



7/ ForTesSE

Formal Testing and System Exploration



équipe Test Formel et Exploration de Systèmes

Responsable: Marie-Claude Gaudel

L'équipe ForTesSe travaille dans le domaine des méthodes formelles appliquées à la vérification formelle et au test systématique de logiciels. Les méthodes et outils de test vont du test unitaire, séquentiel ou non, au test de composant, du test contrôlé au test passif, du test déterministe au test statistique.

Une importance particulière est donnée aux méthodes pour la génération automatique de données de test, ou de procédures de test, à partir de modèles. Parmi les modèles considérés on trouve: des modèles au sens des méthodes de développement MDE ou MDA, des annotations par pre- et post-conditions, des systèmes de transitions, des descriptions en logique du premier ordre ou d'ordre supérieur. Une des spécialités de l'équipe est le développement d'algorithmes d'exploration de très grands modèles, basés sur le tirage uniforme de structures combinatoires. Ces méthodes sont applicables au test aléatoire, mais aussi au model-checking et à la preuve de théorèmes.

Un autre domaine de recherche est le Génie Logiciel des systèmes distribués communicants, comme la conception et la validation de protocoles ou de systèmes "orientés services". Dans le premier cas, l'équipe développe des techniques de test pour les protocoles de routage auto-organisés. Pour le deuxième type de système, une importante activité se développe autour de la vérification et du test de la composition de services (orchestration, chorégraphie), et du problème de la composition automatique de services, en particulier des processus d'adaptation.



Formal Testing and System Exploration

Head: Marie-Claude Gaudel

ForTesSE

The research of the ForTesSE team lies at the heart of formal methods, namely their application to the formal verification and systematic test of software systems. The range of testing methods covers unit testing as well as sequence testing, component testing, active and passive testing, deterministic and statistical testing.

Particular emphasis is put on methods for the automated generation of test-data and/or test-procedures from models. Such models non exclusively include: models in the sense of model-driven engineering (MDE, MDA), pre- and postcondition style annotations of programs, transition systems, models described in first- and higher-order logics, etc. One of the specialities of the team is the study of algorithms for exploring uniformly at random very large models. These algorithms are based on uniform drawing of combinatorial structures. They are applicable to random testing, but also to model-checking and theorem proving based approaches.

Another research domain of the ForTesSE team is software engineering for distributed communicating programs, more specifically Protocol Engineering and Service-Oriented Computing. In the former field, the team develops testing techniques dedicated to routing protocols for Self Organising Networks. In the later field, the team develops techniques for the verification and test of service compositions (orchestrations, choreographies). Further, the team targets the automatic service composition issue, including composition processes with behavioural adaptation features.

Research Group Members

Permanent faculty (1 october 2008)			
Name	First name	Position *	Institution
BOUDET	Alexandre	CR1	CNRS
GAUDEL	Marie-Claude	PREM	PARIS 11
POIZAT	Pascal	MCF	EVRY
VOISIN	Frédéric	MCFHC	PARIS 11
WOLFF	Burkhart	PR2	PARIS 11
ZAIDI	Fatiha	MCF	PARIS 11

Doctoral students (1 october 2008)			
Name	First name	Position *	Institution
BENTAKOUK	Lina	Contract	PARIS 11
OUDINET	Johan	AM	PARIS 11

Temporary personnel (2005-2008)					
Name	First name	Position *	Institution	Arrival	Departure
FAYOLLE	Julien	ATER Post-Doc	IUT Orsay	04.2006	08.2008

* See the glossary for the acronyms.

Group evolution

This new group is the result of splitting the former Software Engineering group into three smaller, more focused, groups, as it was suggested by the evaluation committee in 2004, despite the small size of this sub-group.

Since 2004, one permanent member has left the group (PETITJEAN Eric, MC, Paris Sud University, in March 2006) and one Ph.D. student has left to industry, after completing his thesis (LESTIENNES Gregory, in January 2006).

Sandrine-Dominique GOURAUD, a former Ph.D. student, has been recruited as MC in September 2005 after one year as a Post-Doc in IRISA. She will be on leave for personal reasons from September 30, 2008.

Julien Fayolle has spent two years and a half in the group, from April 2006 until August 2008, as a post-doc and then ATER.

Two Ph.D. students joined the group in september 2007.

Alexandre BOUDET joined the team in January 2008; he is CR1 CNRS, working half time for therapeutic reasons. He has been absent from work since April 28, 2008 and this will last until April 2009. Currently, he must not be counted as contributing to the scientific production of the group.

In September 2008, two new permanent members have joined the group, namely:

- WOLFF Burkhart, PR, Paris Sud University
- POIZAT Pascal, MC, Evry University

Highlights

ForTesSE means **F**ormal **T**esting and **S**ystem **E**xploration.

There are slightly more than ten groups working on software testing in France. The LRI group was the first to study testing based on formal specifications and has maintained a leadership role. This was recently recognised by the fact that Fatiha Zaidi was made co-director, together with Arnaud Gotlieb of IRISA, of the Testing WG of the new CNRS GDR “Génie de la Programmation et du Logiciel”.

At the international level, the group is present in almost all of the program committees in the domain: TestCom-Fates, ETAPS MBT workshop, ACM Int. Workshops on Random Testing, IEEE-ICST, IEEE-QSIC, Applied Computing, WS-Mate; and in several journal editorial boards, SCP, FAC, STVR. Marie-Claude Gaudel has been general chair of the 2nd ACM workshop on Random Testing that took place in Atlanta in November 2007. She has been general chair of QSIC (International Conference on Quality Software) in Oxford in August 2008, and is the general chair of the 3rd IEEE-ICST (International Conference on Software Testing) planned in April 2010 in ENST, Paris.

As described below, the group is involved in several collaborative projects:

- Usine Logicielle, in the System@tic competitiveness cluster,
- WEBMOV, an ANR project (Software Technology Programme),
- A Joint International Project with the University of York, funded by the Royal Society.

Moreover, the group participates in the VERAP ANR project (SESUR Security and Safety Programme) on probabilistic verification that is led by the ALGO group of LRI. It is the concretisation of a long lasting collaboration on this subject between the two groups and the PARALL group.

The group is leader in the animation of the RASTA Working group (RANdom System Testing and Analysis), which is a *transversal activity* in LRI, involving members of the following groups: BioInfo, ForTesSE, Parall, and moreover the Equipe de Logique Mathématique de Paris 7.

