARCHÉ	Hi-Lite	Inria	05.2010	36	51.59
ANR LabCom	MARCHÉ	ProofInUse	Inria	04.2014	36	300.00
Digicosme	BOLDO	ELFIC		01.2014	24	
ANR	CHARGUÉRAUD	Ajacs	Inria	10.2014	42	64.60
ANR	BOLDO	FastRelax	Inria	10.2014	48	51.76
ANR	CONCHON	Soprano		10.2014	48	
ANR	CONCHON	CAFEIN		02.2013		38.35
ANR	MARCHÉ	CoLiS	Inria	10.2015	48	69.16
ANR	FILLIÂTRE	Vocal		10.2015	48	
ANR	CONTEJEAN	Datacert		01.2016	48	
Digicosme	BOLDO	ELEFFAN	Inria	10.2016	36	113.77
FUI	CONCHON	LCHIP		04.2016	36	
ANR	CONCHON	PARDI		2016	48	

ProofInUse Joint Lab

Partners: AdaCore (Paris)

See **http://www.spark-2014.org/proofinuse**

Type: ANR LabCom
Amount: 300.00 k€
Duration: 36 months
Scientific director for LRI: MARCHÉ

ProofInUse is a joint lab between the Inria team Toccata and the SME AdaCore. It was selected and funded by the ANR programme "Laboratoires communs", starting from April 2014, for 3 years. AdaCore is a software publisher specializing in providing software development tools for critical systems. A previous successful collaboration between Toccata and AdaCore enabled Why3 technology to be put into the heart of the AdaCore-developed SPARK technology. The goal is to promote and transfer the use of deduction-based verification tools to industry users, who develop critical software using the programming language Ada. The proof tools are aimed at replacing or complementing the existing test activities, whilst reducing costs.

CoLiS

Type: ANR
Amount: 69.16 k€
Duration: 48 months
Scientific director for LRI: MARCHÉ

Partners: Université Paris-Diderot, IRIF, coordinator; Inria Lille, team LINKS

See **http://colis.irif.univ-paris-diderot.fr/**

The project aims at developing formal analysis and verification techniques and tools for scripts. These scripts are written in the POSIX or bash shell language. Our objective is to produce, at the end of the project, formal methods and tools allowing to analyze, test, and validate scripts. For this, the project will develop techniques and tools based on deductive verification and tree transducers stemming from the domain of XML documents.

Private contracts and grants (jan 2013 - jun 2018)

Type	*Scientific director*	*Name*	*Managing Institution*	*Start / Duration*		*Amount*
CIFRE	MARCHÉ	AdaCore,Paris	Inria	01.2012	36	42.75
Industriel	MARCHÉ	AdaCore, Paris	Inria	04.2014	36	209.28
CIFRE	MELQUIOND	TrustInSoft, Paris	Inria	10.2017	48	45.00
Intel grant	CONCHON	Intel Strategic Cad Labs, Hillsboro, OR, USA		12.2012	24	
Oracle grant	BENZAKEN, NGUYEN	Oracle Labs, Grenoble, France	Université Paris-Sud	09.2015	36	75

ProofInUse

Type: Privé
Amount: 209.28 k€
Duration: 36 months
Scientific director for LRI: MARCHÉ

Partners: SME AdaCore (Paris)

See **http://www.spark-2014.org/proofinuse**

This contrat is the supplementary funding of the ProofInUse joint lab provided by the AdaCore company.

BOLDR

Type: Privé
Amount: 75 k€
Duration: 36 months
Scientific director for LRI: BENZAKEN NGUYEN

Partners: Oracle Labs (Grenoble)

See **https://labs.oracle.com/pls/apex/f?p=labs:50:0:::::**

This contrat is an unrestricted grant for the BOLDR project of the data-centric languages activty.

Projet-PST

Type: Privé
Amount: 130.28 k€
Duration: 36 months
Scientific director for LRI: WOLFF

Partners: IRT SystemX / Althom

See **https://www.irt-systemx.fr/project/pst/**

This contrat is jointly funded by the IRT SystemX lab and Alstom and was used for the delegation of B. Wolff for one year from Sept. 2016 to Aug. 2017.

