**PEPR EXPLORATOIRES**
**PROJET CIBLE**
**2022**

***PROGRAMME ENSEMBLE***

**DOCUMENT PRÉSENTATION PROJET**

# PILOT

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| **Acronyme** | **PILOT** |
| **Titre du projet en français** | *Collaboration à long terme* |
| **Titre du projet en anglais** | *Practices and infrastructure for long term collaboration* |
| **Mots-clefs** | Collaborative environments, Long-term collaboration, Collaborative practices, Users experience, Computer-Supported Cooperative Work, Human-computer interaction, Distributed platforms, Interoperability, Sovereignty<br><br>Environnements numériques collaboratifs, Collaboration à long terme, Pratiques coopérative, Expérience Utilisateurs, Travail Coopératif Assisté par Ordinateur, Interaction Humain-Machine, Plateformes distribuées, Interopérabilité, Souveraineté. |
| **Établissement porteur** | **Inria** |
| **Responsable du projet** | **Responsable:**<br>- **Claudia-Lavinia Ignat, Chargée de recherche, Inria**<br><br>Co-responsables :<br>- François Charoy, Professeur des Universités, Université de Lorraine<br>- Myriam Lewkowicz, Professeure des Universités, Université de Technologie de Troyes<br><br>**Courriel** : claudia.ignat@inria.fr<br>**Téléphone** : **03.83.59.20.44** |

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| **Durée du projet** | 84 mois | | |
| **Aide totale demandée** | 5 160 000 € | **Coût complet** | 19 555 229,27 € |

**Liste des établissements du consortium :**

| **Établissements d'enseignement supérieur et de recherche** | ***Secteur(s) d'activité*** |
|---|---|
| ***Université Grenoble Alpes*** | *Informatique, Génie mécanique* |
| ***Université Paris-Saclay*** | *Informatique, IHM* |
| ***Sorbonne Université*** | *Informatique, Systèmes distribués* |
| ***IMT*** | *Informatique, SHS* |
| ***Université de Technologie de Troyes*** | *Informatique (IHM, CSCW, ingénierie des connaissances), SHS (sociologie, psychologie sciences de gestion, sciences de l'information et de la communication)* |
| ***INSA Lyon*** | *Informatique, Systèmes distribués, Réseaux* |
| ***Université Claude Bernard*** | *Informatique, IHM, CSCL* |
| ***Nantes Université*** | *Informatique, Gestion de données distribuées* |
| ***ENSAM*** | *Informatique, Collaborative methods and tools* |
| ***Université de Lille*** | *Informatique, IHM* |
| ***Université de Toulouse III*** | *Informatique* |

| **Organismes de recherche** | ***Secteur(s) d'activité*** |
|---|---|
| ***Inria*** | *Informatique, Systèmes distribués, CSCW, IHM* |
| ***CNRS*** | *Informatique* |

***Résumé du projet en français (Non Confidentiel – 4000 caractères maximum, espaces inclus)***

Les deux dernières décennies ont vu l'essor de nombreux outils et plateformes qui favorisent la collaboration, la communication et la coordination au sein d'un groupe. La pandémie de COVID-19 a accéléré l'acculturation à ces services. Cependant, la mise en place d'un environnement collaboratif pour un projet pour des semaines ou des mois, ayant des participants issus de différentes organisations, nécessite toujours de nombreuses décisions basées sur des exigences contradictoires telles que la sécurité, la confiance, les politiques de l'organisation, la facilité d'utilisation, les connaissances préalables et le coût. De mauvaises décisions vont produire une collaboration inefficace. Elles vont amener les gens à se rabattre sur des méthodes dépassées comme les pièces jointes aux courriels. Les gens veulent travailler de manière transparente à partir de différents lieux et appareils et adapter leur environnement à de nouveaux besoins.