Recently, the proposal for the “HOL-TestGen-XT” project was accepted as the first award of the new “Chaire d’excellence” program of the University Paris-Sud. This program has been set to attract young foreign professors. Burkhart Wolff is the first recipient. The goal of this project is to extend the realm of feasible state-spaces for HOL-TestGen system, a test generation environment based on higher-order logic and the Isabelle theorem prover.

Key Publications

- N. Baskiotis, M. Sebag, M.-C. Gaudel, and S.-D. Gouraud. A machine learning approach for statistical software testing. In *IJCAI, Proceedings of the 20th International Joint Conference on Artificial Intelligence*, pages 2274–2279, 2007
- A. Cavalcanti and M.-C. Gaudel. Testing for refinement in CSP. In *Formal Methods and Software Engineering, ICFEM 2007*, volume 4789 of *Lecture Notes in Computer Science*, pages 151–170. Springer Verlag, 2007

- A. D. Brucker and B. Wolff. An extensible encoding of object-oriented data models in hol with an application to IMP++. *Journal of Automated Reasoning (JAR)*, Selected Papers of the AVOCS-VERIFY Workshop 2006, 2008
- C. Canal, P. Poizat, and G. Salaün. Model-based adaptation of behavioural mismatching components. *IEEE Transactions on Software Engineering*, 34(4):546–563, 2008
- A. Denise, M.-C. Gaudel, S.-D. Gouraud, R. Lassaigne, and S. Peyronnet. Uniform random sampling of traces in very large models. In *1st International ACM Workshop on Random Testing*, pages 10–19, July 2006
- E. Bayse, A. Cavalli, M. Nunez, and F. Zaidi. A passive testing approach based on invariants: application to the wap. In *Computer Networks*, volume 48, pages 247–266. Elsevier Science, 2005
- M. Lallali, F. Zaidi, and A. Cavalli. Timed modeling of web services composition for automatic testing. In *SITIS IEEE/ACM 2007*, pages 411–427, Shanghai, December 2007. IEEE Computer Society

7/ ForTesSE

Research Description

The research activity of the ForTesSe group is in the area of formal methods applied to the verification and validation of software systems. An important part of this activity is devoted to testing methods based on formal descriptions. The considered descriptions non-exclusively include: axiomatic methods, transition systems, and data flow graphs. The developed methods consider unit testing as well as component testing, active and passive testing, deterministic and random testing. Meanwhile, the team develops algorithms for exploring very large models. These methods are based on uniform drawing of combinatorial structures. They are, of course, applicable to random testing, but also to model-checking.

The activities during the last four years include:

- Software testing based on formal specification, generation, execution, oracle
- Random testing biased toward coverage criteria
- Probabilistic exploration of large models, uniform random walks
- Testing methods for communicating systems including ad hoc networks and web-based systems

We use this classification for presentations, but there are strong intersections among all these activities. The first is pervasive in all our activities. Random testing and probabilistic exploration rely on common bases, and are developed with the idea of applying them to communicating systems. In addition to these items, we conducted exploratory work on learning and testing, which was led in collaboration with the I & A /TAO LRI group and resulted in a publication at IJCAI 2007 [8].

Moreover, with the arrival of a new professor, Burkhart Wolff, it is planned to develop the use of powerful theorem provers for our current test generation activities, on the basis of the HOL-TestGen tool.



Software testing based on formal specification, generation, execution, oracle

A classical approach to software testing based on formal specification starts from an IOTS (Input-Output Transition Systems) and tests whether the implementation under test satisfies the so-called “ioco” relation (input-output conformance) with respect to the IOTS. A drawback of this approach is that it assumes that the implementation is “input-enabled”, i.e. it accepts any input in any state. This is often unrealistic. A Ph.D. thesis, defended in 2005, was devoted to the study of how to generate tests for systems with restricted inputs in certain states, including the test that forbidden inputs are not accepted. It led to the definition of R-IOLTS (Restricted-Input Output Labelled Transition Systems) and the corresponding relation “rioco”. A notion of exhaustive test set has been defined and proved. This work was published at MSR'05 [25]. Following the same line, the test of systems where some inputs take priority over others has been studied in [35]. More recently, in the framework of a Joint International Project of the Royal Society, similar work was done for CSP specifications and trace and failure refinements and published in various conferences [11, 12]. These results confirm the genericity of the concepts we have developed for testing based on formal specifications.

Random testing biased toward coverage criteria

The group has been involved in the “Usine Logicielle” project of the System@tic Competitivity Cluster. The goal is to study how to exploit our previous work on coverage-biased statistical testing of C programs for testing critical embedded programs described by a Lustre specification. The sALLUSTe prototype has been developed in collaboration with CEA-LIST, and tested by some industrial partners. Encouraging results were observed but much remains to be done to scale up the method and the tool. This work was published at the international congress ERTS 2008 (Embedded Real Time Software)[15]. Considering the interest raised by this kind of testing, we have started a complete re-engineering of our AuGuSTe tool for statistical testing of C programs, under the direction of F. Voisin.

Probabilistic exploration of large models, uniform random walks

In the line of our previous work on statistical testing, we are studying how to perform uniform random walks (where every trace has the same probability of occurrence) in extremely large models. We take advantage of the fact that they are composed of several components: it is possible to combine local uniform drawings of traces, and to obtain some global uniform random sampling, without construction of the global model. Experiments have been successfully led on models with 10^{34} states, with performances that show that the approach makes it possible to uniformly explore even larger models.

Moreover, we have proposed a method for drawing traces at random according to a given coverage criterion and we have defined a notion of randomised coverage satisfaction. The various works above rely on combinatorial algorithms, based on a representation of the models by an automaton or a by a product of several automata, synchronised or not. They have been published in the 1st and 2nd ACM International workshops on Random Testing [13, 22]; they have been presented as an invited talk to the ETAPS workshop on Model-Based Testing (a full paper is to appear in ENTCS [7]); a journal version has been submitted [31].

This work is carried on in the transversal working group RASTA (Random Software Testing and Analysis) with participations of colleagues of several other

groups of LRI: BioInformatics, Parallelism, and Algorithmic; of Equipe de Logique de Paris 7, and more recently the SPIRAL team of LIP6.

Testing methods for communicating systems including ad hoc networks and web-based systems

A significant contribution has been made to the definition of methods for testing communication protocols without interacting with them. This kind of approach is known as passive testing. Using such techniques for testing purpose is a rather novel approach: it is similar to some monitoring methods but those are used for on-line surveillance and alarm triggering. The specificity of this approach is that it is based on properties to be sought in the real traces, that are checked against the formal model (when there is one) of the protocol under test, the aim being off-line fault detection. The method has been experimented on the WAP (Wireless Application Protocol). This work has been done in collaboration with Telecom and Management Sud Paris (formerly INT) and the Universidad Complutense in Madrid. It has led to several publications, for instance [1].