Training and Education

Master Internships

- T. Balabonski and X. Urbain supervised the M2 internship of Robin Pelle, who formalised asynchronous execution of mobile sensors networks.
- S. Conchon supervised the M2 internship of M. Roux, who developed a new reachability algorithm for the Cubicle Model Checker.
- A. Charguéraud supervised, with F. Pottier (Inria Paris) the M2 internship of Armaël Guéneau, who developed a formalization in Coq of the big-O notation, and put it to practice to establish big-O asymptotic bounds in CFML, in particular for a sequence data structure with logarithmic-time random access operations.
- C. Paulin supervised with F. Hivert (LRI) the magistère of Mathematics internship of Olivier Stietel, who developed a proof in Coq of a result in combinatorics (a result of Frame, Robinson and Thrall counting the number of Young tableaux of a given shape) using a probabilistic method. ...
- R. Rieu-Helft (ENS, Paris), pre-PhD student under supervision of C. Marché, G. Melquiond and A. Paskevich. He worked on the design and the formal verification of a library for unbounded integer arithmetic. Why3 is used for formally verifying the functional behaviour of the library operations. Raphaël also implemented in Why3 a mechanism for extracting code to the C language, in order to obtain a certified code that runs very efficiently (A106, A173).
- Lucas Baudin (ENS, Paris) was a master 1 intern under the supervision of J.-C. Filliâtre between September 2016 and January 2017. He is working on the inference of loop invariants by abstract interpretation in the tool Why3.
- F. Faissole was a master 2 trainee under the supervision of S. Boldo between March and August 2016. He worked on the formal proof of the Lax-Milgram theorem.
- D. Gallois-Wong was a Master-2 intern for 4 months under the supervision of S. Boldo. She began the formalization in Coq of numerical filters.
- V. Tourneur was a Master-1 intern for 4 months under the supervision of S. Boldo. He developed and proved a new algorithm for computing the average of two floating-point numbers when the radix is 10.
- Julien Grangier, M1 intern ENSIEE, from Jun 2014 until Sep 2014
- K. Nguyen supervised the M2 internship of Romain Vernoux, who formalized an intermediate representation for database queries using an extended lambda-calculus.
- E. Raquel-Martins was a M2 intern for 6 months under the supervision of V. Benzaken, É. Contejean and C. Keller. She worked on a formalization of SQL physical algebra.
- R. Zucchini was a M2 intern for 6 months under the supervision of V. Benzaken, É. Contejean and C. Keller. She works on a formalization of database provenance in scientific workflows.
- A. Bousalem and Q. Garcheyr were M2 interns for 6 months under the supervision of C. Keller. They work on Coq automatic tactics based on SMTCoq.
- G. Mével was a M2 intern for 6 months under the supervision of J.-H. Jourdan and F. Pottier (Inria Paris). He works on formalization of complexity proofs in the Iris separation logic.

Graduate Courses

- Master Parisien de Recherche en Informatique (MPRI) **https://wikimpri.dptinfo.ens-cachan.fr/doku.php**:
  - *Automated Deduction*: S. Conchon (2013), É. Contejean (2013)
  - *Proofs of Programs* **http://www.lri.fr/~marche/MPRI-2-36-1/**, C. Marché (2013-2017), G. Melquiond (2013), A. Charguéraud (2014-2017)
- Master: Fondements de l'informatique et ingénierie du logiciel (FIIL) **https://www.lri.fr/~conchon/parcours_fiil/**:
  - *Programmation C++11 avancée*: G. Melquiond (2015-2017)
  - *Preuves Interactives et Applications*: C. Paulin (2015)
  - *Vérification déductive de programmes*: A. Paskevich (2015-2017)
  - *Software Model Checking*: S. Conchon, F. Zaïdi (2015-2017)
  - *Test Fonctionnel de Protocoles*: F. Zaïdi (2015-2017)
  - *Test de Conformité*: F. Zaïdi (2017)
  - *Outils de test et stratégies de couverture*: D. Longuet (2015-2016)
  - *Langages : sémantique et modèles d'exécution*: T. Balabonski (2017)
- MasterSchool EIT Digital, Interaction Homme-Machine et Design (HCID) **https://www.dep-informatique.u-psud.fr/formation/lmd/M2int-EIT-ICT-HCID**, M.-C. Gaudel (2015)

Internships

- Yohan Chatelain, L3 intern Univ. Paris-Sud, from May 2014 until Jun 2014
- Jacques-Pascal Deplaix, intern EPITECH, from May 2014 until Aug 2014
- Xavier Onfroy, L3 intern ENS Lyon, from Jun 2014 until Jul 2014
- Lucas Baudin, stagiaire Ecole Normale Supérieure Paris, until Jan 2017
- Ilham Dami, L3 intern Univ. Paris-sud, May 2017-Jul 2017, supervised by C. Marché. Software toolset for the CoLiS project (A206)
- Romain Liautaud, L3 intern ENS Lyon, from Jun 2017 until Aug 2017
- Léo Andrès, L3 intern Univ. Paris-Sud, from Jun 2017 until Aug 2017

- Raphaël Cornet, L3 intern Univ. Paris-Sud, from Jun 2017 until Aug 2017

co-directed theses in foreign countries

Alex Alberto: "Sandwich" thesis, co-directed with Adenilso da Silva Simão of the University of Sao Paulo (Brazil). Alex Alberto spent 8 months in LRI, from may 5, 2016 to january 18, 2017 in the framework of the PVE grant of M.-C. Gaudel.