Le projet vise à concevoir des plateformes de collaboration qui considèrent les défis réglementaires, les théories organisationnelles et les descriptions de terrain. Le projet cherche à anticiper les évolutions technologiques et sociétales et à permettre une exception française (ou européenne) sur les plateformes numériques qui garantissent l'autonomie des acteurs individuels et favorisent l'attention, la confiance et le bien-être numérique. Les principaux défis du projet consistent à revisiter l'environnement socio-technique, incluant de nouveaux modèles conceptuels et des cadres de conception pour les pratiques collaboratives à long terme, pour permettre des expériences collectives fluides qui permettent l'interopérabilité et l'évolution.

# PILOT

***Résumé du projet en anglais (Non Confidentiel – 4000 caractères maximum, espaces inclus)***

The past two decades have witnessed the rise of numerous tools and platforms that support group collaboration, communication, and coordination. The COVID-19 pandemic has accelerated the acculturation of people to these services. However, setting up a collaborative environment for a project that lasts for weeks or months, with participants from different organizations, requires many decisions based on contradictory requirements such as security, trust, organization policies, ease of use, previous knowledge, and cost. Inefficient collaboration occurs due to wrong decisions, leading to people falling back on outdated methods like email attachments. People want to work seamlessly from different locations and devices and adapt their environment to new needs.

The project aims to design and engineer collaborative platforms that build upon regulatory challenges, organizational theories, and field descriptions. The project seeks to anticipate technological and societal evolutions and enable a French (or European) exception on digital platforms that guarantee individual actors' autonomy and foster care, trust, and digital well-being. The project’s key challenges stem from revisiting the socio-technical stack, which includes novel conceptual models and design frameworks for long-term collaborative practices and enabling fluid collective experiences that support interoperability and evolution.

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# 1. Context, objectives and previous achievements

## 1.1. Context, objectives and innovative features of the project

### Context

The last 20 years have seen the rise of a large collection of tools and platforms that provide services to support group collaboration, communication and coordination. The acculturation of people to these services has grown at the same pace, with an acceleration during the last three years due to the COVID-19 pandemic. Indeed, it has become fairly easy to share and work on data and documents, to organize communication through different channels, workspaces, and platforms that can be integrated into all kinds of business applications, and to coordinate actions through boards or workflows that mimic the office environment.

Despite these advances, we must recognize that we are still far from the ideal situation that we dream of since Engelbart. Setting up a collaborative environment for a project that may last weeks or months, with participants belonging to different organizations, requires many decisions based on contradictory requirements, including interoperability, security, trust, organization policies, ease of use, previous knowledge, and cost. We always face the double binding injunction between organizations' policies and ease of collaboration: should we use this public centralized platform offered by a global, private third party, or rely on the internal solution that we will have to impose on the group? How is organized the governance of the collaboration for group management, data ownership, and the definition of the collective process? Wrong decisions lead to inefficient collaboration. People do not adopt the offered technical solutions and fall back to unadapted ones such as email attachments. They prefer to use their own devices and usual applications to collaborate. They want to be able to work seamlessly from their office, from home, or on the go. They also want to be able to adapt their environment to new needs that may arise during their activities.

On the other hand, during the pandemic, with the emergency to devise new solutions to unknown problems, teachers, healthcare workers, first responders, have been relying on existing tools to solve new problems in totally unexpected ways. Slack has been used to manage bed availability between hospitals, WhatsApp has been used among care professionals to collectively take care of patients when they were not able to meet, Discord has been used at a very large scale by teachers and students for homeschooling. New modes of organizations have been created most of the time out of the control of managers. These new practices need to be acknowledged.

### Objectives

In PILOT, the design and engineering of collaborative platforms will build upon regulatory challenges, organizational theories, and thick descriptions of practices from the field. PILOT will demonstrate alternative digital futures to anticipate rather than react to technological and societal evolutions. Anticipating changes and regulations should also enable us to assert sovereignty while enabling a “French (or European) exception” on digital platforms that guarantee individual actors' autonomy and foster care, trust, and digital well-being in a time of increasing fracture and tension, as stated by the European Commission for the “Europe’s digital decade”[1].