Still in the domain of communication protocols, some research has been led on ad hoc routing protocols in the framework of MANET (Mobile Ad Hoc network) and in this class of family especially the pro-active protocol that maintains routing table to construct a route between different nodes. Validation of such protocols is often handled by simulation and/or emulation and no formal validation is provided. We have defined a stepwise approach to validate such protocol that raises new problems for modeling languages and for testing methods. We investigated these issues on two modeling languages, i.e. SDL and PROMELA. This work has been published in [20, 21] It continues in collaboration with the ASAP INRIA project.

A new important application area for ForTesSe is web-based systems, their modeling, composition, testing and evolution. We developed a specific modeling method based on UML models which makes it possible to perform automatic execution of test cases for checking the conformance of the Web application to its specification. Moreover, this approach is also relevant for dealing with non-regression testing that must be done automatically, to guarantee that the system still accepts the previous tests after a new evolution. This work was published in NOTERE 2005 [24].

We also started to work on Web services composition. We chose the Web Services Business Process Execution Language (WS-BPEL) since it is increasingly recommended for service composition descriptions. For testing purposes, we propose a model-based approach that relies on formal description languages. WS-BPEL descriptions are translated into another formalism, the Time Extended Finite State Machines for Web Services (WS-TEFSM) [17], which is well adapted for modeling and testing.

Based on this first experience of Web services modeling, we lead an ANR project, called Webmov, with five other partners, (GET/INT, SOFTEAM, MONTIMAGE, UNICAMP, and LABRI). Started in November 2007, the project covers several aspects for the development of Web services: the modeling at a SOA (Software Oriented Architecture) level, the test generation, the test execution and fault injection to evaluate the robustness of the Web services. Some colleagues of the IASI/GEMO group of LRI are involved: they bring their expertise in diagnosis.



Zoom-in on RASTA

RANdom System Testing and Analysis

The RASTA Working group is a transversal activity of LRI, involving members of the following groups: *BioInfo*, *ForTesSE*, *Parall*. There is a strong collaboration with the *Equipe de Logique Mathématique de Paris 7*, and more recently some common work has started with the SPIRAL team of LIP6.

Working Group members

- DENISE Alain, PR1, LRI/BioInfo
- GAUDEL Marie-Claude, PREM, LRI/ForTesSE
- GOURAUD Sandrine-Dominique, MCF, LRI/ForTesSE (until Sept. 30, 2008)
- LASSAIGNE Richard, MCF, Equipe de Logique Mathématique de Paris 7
- OUDINET Johan, Ph. D. student, LRI/ForTesSE (since September 2007)
- PEYRONNET Sylvain, MCF, LRI/Parall

Moreover, some work has recently started with Carine Pivoteau and Michèle Soria, at LIP6/SPIRAL.

Aims and Scope

In the recent years, the problem of studying and simulating random processes has particularly benefitted from progresses in the area of random generation of combinatorial structures. The seminal works of Wilf and Nijenhuis in the late 70's have led to efficient algorithms for generating uniformly at random a variety of combinatorial structures. In 1994, Flajolet, Zimmermann and Van Cutsem have widely generalised and systematised the approach. Briefly, their approach is based on a non-ambiguous recursive decomposition of the combinatorial structures to be generated. Their work constitutes the basis of powerful tools for uniform random generation of complex entities, as graphs, trees, words, paths, etc.

The RASTA Working Group activity is centred on the application of these powerful results to software testing, and more generally to verification.

Methods based on randomness seem attractive for testing large programs or checking large models. However, designing efficient random methods, i.e. methods that have a good and assessable fault detection power, is far from being obvious: the underlying probability distribution must be carefully designed if one wants to ensure a good coverage of the program or model, or of potential fault locations, and to quantify coverage or fault detection.

Sidebar

(continued)

A classical way to explore large graphs at random is random walk. A random walk in the state space of a model is a sequence of states s_0, s_1, \dots, s_n such that s_i is a state that is chosen uniformly at random among the successors of the state s_{i-1} , for $i = 1, \dots, n$. It is easy to implement and only requires local knowledge of the model.

However, random walk methods have some drawbacks. In case of irregular topology of the underlying transition graph, uniform choice of the next state is far from being optimal from a coverage point of view. Moreover, for the same reason, it is generally not possible to get any estimation of the coverage obtained after one or several random walks: it would require some complex global analysis of the topology of the model.

In RASTA, we are studying how to perform uniform random walks (where every trace has the same probability to occur) in extremely large models taking advantage that they are composed of several components: it is possible to combine local uniform drawings of traces, and to obtain some global uniform random sampling, without construction of the global model. Experiments have been successfully led on models with 10^{34} states, with performances that show that the approach makes it possible to uniformly explore even larger models.

However, we are faced with two important problems. At first, multiple or partial synchronisations provoke a multiplication of auxiliary models and tables and thus limit the scalability of the method. One way to attack this issue is to study architectural patterns, inspired from practical distributed systems or protocols, and to propose specific strategies (mainly regroupments or decompositions) to deal with such models.

The second problem is that current implementations of uniform random generation algorithms (namely recursive methods) need tables whose size grows with the length of the words that are to be generated. We study two different strategies to get rid of these tables: the first one consists in performing a kind of “on line” random generation of traces by inverting the recurrences that are used in the classical recursive method ; the second one consists in generating traces with the newer so-called Boltzmann random sampling method.

Besides, we have proposed a method for drawing traces at random according to a given coverage criterion and we have defined a notion of randomised coverage satisfaction. This notion turns out to be related to the assessment of probabilities of fault detection, under the assumption of some fault model. It has been applied successfully to state-coverage and transition-coverage. We now plan to consider more sophisticated ones such as data-flow coverage criteria, or MC/DC.

The various works above all rely on combinatorial algorithms, based on a representation of the models by an automaton or a by a product of several automata, synchronised or not.

Sidebar

(continued)

They have been published in the 1st (Denise et al., 2006) and 2nd (Oudinet, 2007) ACM International workshops on Random Testing ; they have been presented as an invited talk to the ETAPS workshop on Model-Based Testing (a full paper will appear in ENTCS); a journal version is submitted.