Schools

- M.-C. Gaudel, 7th Halmstad Summer School on Testing, HSST 2017, **http://ceres.hh.se/mediawiki/HSST2017**.
- M.-C Gaudel, "Le test de logiciel, pourquoi et comment", *Ecole Informatique de l'IN2P3*, Lyon, 28-30 sept. 2015, **https://indico.in2p3.fr/event/11728/**
- M-C. Gaudel, "Prouver des programmes, tester des systèmes, vérifier des modèles", Journée ISN-EPI, Nancy, 17 march 2016, training for teachers of the ISN option in secondary schools. **http://idees.loria.fr/index.php?n=Main.ProgrammeJourneeISN-EPI2016**

Thesis

Habilitation à Diriger des Recherches	
Name	*Defense*
Sylvie BOLDO	10.06.2014
Evelyne CONTEJEAN	06.13.2014

Defended thesis				
Name	*Start*	*Defense*	*Funding*	*Advisor*
Romain AISSAT	01.10.2012	30.01.2017	Alloc. Ministère	GAUDEL, VOISIN, WOLFF
Fréderic TUONG	01.02.2013	06.04.2016	IRT SystemX, Projet FSF	WOLFF, LONGUET
Yakoub NEMOUCHI	01.10.2012	30.03.2016	EU PROJECT EUROMILS	WOLFF
Martin CLOCHARD	14.09.2013	30.03.2018	Alloc. ENS Paris	MARCHÉ, PASKEVICH
Claire DROSS	01.01.2011	04.01.2014	CIFRE AdaCore	MARCHÉ, PASKEVICH
Stefania DUMBRAVA	01.10.2012		Alloc. Ministère	BENZAKEN, CONTEJEAN
Léon GONDELMAN	01.10.2013	12.13.2016	Contrat ANR BWare	FILLIÂTRE, PASKEVICH
Paolo HERMS	2011	01.14.2013	CEA grant	MARCHÉ, MONATE (CEA-List)
Huu Nghia NGUYEN	2010	31.10.2013	Alloc. Ministére	ZAÏDI, POIZAT
Mohamed IGUERNELALA	2010	06.10.2013		CONCHON, CONTEJEAN
Catherine LELAY	03.10.2011	06.15.2015	contrat Digiteo-Inria	BOLDO, MELQUIOND
Alain MEBSOUT	01.10.2011	09.29.2014	Alloc. Ministère	CONCHON, ZAÏDI
Hernán PONCE DE LEÓN	01.09.2011	07.09.2014	Projet DIM Digiteo	LONGUET, HAAR (INRIA)
Asma TAFAT	2009	09.06.2013	Alloc. Ministère	MARCHÉ

Position after the thesis	
Name	*Position*
Prenom NOM	Post-doc, où

Thesis in progress			
Name	*Start*	*Funding*	*Advisor*
José ALVAREZ	01.10.2015	Digicosme	ZAÏDI, MAAG
Albin COQUEREAU	09.2015		CONCHON, LE FESSANT, MAUNY
David DECLERCK	09.2014		ZAÏDI, CONCHON
Florian FAISSOLE	10.2016		BOLDO, CHAPOUTOT
Diane GALLOIS-WONG	10.2017		BOLDO, HILAIRE
Julien LOPEZ	09.2015		BENZAKEN, NGUYEN
Georges OUFFOUÉ	01.10.2015	Alloc. Ministére	ZAÏDI
Robin PELLE	10.2016		BALABONSKI, CONTEJEAN
Mário PEREIRA	05.2015	Grant Portuguese government	FILLIÂTRE
Raphaël RIEU-HELFT	10.2017	CIFRE TrustInSoft	MELQUIOND, CUOQ (TrustInSoft)
Mattias ROUX	09.2015		CONCHON
Hai NGUEN-VAN	09.2013		WOLFF, BOULANGER

Software Licensing and Distribution

Pff library - Pff library

Contact: Sylvie BOLDO

The Pff library is a Coq library of definitions and properties about floating-point arithmetic. It is now superseded by the Flocq library and is not maintained anymore.

CiME - CiME: a tool box for automated deduction.

http://cime.lri.fr

Contact: Evelyne CONTEJEAN

CiME 3 is a rewriting toolbox that provides Coq certificates for termination proofs (standard rewriting) obtained using various criteria: Dependency pairs: plain/marks, graphs refinements with or without subterm criterion as well as various orderings: Polynomial interpretations, Matrix interpretations, Full RPO with status, with AFS refinements

Frama-C - Framework for Modular Analysis of C

http://frama-c.cea.fr/

Contact: Claude MARCHÉ

Frama-C is a suite of tools dedicated to the analysis of the source code of software written in C. Frama-C gathers several static analysis techniques in a single collaborative framework. Some parts of the framework are nearing completion and can already provide useful results, while other parts should still be considered experimental. The collaborative approach of Frama-C allows static analyzers to build upon the results already computed by other analyzers in the framework. Thanks to this approach, Frama-C already provides sophisticated tools such as a slicer and dependency analysis.