Key Publications

- A. Denise, M.-C. Gaudel, and S.-D. Gouraud. A generic method for statistical testing. In *IEEE Int. Symp. on Software Reliability Engineering (ISSRE)*, pages 25–34, 2004.
- A. Denise, M.-C. Gaudel, S.-D. Gouraud, R. Lassaigne, and S. Peyronnet. Uniform random sampling of traces in very large models. In *1st International ACM Workshop on Random Testing*, pages 10–19, July 2006.
- Johan Oudinet. Uniform random walks in very large models. In *RT '07, 2nd international workshop on Random testing*, pages 26-29, Atlanta, GA, USA, November 2007. ACM Press.
- Marie-Claude Gaudel, Alain Denise, Sandrine-Dominique Gouraud, Richard Lassaigne, Johan Oudinet, and Sylvain Peyronnet. Coverage-biased random exploration of large models. In *ETAPS Workshop on Model Based Testing*, Electronic Notes in Theoretical Computer Science, March 2008. invited lecture, 11 pages.
- Alain Denise, Marie-Claude Gaudel, Sandrine-Dominique Gouraud, Richard Lassaigne, Johan Oudinet, and Sylvain Peyronnet. Coverage-biased random exploration of large models and application to testing. Technical Report 1494, LRI, Université Paris-Sud XI, June 2008. 26 pages, submitted.
- Johan Oudinet. Uniform random exploration of concurrent systems. In *Modelling and Verifying parallel Processes (MOVEP)*, pages 323-328, June 2008.

Perspectives

In addition to the various current work mentioned above, our immediate perspective is to generalise uniform drawing of paths to uniform drawing of so-called “lassos” that are interesting for Monte-Carlo model-checking of LTL formulas. This implies counting and drawing elementary circuits, which is known as a hard problem. However, efficient solutions exist for specific graphs, such as reducible data flow graphs. They could be applicable to program model-checking.

With the LIP6/SPIRAL group, we study how to apply their work on Boltzmann samplers in our framework: this would make possible to draw very long paths and traces, leading to test or check of load-robustness properties.

ForTesSE

Research Description

Strategic Planning

Original LRI Goals

With respect to the current plan of LRI, the group has directly contributed to the following research challenges:

- **Embedded Systems:** as described above, in the framework of the Usine Logicielle project of the Systematic cluster, we developed a method and the sAL-LUSTe tool for statistical testing of embedded systems described in Lustre.
- **Dynamic Networks:** the WEBMOV ANR project is devoted to the dynamic composition and testing of web services.

Moreover, all our activities on statistical and random testing are motivated by the necessity of quantifiable validation methods for very large systems. In this sense, we address the *Masses of Data* challenge. This aspect of our activity is led in collaboration with the ALGO, PARALL, and Bioinformatics groups.

Self Assessment

The research and the competence of our group is very well recognised at the international level, as mentioned above (publications, invited lectures, conference programme committees, journal editorial boards, project evaluations for: ERC, EPSRC, Germany, belgian FNRS, The Netherlands, Hong Kong, etc).

In our opinion, a strong positive point of our activity is our numerous and fruitful collaborations. Several are internal to LRI; others are national or international.

Within LRI, we work intensively with the following groups: Algo, Bioinfo, I & A, IASI, and Parall. This is attested by common publications and projects.

At the national level we have been very active in the creation of the Software Testing WG of the new CNRS GDR "Génie de la Programmation et du Logiciel" and in the submission and organisation of the Webmov ANR project.

At the international level we have numerous informal collaborations and three formal ones: one with the University of York, one with the University of Sao Paulo (co-tutelle of a Ph.D. student), one multi-party COFECUB project, and a recent collaboration with ETH Zurich (project MBTSEC).

A less positive point is our publication activity: we should (and could) have more journal publications. Three long articles are currently submitted to international journals:

- *One step forward: Linking Wireless Self-Organising Networks Validation Techniques with Formal Testing approaches*, by Stéphane Maag (Telecom and Management Sud Paris), Aline Carneiro (INRIA Saclay), Fatiha Zaidi (LRI, Univ. Paris Sud), under revision for Computing Surveys.
- *Coverage-biased random exploration of large models and application to testing*, by Alain Denise, Marie-Claude Gaudel, Sandrine-Dominique Gouraud (LRI, Univ. Paris Sud), Richard Lassaigne (Equipe de Logique, Univ. Paris 7), Johan Oudinet, Sylvain Peyronnet (LRI, Univ. Paris Sud), submitted to Software Tools for Technology Transfer (STTT Journal).

- *Approximations in Model-Checking and Testing*, by M.C. Gaudel (LRI, Univ. Paris Sud), F. Magniez (LRI, Univ. Paris Sud), R. Lassaigne (Equipe de Logique, Univ. Paris 7), M. de Rougemont (LRI, Univ. Paris Sud), under revision for Computing Surveys.

Our main problem during the last four years was that the group has been of sub-critical size for a while. Moreover, F. Voisin and M.-C. Gaudel have been in charge of important local and external administrative duties. However, the arrival of two confirmed permanent members should improve our performance in number of publications, Ph. D. dissertations and project participations, during the next four years.

Relationship to LRI Strategic Plan

The future orientation of the group definitely depends on the integration and the choices of the two new permanent members, Pascal Poizat and Burkhart Wolff. It is planned that Burkhart Wolff will become head of the group at the end of the current academic year.

The expertise in theorem proving brought by Burkhart Wolff will be exploited for developing our current activities on testing. Generally speaking, theorem provers are essential components of testing tools. We plan to use HOL-TestGen, and some powerful constraint solvers (for instance Z3) to help the detection of unfeasible paths and tests in a more effective way. We also plan to explore the combination of proofs (for instance of testing hypotheses) and tests on rigorous and formal bases. These activities will be led within the "Program analysis and proofs" item of the Multimodeling area.

Another perspective is the use of random methods in theorem proving and constraint solving. Some of our results are promising, and our group is definitely in a position to bring innovative ideas and to implement and experiment them. Random methods based on combinatorial approaches will continue to be developed within the RASTA group. They are clearly relevant to "Scalability", more precisely "Combinatorial Complexity", and to the "Design for robustness and self-healability" sub-theme of the "Uncertainty and Approximation" area.

In our work on adaptation and dependable composition of software entities, we plan to enhance efficiency and correctness through the combination of planning-as-model checking and SAT solving for richer service models. Further, runtime composition and adaptation for evolving systems will be studied, addressing modeling and testing issues. These issues are linked to the "Model-based reasoning about physical systems behavior" sub-theme of Multi-modeling. There is some link with the "Service Coordination and Adaptation" item of the Dynamic Systems area.

Concerning the composition of Web services the main issue remains the automation of the correctness of composition by means of both active testing techniques and on-line monitoring techniques. Web services are a typical example of "Dynamic Systems".

We will also continue the work on formal validation of Wireless Self Organising Network by promoting and proposing solutions to bridge the gap that exists between the network research community and the formal design and validation research community. This point is also relevant to the "Multi-modeling" area and to the "Dynamic Systems" one.

Honors

Keynote Addresses

International

- M.-C. Gaudel, *Formal Methods 2005*, 2005: Formal Methods and Testing: Hypotheses, and Correctness Approximations
- M.-C. Gaudel, *ETAPS Workshop on Model Based Testing*, 2007: Coverage-biased random exploration of large models

Evaluation of Research

Editorial Boards

International

- SCP, *Science of Computer Programming*, Elsevier: M.-C. Gaudel (since the creation in 1981)
- FAC, *Formal Aspects of Computing*, Springer-Verlag: M.-C. Gaudel (since the creation in 1989)
- STVR, *Software Testing, Verification and Reliability*, Wiley, M.-C. Gaudel (since the creation in 1991 until 2006)
- JUCS, *Journal of Universal Computer Science*: P. Poizat (guest editor, special issue on Software Adaptation, 2008)

National

- L'Objet, *L'Objet*, Lavoisier: P. Poizat (guest editor, Special issue on Software Adaptation, 2006)

Program Committees

Chair

- RT07, *2nd ACM International Workshop on Random Testing*, Atlanta: M.-C. Gaudel (2007, co-chair)
- FOCLASA, *International Workshop on the Foundations of Coordination Languages and Software Architectures*, Lisbon, Reykjavik: P. Poizat (2007, 2008, co-chair)
- FATES/RV, *Intl. Conference on Formal Aspects of Testing and Runtime-Verification*, Seattle: B. Wolff (2006, co-chair)
- QSIC, *8th International Conference on Quality Software*, Oxford: M.-C. Gaudel (2008, general chair)
- ICST, *3rd IEEE International Conference on Software Testing, Verification and Validation*, Paris: M.-C. Gaudel (2010, general chair)

Member (international events)

- IADIS AC, *Applied Computing*: F. Zaidi (2005)
- TAROT Summer School, *Training and Research on Testing*: F. Zaidi (2005)
- FOCLASA, *International Workshop on the Foundations of Coordination Languages and Software Architectures*: P. Poizat (2006)
- WCAT, *International Workshop on Coordination and Adaptation Techniques*: P. Poizat (2005, 2006, 2007)
- WS-MATE, *International Workshop on Web Services - Modeling and Testing*: F. Zaidi (2005, 2006)
- ProVeCS, *Workshop on Property Verification for Software Components and Services*: P. Poizat (2007)
- RT'07, *2nd ACM International Workshop on Random Testing*, Atlanta: S.-D. Gouraud, (2007)
- TPHOLS, *Intl. Conference on Theorem Proving in Higher-Order Logics*: B. Wolff (2008)
- TestCom-Fates, *Intl. Conference on Testing of Communicating Systems and Formal Approaches to Testing of Software*: M.-C. Gaudel, B. Wolff (2007, 2008)
- SASE, *Workshop on Self-Adaptive Software Engineering*: P. Poizat (2008)
- WASELF-*, *Workshop on Autonomic and SELF-adaptive systems*: P. Poizat (2008)
- TAP, *Test and Proof*: B. Wolff (2008)
- MBT, *Model Based Testing Workshop*: M.-C. Gaudel (2007, 2008, 2009)
- ICEBE, *IEEE International Conference on e-Business Engineering*: P. Poizat (2008)
- FACS, *International Workshop on Formal Aspects of Component Software*: P. Poizat (2008)
- ICST, *IEEE International Conference on Software Testing, Verification and Validation*: M.-C. Gaudel (2008, 2009)
- FM, *Formal Methods*: M.-C. Gaudel (2009)

Member (national events)

- MSR, *Modélisation des Systèmes Réactifs*: M.-C. Gaudel (2007)
- CAL, *Conférence Francophone sur les Architectures Logicielles*: P. Poizat (2006, 2008)

Evaluation Committees and Invited Expertise

International

- European Research Council (ERC), Evaluation panel for the starting grants, Europe: M.-C. Gaudel, (2006, 2008)
- Engineering and Physical Sciences Research Council (EPSRC), UK: M.-C. Gaudel (2006-2009), invited expertises
- Commission 23 du Fond National de la Recherche Scientifique (FNRS), Belgium: M.-C. Gaudel, (since 2005)
- Deutschen Forschungsgemeinschaft (DFG), Selection of Clusters of Excellence, Germany: M.-C. Gaudel, (2006)
- COFECUB, coopération universitaire franco-brésilienne, Board, M.-C. Gaudel, (2001-2006)

France

- ANR, selection committee of excellence chairs, M.-C. Gaudel, (2007)
- CEA, M.-C. Gaudel, chair of the scientific committee of DCIS (LIST + LETI), (2005-2008)

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Evaluation
of Research

Other evaluation activities

- Evaluation of a project, Contrat de Plan Etat-Région Lorraine, P. Poizat, (2007)

7/ ForTesSE

Volunteer Professional Service

Management Positions in Scientific Organisations

- RENATER: Marie-Claude Gaudel, member of the board, (since 2001)
- Digiteo: Marie-Claude Gaudel, president of the programme committee, (since 2004)
- new CNRS GDR “Génie de la Programmation et du Logiciel”: Fatiha Zaidi, co-director of the Testing WG (2007 -).
- Université de Paris-Sud XI: Frédéric Voisin, elected member of Conseil des Etudes et de la Vie Universitaire (CEVU), (2006-2008)
- Faculté des Sciences d’Orsay: Marie-Claude Gaudel, Research Council (2003-2008)
- Faculté des Sciences d’Orsay: Frédéric Voisin, Vice-President for Teaching of the Computer Science department, member of the council of “Division des Formations”, and member of the “Commission des Enseignants d’Orsay”, (2004-2008)
- Commissions de Spécialistes 27ème section:
 - Université de Paris-Sud XI: Frédéric Voisin, (2004-2008), Marie-Claude Gaudel (2004-2006), Fatiha Zaidi (Commission mixte IFIPS, 2008)
 - Université de Paris 12 Val-de-Marne: Frédéric Voisin, (2004-2006)
 - Université de Versailles St-Quentin en Yvelines: Marie-Claude Gaudel, (2004-2007)
 - Université d’Evry Val d’Essonne: P.Poizat (2004-), Fatiha Zaidi (2004-)
 - CNAM Paris: P.Poizat (2004- 2007)
- LRI, Marie-Claude Gaudel and Julien Fayolle, Laboratory Council (2006-)
- LRI, Fatiha Zaidi, Office space committee (2007-)
- LRI, Johan Oudinet, Web committee (2007-)
- LRI Frédéric Voisin (2004-2008), then Pascal Poizat (2008 -), equipment committee