Isabelle/HOL - Isabelle/HOL

http://www.cl.cam.ac.uk/research/hvg/isabelle/

Contact: Markus WENZEL

Isabelle is one of the top five interactive theorem proving systems. It is used in numerous academic projects on formal theory development (Kepler Conjecture, Prime Number Theorem) and a few major industrial verifications (NICTA Verification of the L4 Kernel). Isabelle is jointly developed at University of Cambridge, Technische Universität München and Université Paris-Sud. The development at UPSud is focussed on the parallelization of the prover kernel and the development of asynchronous proof checking facilities and the development of new Prover IDE exploiting these features.

CFML - CFML

http://arthur.chargueraud.org/softs/cfml/

Contact: Arthur CHARGUERAUD

CFML is a tool that can be used to verify Caml programs using the Coq proof assistant. It is based on Characteristic Formulae, which have been developed in Charguérauds thesis. CFML consists of two parts: a generator that parses Caml code and produces characteristic formulae expressed as Coq axioms (the generator itself is implemented in Caml), and a Coq library that provides tactics for manipulating characteristic formulae interactively. A collection of algorithms and data structures, some purely functional and other using imperative code, have been verified using CFML.

Alt-Ergo - The Alt-Ergo theorem prover

http://alt-ergo.lri.fr/
Contact: Sylvain CONCHON

Alt-Ergo is a little engine of proof dedicated to program verification, whose development started in 2006. It solves goals that are directly written in the Whys annotation language; this means that Alt-Ergo fully supports first order polymorphic logic with quantifiers. It also supports the SMT standard defined by the SMT-lib initiative.

CUBICLE - A PARALLEL SMT-BASED MODEL CHECKER FOR PARAMETERIZED SYSTEMS

Contact: Sylvain CONCHON

Coccinelle - Coccinelle

http://www.lri.fr/~contejea/Coccinelle/coccinelle.html
Contact: Evelyne CONTEJEAN

bibtex2html - Bibtex to HTML

http://www.lri.fr/~filliatr/bibtex2html/
Contact: Jean-Christophe FILLIÂTRE

bibtex2html is a collection of tools for translating from BibTeX to HTML. They allow to produce, from a set of bibliography files in BibTeX format, a bibliography in HTML format. Here are some features: * Handle any BibTeX style (even those producing multiple bibliographies); * Use additional fields like abstract, url, ps, etc. to insert web links; * Crossrefs are also replaced by links; * Sort by dates or authors, in increasing or decreasing order; * Read simple macros in TeX or LaTeX files; * Show syntax errors in BibTeX files; * Extract from one or several BibTeX files the set of entries satisfying a given criterion.

Mlpost - Mlpost: an Objective Caml interface to Metapost

http://mlpost.lri.fr/
Contact: Jean-Christophe FILLIÂTRE

Mlpost is an Objective Caml library to draw scientific figures to be integrated in LaTeX documents. Mlpost is based on MetaPost.

ALEA - ALEA : A library for reasoning on random algorithms in Coq

http://www.lri.fr/~paulin/ALEA/HTML/
Contact: Christine PAULIN-MOHRING

ReactiveML - The ReactiveML language

http://rml.inria.fr
Contact: Louis MANDEL

ReactiveML is a programming language dedicated to the implementation of interactive systems as found in graphical user interfaces, video games or simulation problems. ReactiveML is based on the synchronous reactive model of Boussinot embedded in an ML language (here Objective Caml). The Synchronous reactive model provides synchronous parallel composition and dynamic features like the dynamic creation of processes. In ReactiveML, the reactive model is integrated at the language level (not as a library) which leads to a safer and a more natural programming.

Flocq Library - Flocq Library

http://flocq.gforge.inria.fr/
Contact: Sylvie BOLDO

Flocq (Floats for Coq) is a floating-point formalization for the Coq system. It provides a comprehensive library of theorems on a multi-radix multi-precision arithmetic. It also supports efficient numerical computations inside Coq.

ocamlgraph - Ocaml graph library

http://ocamlgraph.lri.fr/
Contact: Jean-Christophe FILLIÂTRE

Ocamlgraph is a graph library for Objective Caml. It provides many graph data structures (bother persistent and imperative) and many graph algorithms. Data structures and algorithms are provided independently, thanks to Ocaml module system.

Functory - place where functional workers are manufacturing programs

http://functory.lri.fr
Contact: Jean-Christophe FILLIÂTRE

Datacert - DataCert: A coq library for Data Intensive Languages and Systems Certification

Contact: Evelyne CONTEJEAN

The Datacert library provides a Coq formalization of data intensive systems

Why3 - The Why3 platform

http://why3.lri.fr/
Contact: Jean-Christophe FILLIÂTRE

Why is a software verification platform. It provides a set of tools for deductive verification of Java and C source code. Requirements are specified as annotations in the source, in a special style of comments. For Java, these specifications are given in JML and are interpreted by the Krakatoa tool. For C, we designed our own specification language, largely inspired from JML. Those are interpreted by the Caduceus tool. A back-end tool also called Why serves as the VCG. It differs from other systems in that it outputs conditions for several existing provers: interactives ones (Coq, Isabelle/HOL, PVS, HOL-light, Mizar) and automatic ones (Simplify, Alt-Ergo, and SMT provers Yices, CVC3, Z3, haRVey, etc.).