Working Groups

- IFIP WG 1.3 on Foundations of System Specification, M.-C. Gaudel since its creation in 1998

Other Professional Service

- Steering Committee of the ETAPS conference: Marie-Claude Gaudel, 1998-2006
- Steering Committee of the FM conference: Marie-Claude Gaudel, since 2005
- “Comité Consultatif de Régional pour la Recherche, l’Enseignement Supérieur et l’Innovation” (CCRRESTI), Marie-Claude Gaudel, member since 2002, then member of the board since 2006



Contracts and grants

Contracts and grants (jan 2005 - dec 2008)				
Type	Name	Managing Institution	Start / Duration	Amount
ANR	WebMov	Université Paris-Sud 11	12.2007 / 30 mo.	163 k€
Industry	Usine Logicielle	Université Paris-Sud 11	04.2006 / 24 mo.	107 k€

WebMov

Partners: Université Bordeaux 1, Groupes des écoles des Télécommunications, MONTIMAGE, SOFTEAM, UNICAMP Brésil

Type: ANR
Amount: 163 k€
Duration: 30 months
Scientific director for LRI:
Fatiha ZAIDI

The main objective of WebMov is to contribute to the design, composition and validation of Web Services through a high level of abstraction view and a SOA based logical architecture vision. In this domain, industry usually constructs new services by composition of modules which describe existing Web Services. These composition mechanisms are called orchestration. In this proposal, we are interested in the design and composition mechanisms for Web Services as well as their validation using different types of testing techniques. WebMov will define logical models for SOA architectures in order to provide a high level of abstraction to design the architecture, the service orchestration and the test specifications and purposes. To achieve composition, IBM and other companies have defined an executable standardized language, BPEL, that allows the description of Web Services and their composition. We propose to use this language as specification service language. Once the modules are described using BPEL, a mapping to a formal model, close to that of extended finite state machines with temporal constraints will be followed. This formalism will facilitate timed test generation. These tests will be executed following two approaches: active testing, consists of executing the produced tests on the system under test; and, passive testing, consist of installing a probe in the system architecture. Main web domain stakeholders will profit from the approaches developed in WebMov since it will contribute to the reliability of Web Services. The fact that it is based on widely used standardized languages makes these approaches easier to adopt. It must also be noted that Web Services, when executed, use public resources. Errors or deadlocks in their behaviour have a negative impact on the user community and, thus, eliminating them will benefit not only industry but the community as a whole.

See <http://webmov.lri.fr>

Software Factory

Partners: Thalès, Dassault, MBDA, Hispano-Suiza, IFP, CEA, LIP6, Supélec, Ecole Polytechnique

Type: Industry
Amount: 107 k€
Duration: 24 months
Scientific director for LRI:
Marie-claude GAUDEL

The LRI team is involved in the Modrival sub-project of the Software Factory Project. This sub-project develops a coordinated set of tools for modelling, validating and verifying software systems. The LRI develops with CEA-LIST the tool sALLUSTe for statistical testing of reactive systems described in the Lustre language.

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Contracts
and grants

Collaborations

Cooperation Agreements

- Joint International Project of the British Royal Society, Ana Cavalcanti, University of York: Testing based on Circus Specifications, Partners: Computer Science Departments, Orsay and York, [11, 12]
- Cotutelle on simulation and validation of large multi-agents systems, Marie-Claude Gaudel and Ana C. V. de Melo, Université de Paris-Sud and Universidade de Sao Paulo.
- Project PERSO, ANR Young Researchers Program, Coordinator: Pascal Poizat, Partners: INRIA/ARLES, IBISC, LAMSADE, (2007-2010) <http://anr-perso.ibisc.univ-evry.fr/>
- Robust Web, COFECUB, coordinator: Eliane Martins, UNICAMP(Brazil), INT, Univ. Paris-Sud, (2008-2010)

Collaborations Leading to Joint Publications

- Carlos Canal and Gwen Salaun, Universidad de Malaga, Formal methods for system composition and adaptation [3]
- Serge Haddad, Université de Paris-Dauphine, Formal methods for system composition and adaptation
- Ana Cavalli, Stephane Maag, INT-Evry, passive testing, test of communicating systems [4], [1], [17]
- Richard Lassaigne, Equipe de Logique Mathématique de Paris 7, randomised model-checking [13], [7]
- Radu Matescu, projet INRIA/VASY, Formal methods for system composition and adaptation
- ETH Zurich, MBTSEC project, <http://www.infsec.ethz.ch/research/projects/mbtsec/>
- Aline Carneiro Viana, projet ASAP, INRIA Saclay, Wireless Self-Organising Networks Validation Techniques, an article is under revision.

Dissemination and Technology Transfer

Software Licensing and Distribution

AuGuStE - Statistical Testing of C Programs

<http://www.lri.fr/~fayolle/Auguste.html>

Contact: *Frédéric VOISIN*

The AuGuStE system (Automated Generation of Statistical Tests) is a random test generation tool for C programs that ensure, depending on the options, a uniform coverage of execution paths (with a bounded length) or a randomised coverage of statements or branches: the number of drawn tests can be tuned such as the probability to satisfy the coverage criterion is as high as desired.

AuGuStE has been developed by Sandrine-Dominique Gouraud. It is currently re-engineered under the direction of Frédéric Voisin.

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.

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.

sALLUSTe - Statistical Testing based on Lustre Descriptions

Contact: *Julien FAYOLLE*

Salluste is a tool for automatic test generation based on Lustre descriptions of the system under test. Lustre is a data-flow formal language used for the description of synchronous reactive systems. Salluste produces test sequences uniformly at random that ensure a uniform coverage of the behaviours of the Lustre description.

Salluste has been developed jointly with CEA-LIST (Bruno Marre) in the framework of the Usine Logicielle project of the Systematic pole of competitiveness.

It makes use of GATEL to check the feasibility of the drawn test cases.