SMTCoq - Coq plugin that checks proof witnesses coming from external SAT and SMT solvers

https://smtcoq.github.io/
Contact: Chantal KELLER

SMTCoq is a Coq plugin that checks proof witnesses coming from external SAT and SMT solvers. It provides: - a certified checker for proof witnesses coming from the SAT solver ZChaff and the SMT solvers veriT and CVC4. This checker increases the confidence in these tools by checking their answers a posteriori and allows to import new theroems proved by these solvers in Coq; - decision procedures through new tactics that discharge some Coq goals to ZChaff, veriT and CVC4.

Gappa - Gappa, a tool for certifying numerical applications

http://gappa.gforge.inria.fr/
Contact: Guillaume MELQUIOND

Gappa is a tool intended to help verifying and formally proving properties on numerical programs dealing with floating-point or fixed-point arithmetic. It has been used to write robust floating-point filters for CGAL and it is used to certify elementary functions in CRlibm. While Gappa is intended to be used directly, it can also act as a backend prover for the Why3 software verification plateform or as an automatic tactic for the Coq proof assistant.

HOL-OCL - A proof system for UML/OCL

http://www.brucker.ch/projects/hol-ocl/
Contact: Burkhart WOLFF

HOL-OCL is an interactive proof environment for the Object Constraint Language (OCL). It is implemented as a shallow embedding of OCL into the Higher-order Logic (HOL) instance of the interactive theorem prover Isabelle. HOL-OCL is developed by Achim D. Brucker and Burkhart Wolff.

The Coquelicot library - The Coquelicot library

http://coquelicot.saclay.inria.fr/
Contact: Sylvie BOLDO

Coquelicot is a user-friendly Coq library for real analysist. An easier way of writing formulas and theorem statements is achieved by relying on total functions in place of dependent types for limits, derivatives, integrals, power series, and so on. To help with the proof process, the library comes with a comprehensive set of theorems that cover not only these notions, but also some extensions such as parametric integrals, two-dimensional differentiability, asymptotic behaviors. It also offers some automations for performing differentiability proofs. Moreover, Coquelicot is a conservative extension of Coq's standard library and we provide correspondence theorems between the two libraries. We have exercised the library on several use cases: in an exam at university entry level, for the definitions and properties of Bessel functions, and for the solution of the one-dimensional wave equation

Coq.Interval - The Coq.Interval library for automatically proving bounds of real-valued expressions

http://coq-interval.gforge.inria.fr/
Contact: Guillaume MELQUIOND

The Coq.Interval library provides tactics for simplifying the proofs of inequalities on expressions of real numbers for the Coq proof assistant.

HOL-TestGen - A generator of test-data from HOL specifications

http://www.brucker.ch/projects/hol-testgen/index.en.html
Contact: Burkhart WOLFF

HOL-TestGen allows one to: write test specifications in Higher-order logics (HOL) (semi-) automatically partition the input space, resulting in abstract test cases automatically select concrete test data automatically generate test scripts (in SML) using a foreign language interface, implementations in arbitrary languages (e.g. C) can be tested. HOL-TestGen is free software; you can redistribute it and/or modify it under the terms of a BSD-style licence. It is developed by Achim D. Brucker and Burkhart Wolff. HOL-TestGen has been deposited in the Agency for the protection of programs (APP) IDDN.FR.001.220032.000.S.A.2011.000.10000 (Signed Paris, 3.6. 2011)

Iris - A Higher-Order Concurrent Separation Logic Framework implemented and verified in the proof assistant Coq.

http://iris-project.org/
Contact: Jacques-Henri JOURDAN

Iris is a Higher-Order Concurrent Separation Logic Framework implemented and verified in the proof assistant Coq. It can be used for reasoning about safety of concurrent programs, as the logic in logical relations, to reason about type systems, etc. Iris est developed at LRI, jointly with MPI-SWS (Germany), the Delft University of Technology (Pays-Bas) and with the Aarhus University (Denmark).

Coq - The Coq proof assistant

https://coq.inria.fr/
Contact: Guillaume MELQUIOND

Coq provides both a dependently-typed functional programming language and a logical formalism, which, altogether, support the formalisation of mathematical theories and the specification and certification of properties of programs. Coq also provides a large and extensible set of automatic or semi-automatic proof methods. Coq's programs are extractible to OCaml, Haskell, Scheme, ...

BOLDR - Query Intermediate Representation Library

https://gitlri.lri.fr/jlopez/qir

Contact: Kim NGUYEN

Query representation library. Used as intermediate format to represent database queries to different backends : SQL, Hive, HBase,

VALS team publications (20 %)

Journal articles

Major international journals

(1) C. Dross, S. Conchon, J. Kanig, and A. Paskevich. Adding Decision Procedures to SMT Solvers using Axioms with Triggers. *Journal of Automated Reasoning*, 56(4):387–457, 2016.