Popularisation of Research Results

- Club "Science Ouverte" of Bobigny-Drancy, Marie-Claude Gaudel, Member of the Scientific Committee, organisation of several conferences every year for school pupils and the public
- Centre d'Alembert, Marie-Claude Gaudel, Member of the scientific board, see www.centre-dalembert.u-psud.fr
- Seminar on Science History, CIES, Orsay, Marie-Claude Gaudel, Alan Turing's secrets, May 2008

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Dissemination and
Technology Transfer

Summer Schools, Tutorials, Invited Seminars

International

- Marie-Claude Gaudel, *Pernambuco School on Software Engineering: Testing*, summer school, Recife, Brazil, Dec 3-7, 2007, <http://www.cin.ufpe.br/~psse/2007/>
- Marie-Claude Gaudel, *Resilience in Computing Systems and Information Infrastructures, from Concepts to Practice*, summer school, Porquerolles, 24-28 September 2007, see <http://www.resist-noe.org/events/summerschool.html>
- Marie-Claude Gaudel, various seminars in Bremen (Germany), Leicester, Swansea, York (UK), Braga (Portugal) in 2006-2007
- P. Poizat, *Shell Scripting for Scientific Programming : the Python example*, International Workshop on Computing for Heavy Ion Physics, Nantes, France, April 26th 2005.
- P. Poizat, *Extension of Behaviours with Formal Datatypes*, Invited seminar, University of Extremadura (Spain), June 2005.
- P. Poizat, *Model-based Software Adaptation. Open Systems and Semantics*, Invited seminar, University of Malaga (Spain), March 2007.
- Achim Brucker and Burkhardt Wolff: The HOL-OCL Tutorial at the MoDELS 2008, Toulouse, 29.9.08. http://www.lri.fr/~wolff/BurkhardtWolff_home-Dateien/documents/tutorials/talk-brucker_ea-analyzing-2008.pdf
- Achim Brucker and Burkhardt Wolff: Theorem-prover Based Testing with HOL-TestGen. TestCom/Fates 27.6.2007, Tallin, Estonia. Also held at the NII, Tokyo, 9.6.08. http://www.lri.fr/~wolff/BurkhardtWolff_home-Dateien/documents/tutorials/hol-testgen-tutorial.pdf
- Burkhardt Wolff : The HOL-Z Tutorial. Tutorial at the National Institute of Informatics, Tokyo, 9.6.08. http://www.lri.fr/~wolff/BurkhardtWolff_home-Dateien/documents/tutorials/2008-nii-hol-z-tutorial.pdf
- F. Zaidi: *From components Testing to Interoperability Testing*, Tutorial, TAROT RTN project summer school, Paris, 27/6 - 1/7/ 2005.
- F. Zaidi: *UML Oriented to Web Services*, Tutorial, E-Lane project summer school, Buenos Aires, Argentina, 28/8 - 1/9/2006.
- F. Zaidi: *The WebMov project*, TAROT RTN project summer school, Bath, UK, 22-27 june 2008.

France

- P. Poizat, *Adaptation Logicielle*, ACI FIACRE project meeting, ENST, February 2006.
- P. Poizat, *Adaptation Logicielle*, MeFoSyLoMa Group seminar, Univ. Paris XIII, May 2006. <http://www.mefosyloma.fr/j2006-05-12.html>
- P. Poizat, *Adaptation Logicielle*, INRIA Rhone-Alpes seminar, Grenoble, May 2006.
- F. Zaidi, *Méthodes de Test Passif*, LIRIS, Lyon, France, Sept. 2008.

7/ ForTesSE

Training and Education

Graduate Courses

- Master Informatique, Université Paris-Sud, *Tests de Systèmes Informatiques* : M.-C. Gaudel, S.-D. Gouraud, B. Wolff, F. Zaidi
- Master Informatique (MOPS), Université d'Evry Val d'Essonne, *Méthodes Formelles pour la Conception de Logiciel* : P. Poizat



Publications

Journal articles

Major international journals

- [1] E. Bayse, A. Cavalli, M. Nunez, and F. Zaidi. A passive testing approach based on invariants: application to the wap. In *Computer Networks*, volume 48, pages 247–266. Elsevier Science, 2005.
- [2] A. D. Brucker and B. Wolff. An extensible encoding of object-oriented data models in hol with an application to IMP++. *Journal of Automated Reasoning (JAR)*, Selected Papers of the AVOCS-VERIFY Workshop 2006, 2008.
- [3] C. Canal, P. Poizat, and G. Salaün. Model-based adaptation of behavioural mismatching components. *IEEE Transactions on Software Engineering*, 34(4):546–563, 2008.
- [4] A. Cavalli, A. Mederreg, F. Zaidi, P. Combes, W. Monin, R. Castanet, M. MacKaya, and P. Laurencot. Une Plate-forme de Validation Multi-Services et Multi-Protocoles - Résultats d'Expérimentations. *Annales des Télécommunications*, 60(5-6):588–609, June 2005.
- [5] C. Jones, D. Lomet, A. Romanovsky, G. Weikum, A. Fekete, M.-C. Gaudel, H. F. Korth, R. de Lemos, E. Moss, R. Rajwar, K. Ramamritham, B. Randell, and L. Rodrigues. The atomic manifesto: a story in four quarks. *Journal of Universal Computer Science*, 11(5):636–650, 2005.

Invited conferences

- [6] M.-C. Gaudel. Formal methods and testing: Hypotheses, and correctness approximations. In *FM 2005: Formal Methods: International Symposium of Formal Methods*, volume 3582 of *Lecture Notes in Computer Science*, pages 2–8. Springer Verlag, 2005. keynote talk.
- [7] M.-C. Gaudel, A. Denise, S.-D. Gouraud, R. Lassaigne, J. Oudinet, and S. Peyronnet. Coverage-biased random exploration of large models. In *ETAPS Workshop on Model Based Testing*, *Electronic Notes in Theoretical Computer Science*, March 2008. invited lecture, 11 pages.

Conference articles

Major international conferences and workshops

- [8] N. Baskiotis, M. Sebag, M.-C. Gaudel, and S.-D. Gouraud. A machine learning approach for statistical software testing. In *IJCAI, Proceedings of the 20th International Joint Conference on Artificial Intelligence*, pages 2274–2279, 2007.

- [9] F. Bassino, J. Clément, J. Fayolle, and P. Nicodème. Counting occurrences for a finite set of words: an inclusion-exclusion approach algorithms. In P. Jacquet, editor, *Proceedings of the 2007 International Conference on Analysis of Algorithms*, pages 95–104. DMTCS, 2007.
- [10] F. Bassino, J. Clément, J. Fayolle, and P. Nicodème. Construction for clumps statistics. In *Fifth Colloquium on Mathematics and Computer Science (Sept. 2008)*, 2008.
- [11] A. Cavalcanti and M.-C. Gaudel. Testing for refinement in CSP. In *Formal Methods and Software Engineering, ICFEM 2007*, volume 4789 of *Lecture Notes in Computer Science*, pages 151–170. Springer Verlag, 2007.
- [12] A. Cavalcanti and M.-C. Gaudel. A note on traces refinement and the conf relation in the Unifying Theories of Programming. In *Unifying Theories of Programming*, volume to appear of *Lecture Notes in Computer Science*, Trinity College Dublin, September 2008. Springer Verlag. 20 pages.
- [13] A. Denise, M.-C. Gaudel, S.-D. Gouraud, R. Lassaigne, and S. Peyronnet. Uniform random sampling of traces in very large models. In *1st International ACM Workshop on Random Testing*, pages 10 –19, July 2006.
- [14] J. Fayolle. Analysis of the size of antidictionary in DCA. In *Combinatorial Pattern Matching 2008*, 2008.
- [15] J. Fayolle, M.-C. Gaudel, S.-D. Gouraud, and B. Marre. Statistical testing of synchronous reactive systems. In *Proceedings of Embedded Real Time Software 2008*, 2008. 15 pages.
- [16] S.-D. Gouraud and A. Gotlieb. Using CHRs to generate functional test cases for the java card virtual machine. In *8th International Symposium on Practical Aspects of Declarative Languages (PADL)*, LNCS 3819, pages 1–15, 2006.
- [17] M. Lallali, F. Zaidi, and A. Cavalli. Timed modeling of web services composition for automatic testing. In *SITIS IEEE/ACM 2007*, pages 411–427, Shanghai, December 2007. IEEE Computer Society.
- [18] M. Lallali, F. Zaidi, and A. Cavalli. Transforming bpel into intermediate format language for web services composition testing. In *4th International Conference on Next Generation Web Services Practices*, Seoul, october 2008. IEEE Computer CS. 191–197.
- [19] M. Lallali, F. Zaidi, A. Cavalli, and I. Hwang. Automatic timed test case generation for web services composition. In I. C. S. Press, editor, *The 6th IEEE European Conference on Web Services (ECOWS'08)*, Dublin, november 2008. 53–63.
- [20] S. Maag and F. Zaidi. A step-wise validation approach for a wireless routing protocol. In *IEEE International Conference on Communications and Electronics (ICCE'06)*, Hanoi, Vietnam, October 2006. IEEE.
- [21] S. Maag and F. Zaidi. Testing methodology for an ad hoc routing protocol. In *PM2HW2N '06: Proceedings of the ACM international workshop on Performance monitoring, measurement, and evaluation of heterogeneous wireless and wired networks*, pages 48–55, Terromolinos, Spain, 2006. ACM. <http://doi.acm.org/10.1145/1163653.1163663>.
- [22] J. Oudinet. Uniform random walks in very large models. In *RT '07: Proceedings of the 2nd international workshop on Random testing*, pages 26–29, Atlanta, GA, USA, November 2007. ACM Press.
- [23] J. Oudinet. Uniform random exploration of concurrent systems. In *MOdelling and VERifying parallel Processes (MOVEP)*, pages 323–328, June 2008.



Major national conferences and workshops

- [24] A. Cavalli, S. Maag, and F. Zaidi. Une approche uml pour la validation des services web. In *5ème Colloque international sur les NOuvelles TEchnologies de la REpartition (NOTERE)*, September 2005.
- [25] G. Lestiennes and M.-C. Gaudel. Test de systèmes réactifs non réceptifs. *Journal Européen des Systèmes automatisés*, 36(1-2-3):255–270, 2005. proceedings of MSR'05.

Other conferences and workshops

- [26] S.-D. Gouraud and A. Gotlieb. Utilisation des CHRs pour générer des cas de test pour la machine virtuelle java card. In *Journées Francophones de Programmation par Contraintes (JFPC)*, pages 383–392, 2005.

Books and book chapters

- [27] M.-C. Gaudel. Toward undoing in composite web services. In *Architecting Dependable Systems III*, volume 3549 of *Lecture Notes in Computer Science*, pages 59–68. Springer Verlag, 2005.
- [28] M.-C. Gaudel. Les objets à l'épreuve des faits. In *Communication, Connaissance : supports et médiations à l'âge de l'information*, J.-G. Ganascia, ed. CNRS Éditions, 2006. 4 pages.
- [29] M.-C. Gaudel. Validation et vérification. In *Encyclopédie de l'informatique et des systèmes d'information*, pages 1136–1150. Vuibert, 2006.
- [30] M.-C. Gaudel and P. L. Gall. Testing data types implementations from algebraic specifications. In *Formal Methods and Testing*, R. Hierons, J. Bowen, and M. Harman, eds, volume 4949 of *Lecture Notes in Computer Science*, pages 209–239. Springer-Verlag, 2007.

Other publications

- [31] A. Denise, M.-C. Gaudel, S.-D. Gouraud, R. Lassaigne, J. Oudinet, and S. Peyronnet. Coverage-biased random exploration of large models and application to testing. Technical Report 1494, LRI, Université Paris-Sud XI, June 2008. 26 pages, submitted.
- [32] M.-C. Gaudel, F. Magnez, R. Lassaigne, and M. de Rougemont. Approximations for model checking and testing (survey, preliminary version). 32 pages, submitted, Université de Paris-Sud, May 2008.
- [33] S.-D. Gouraud. Auguste: a tool for statistical testing (experimental results). Technical Report 1400, Université Paris-Sud 11, 2005.
- [34] M. Lallali, F. Zaidi, and A. Cavalli. Timed modeling of web services composition for automatic testing. Technical Report 07008-LOR, GET/INT, Evry, September 2007. Long version.
- [35] G. Lestiennes and M.-C. Gaudel. Modélisation et test de systèmes comportant des actions prioritaires. Rapport LRI 1434, Université de Paris-Sud, March 2006.

- [36] S. Maag and F. Zaidi. Spécification formelle pour le test d'un protocole de routage ad hoc. Technical Report 06009-LOR, GET/INT, France, October 2006.
- [37] J. Oudinet. Tirages aléatoires uniformes dans des systèmes concurrents. Master's thesis, Université Paris-Sud 11, LRI, September 2007.
- [38] J. Oudinet. Uniform random walks in concurrent models. Master's thesis, Université Paris-Sud 11, LRI, September 2007. Master Thesis.
- [39] F. Zaidi and M. Lallali. Use of verification techniques for components testing. Technical Report 1465, LRI, <http://www.lri.fr/Rapports-internes>, Université Paris-Sud XI, January 2007.