Conference articles

Major international conferences and workshops

(2) V. Benzaken, G. Castagna, L. Daynes, J. Lopez, K. Nguyen, and R. Vernoux. Language-Integrated Queries: a BOLDR Approach. In *WWW 2018 - International World Wide Web Conference*, pages 1–16, Lyon, France, Apr. 2018.

(3) V. Benzaken, G. Castagna, K. Nguyen, and J. Siméon. Static and dynamic semantics of NoSQL languages. In *POPL*, pages 101–114, Rome, Italy, Jan. 2013.

(4) V. Benzaken, E. Contejean, and S. Dumbrava. A Coq Formalization of the Relational Data Model. In Z. Shao, editor, *ESOP - 23rd European Symposium on Programming*, Lecture Notes in Computer Science, Grenoble, France, Apr. 2014. Springer.

(5) V. Benzaken, E. Contejean, C. Keller, and E. Martins. A Coq formalisation of SQL's execution engines. In *International Conference on Interactive Theorem Proving (ITP)*, Oxford, United Kingdom, July 2018.

(6) G. Castagna, K. Nguyen, Z. Xu, and P. Abate. Polymorphic Functions with Set-Theoretic Types. Part 2: Local Type Inference and Type Reconstruction. In *POPL '15 Proceedings of the 42nd ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages*, Mumbai, India, Jan. 2015.

(7) G. Castagna, K. Nguyen, Z. Xu, H. Im, S. Lenglet, and L. Padovani. Polymorphic Functions with Set-Theoretic Types. Part 1: Syntax, Semantics, and Evaluation. In *POPL'14, 41th ACM Symposium on Principles of Programming Languages*, pages 5–17, San Diego, United States, Jan. 2014.

Major national conferences and workshops

(8) M. Clochard. Preuves taillées en biseau. In *vingt-huitièmes Journées Francophones des Langages Applicatifs (JFLA)*, Gourette, France, Jan. 2017.

Theses and habilitations

(9) R. Aissat. *Détection de Chemins Infaisables : un Modèle Formel et un Algorithme*. Theses, Université Paris-Saclay, Jan. 2017.

(10) C. Auger. *Certified compilation of SCADE/LUSTRE*. Theses, Université Paris Sud - Paris XI, Feb. 2013.

(11) S. Boldo. *Deductive Formal Verification: How To Make Your Floating-Point Programs Behave*. Habilitation à diriger des recherches, Université Paris-Sud, Oct. 2014. Reviewers: Yves Bertot; John Harrison; Philippe Langlois.

(12) M. Clochard. *Methods and tools for specification and proof of difficult properties of sequential programs*. Theses, Université Paris-Saclay, Mar. 2018.

(13) E. Contejean. *Facettes de la preuve*. Habilitation à diriger des recherches, Université Paris-Sud, June 2014.

(14) C. Dross. *Generic decision procedures for axiomatic first-order theories*. Theses, Université Paris Sud - Paris XI, Apr. 2014.

(15) S. Dumbrava. *A Coq Formalization of Relational and Deductive Databases -and a Mechanizations of Datalog*. Theses, Université Paris-Saclay, Dec. 2016.

(16) L. Gondelman. *A Pragmatic Type System for Deductive Software Verification*. Theses, Université Paris-Saclay, Dec. 2016.

(17) P. Herms. *Certification of a Tool Chain for Deductive Program Verification*. Theses, Université Paris Sud - Paris XI, Jan. 2013.

(18) M. Iguernelala. *Strengthening the heart of an SMT-solver : Design and implementation of efficient decision procedures*. Theses, Université Paris Sud - Paris XI, June 2013.

(19) C. Lelay. *Reinventing Coq's Reals library : toward a more suitable formalization of classical analysis*. Theses, Université Paris Sud - Paris XI, June 2015.

(20) A. Mebsout. *Invariants inference for model checking of parameterized systems*. Theses, Université Paris Sud - Paris XI, Sept. 2014.

(21) Y. Nemouchi. *Model-based Testing of Operating System-Level Security Mechanisms*. Theses, Université Paris-Saclay, Mar. 2016.

(22) H. N. Nguyen. *A symbolic approach for the verification and the test of service choreographies*. Theses, Université Paris Sud - Paris XI, Oct. 2013.

(23) A. Tafat. *Proofs by refinement of programs with pointers*. Theses, Université Paris Sud - Paris XI, Sept. 2013.

(24) F. Tuong. *Constructing Semantically Sound Object-Logics for UML/OCL Based Domain-Specific Languages*. Theses, Université Paris-Saclay, Apr. 2016.

VALS team publications (all)

Journal articles

Major international journals

(A1) U. A. Acar, A. Charguéraud, and M. Rainey. Oracle-Guided Scheduling for Controlling Granularity in Implicitly Parallel Languages. *Journal of Functional Programming*, 26, Nov. 2016.

(A2) D. Arroyuelo, F. Claude, S. Maneth, V. Mäkinen, G. Navarro, K. Nguyen, J. Sirén, and N. Välimäki. Fast in-memory XPath search using compressed indexes. *Software: Practice and Experience*, 45(3):399–434, 2015.

(A3) T. Balabonski, F. Pottier, and J. Protzenko. The Design and Formalization of Mezzo, a Permission-Based Programming Language. *ACM Transactions on Programming Languages and Systems (TOPLAS)*, 38(4):94, Aug. 2016.

(A4) V. Benzaken, G. Castagna, D. Colazzo, and K. Nguyen. Optimizing XML Querying using Type-based Document Projection. *ACM Transactions on Database Systems*, 38(1):1–45, Mar. 2013.

(A5) F. Bobot, J.-C. Filliâtre, C. Marché, and A. Paskevich. Let's Verify This with Why3. *Software Tools for Technology Transfer (STTT)*, 17(6):709–727, 2015.

(A6) S. Boldo, F. Clément, J.-C. Filliâtre, M. Mayero, G. Melquiond, and P. Weis. Wave equation numerical resolution: a comprehensive mechanized proof of a C program. *Journal of Automated Reasoning*, 50(4):423–456, Apr. 2013.

(A7) S. Boldo, F. Clément, J.-C. Filliâtre, M. Mayero, G. Melquiond, and P. Weis. Trusting computations: a mechanized proof from partial differential equations to actual program. *Computers and Mathematics with Applications*, 68(3):28, Aug. 2014.

(A8) S. Boldo, S. Graillat, and J.-M. Muller. On the robustness of the 2Sum and Fast2Sum algorithms. *ACM Transactions on Mathematical Software*, 44(1), July 2017.

(A9) S. Boldo, J.-H. Jourdan, X. Leroy, and G. Melquiond. Verified Compilation of Floating-Point Computations. *Journal of Automated Reasoning*, 54(2):135–163, Feb. 2015.

(A10) A. D. Brucker and B. Wolff. On Theorem-proving based Testing. *Formal Aspects of Computing*, 25(5):683–721, Sept. 2013.

(A11) A. Cavalcanti and M.-C. Gaudel. Test selection for traces refinement. *Theoretical Computer Science*, 563:1–42, 2015.

(A12) A. Charguéraud. Improving Type Error Messages in OCaml. *Electronic Proceedings in Theoretical Computer Science*, 198:80–97, Dec. 2015.

(A13) A. Charguéraud and F. Pottier. Verifying the Correctness and Amortized Complexity of a Union-Find Implementation in Separation Logic with Time Credits. *Journal of Automated Reasoning*, Sept. 2017.

(A14) M. Clochard, L. Gondelman, and M. Pereira. The Matrix Reproved. *Journal of Automated Reasoning*, pages 1–19, Oct. 2017.

(A15) C. Dross, S. Conchon, J. Kanig, and A. Paskevich. Adding Decision Procedures to SMT Solvers using Axioms with Triggers. *Journal of Automated Reasoning*, 56(4):387–457, 2016.

(A16) J.-C. Filliâtre, L. Gondelman, and A. Paskevich. The Spirit of Ghost Code. *Formal Methods in System Design*, 48(3):152–174, June 2016. Extended version of https://hal.inria.fr/hal-00873187.

(A17) A. Mahboubi, G. Melquiond, and T. Sibut-Pinote. Formally Verified Approximations of Definite Integrals. *Journal of Automated Reasoning*, pages 1–20, Mar. 2018.

(A18) C. Marché. Verification of the Functional Behavior of a Floating-Point Program: an Industrial Case Study. *Science of Computer Programming*, 93(3):279–296, Mar. 2014.

(A19) E. Martin-Dorel, G. Hanrot, M. Mayero, and L. Théry. Formally verified certificate checkers for hardest-to-round computation. *Journal of Automated Reasoning*, 54(1):1–29, 2015.

(A20) E. Martin-Dorel and G. Melquiond. Proving Tight Bounds on Univariate Expressions with Elementary Functions in Coq. *Journal of Automated Reasoning*, 57(3):187–217, Oct. 2016.

(A21) G. Melquiond, W. G. Nowak, and P. Zimmermann. Numerical Approximation of the Masser-Gramain Constant to Four Decimal Digits: delta=1.819... *Mathematics of Computation*, 82:1235–1246, 2013.

(A22) J. Oudinet, A. Denise, and M.-C. Gaudel. A new dichotomic algorithm for the uniform random generation of words in regular languages (journal version). *Theoretical Computer Science*, 502:165–176, Sept. 2013.

(A23) H. Ponce De León, S. Haar, and D. Longuet. Model-based Testing for Concurrent Systems: Unfolding-based Test Selection. *International Journal on Software Tools for Technology Transfer*, pages 14–28, Nov. 2014.

(A24) P. Roux. Formal Proofs of Rounding Error Bounds. *Journal of Automated Reasoning*, page 23, 2015.

Other journals

(A25) M. Aiguier, A. Arnould, P. Le Gall, and D. Longuet. Exhaustive test sets for algebraic specification correctness. *Journal of Software Testing, Verification, and Reliability*, 26(4):294–317, June 2016.

(A26) A. Alberto, A. Cavalcanti, M.-C. Gaudel, and A. Simao. Formal mutation testing for Circus. *Information and Software Technology*, 81:131 – 153, Jan. 2017.

(A27) T. Balabonski, P. Barenbaum, E. Bonelli, and D. Kesner. Foundations of strong call by need. *Proceedings of the ACM on Programming Languages*, 1(ICFP):1 – 29, Aug. 2017.

(A28) B. Bérard, P. Courtieu, L. Millet, M. Potop-Butucaru, L. Rieg, N. Sznajder, S. Tixeuil, and X. Urbain. (Invited Paper) Formal Methods for Mobile Robots: Current Results and Open Problems. *International Journal of Informatics Society*, 7(3):101–114, 2015.

(A29) S. Boldo, C. Lelay, and G. Melquiond. Coquelicot: A User-Friendly Library of Real Analysis for Coq. *Mathematics in Computer Science*, 9(1):41–62, Mar. 2015.

(A30) S. Boldo, C. Lelay, and G. Melquiond. Formalization of Real Analysis: A Survey of Proof Assistants and Libraries. *Mathematical Structures in Computer Science*, 26(7):1196–1233, Oct. 2016.

(A31) A. D. Brucker, B. Lukas, and B. Wolff. Formal Firewall Conformance Testing. *Journal of Software Testing, Verification, and Reliability*, 25(1):34–71, Jan. 2015.

(A32) A. D. Brucker, F. Tuong, and B. Wolff. Featherweight OCL: A Proposal for a Machine-Checked Formal Semantics for OCL 2.5. *Archive of Formal Proofs*, Jan. 2014.

(A33) R. Chen, M. Clochard, and C. Marché. A Formally Proved, Complete Algorithm for Path Resolution with Symbolic Links. *Journal of Formalized Reasoning*, 10(1), Nov. 2017.

(A34) P. Courtieu, L. Rieg, S. Tixeuil, and X. Urbain. Impossibility of gathering, a certification. *Information Processing Letters*, 115(3):447–452, Mar. 2015.

(A35) S. Dailler, D. Hauzar, C. Marché, and Y. Moy. Instrumenting a Weakest Precondition Calculus for Counterexample Generation. *Journal of Logical and Algebraic Methods in Programming*, 99:97–113, 2018.

(A36) A. Feliachi, M.-C. Gaudel, and B. Wolff. Symbolic Test-generation in HOL-TestGen/CirTA: A Case Study. *International Journal of Software and Informatics (IJSI)*, Sept. 2015.

(A37) M. M. Jaghoori, F. S. De Boer, D. Longuet, T. Chothia, and M. Sirjani. Compositional schedulability analysis of real-time actor-based systems. *Acta Informatica*, 54(4):343 – 378, June 2017.

(A38) C. Marché and J. Kanig. Bridging the Gap between Testing and Formal Verification in Ada Development. *ERCIM News*, 100:2, Jan. 2015.

(A39) E. Martin-Dorel, G. Melquiond, and J.-M. Muller. Some issues related to double roundings. *BIT Numerical Mathematics*, 53(4):897–924, Dec. 2013.

(A40) J.-M. Muller and S. Boldo. Des ordinateurs capables de calculer plus juste. *La Recherche : l'actualité des sciences*, pages 46–53, Oct. 2014. Article de vulgarisation.

(A41) H. Ponce De León, S. Haar, and D. Longuet. Model Based Testing for Concurrent Systems with Labeled Event Structures. *Journal of Software Testing, Verification, and Reliability*, 24(7):558–590, Aug. 2014.

(A42) P. Roux. Innocuous Double Rounding of Basic Arithmetic Operations. *Journal of Formalized Reasoning*, 7(1):131–142, Nov. 2014.

(A43) F. Tuong and B. Wolff. A Meta-Model for the Isabelle API. *Archive of Formal Proofs*, Sept. 2015.

(A44) F. Voisin, R. Aissat, and B. Wolff. Infeasible Paths Elimination by Symbolic Execution Techniques: Proof of Correctness and Preservation of Paths. *Archive of Formal Proofs*, Aug. 2016.

Conference articles

Major international conferences and workshops

(A45) U. A. Acar, A. Charguéraud, and M. Rainey. Scheduling Parallel Programs by Work Stealing with Private Deques. In *PPOPP - 18th ACM SIGPLAN symposium on Principles and practice of parallel programming*, Proceedings of the 18th ACM SIGPLAN symposium on Principles and practice of parallel programming, pages 219–228, Shenzhen, China, Feb. 2013. ACM New York, NY, USA. This is the full version of the paper, which includes more detailed proofs than the conference version.

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