The key challenges of PILOT stem from the different aspects of the socio-technical stack that the project is revisiting: the underlying conceptual models of the new digital artefacts we seek to create (key challenge 1) and the necessary infrastructure to enact these interactions (key challenge 2).

**Key challenge 1: Offer novel conceptual models and design frameworks to tackle the future of long-term collaborative practices -** The future of long-term collaborative practices is a complex and multifaceted topic that requires novel conceptual models. Organizations of all kinds are looking for ways to work together to achieve common goals and overcome challenges. However, the success of long-term collaborative practices often depends on factors such as trust, communication, and shared values. It is then necessary to develop new conceptual models and design frameworks that take into account these factors. These models should consider the impact of cultural differences, language barriers, and other social factors on collaboration as well as technical heterogeneity.

**Key challenge 2: Enable fluid collaborative experiences that support interoperability and evolution -** The current approaches to digital services, based on information silos and walled gardens, create unneeded barriers to fluid forms of collaboration. Users need to be able to create their own collaborative environment. They also need to be able to change these environments to adapt them to new requirements, partners, or tools. This requires embracing interoperability at every level of the socio-technical stack. It is also key to enabling accessibility by diverse collectives of users.

## State of the art

The research domain and community that has offered conceptual and design frameworks and technologies to address the aforementioned issues is called CSCW (Computer-Supported Cooperative Work) . Indeed, CSCW research focuses on the problem of incorporating models of coordinative practices in computational artifacts and in such a way that actors are able to deal with contingencies and are supported in that by the functionalities of the computational artifacts. CSCW research is also united in a symmetrical commitment to ground design efforts in studies of actual practices to inform the development of collaborative technologies (Bannon & Schmidt, 1989; Greif 1988; Suchman and Trigg 1986). Ethnographic approaches had an impact beyond expanding the CSCW repertoire of techniques, i.e. the ‘toolbox’ available for documenting phenomena and reporting their accounts. Instances of higher level framework approaches have also been adopted within CSCW in order to capture ‘the socio-technical’ in a broad sense. These include for example

[1] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en

Actor Network Theory, sociomateriality (Orlikowski and Scott 2008), and participatory action research. CSCW has long faced the challenge of building 'an analytic framework of some generality' but nonetheless 'capable of retaining a sensitivity to the details and the variety of work domains' (Hughes et al. 1994, p.129).

While this question that PILOT is targeting remains open, some analytic frameworks have been built mainly through a suite of synthesizing concepts that have been identified 'from the ground up' in domain-specific studies. These conceptual frameworks have often intended to critically approach systems design, although the relationship and mutual interdependence between conceptual and design approaches is not linear and thus hard to unpack. In particular, *design ethnography* emerged in CSCW from the argument for ethnographic fieldwork as directly relevant for the design of systems (Randall, Rouncefield and Harper 2007). The *Locales Framework* (Fitzpatrick, 2003) builds on the concepts of situated action and place to both evaluate and design collaborative systems in organizations. *Sociomaterial-Design* (Bjørn and Østerlund 2014) links design research to sociomateriality as an analytical lens accounting for the entangled and mutually constituting nature of materials, people, and practices. *Grounded Design* (Stevens et al 2018) is based on the understanding of the relationship between social practices and the design space for systems built to support them (Stevens et al 2018). The core technique of this approach is Design Case Studies that sensitively examine and capture complex social practices for contributing to the design of IT artifacts (Wulf et al. 2011).

Significant research has been conducted in diverse domains such as healthcare (Hartswood et al. 2003), (Cormi et al., 2022), crisis management (Reuter et al. 2015), industry (Ludwig et al., 2023) and education, demonstrating the complexity of interrelations between time, place, documents and organizations. Researchers showed that relying on standardized technical solutions to local socio-technical problems does not lead to the benefits that policymakers (Jackson et al., 2014) and managers claim. Another challenge is related to the expansion of cooperation beyond the boundary of one organization, and to the users' environment that is already populated by software systems also called an ecology of artifacts (Lyle et al., 2020) (Bodker & Klokmose, 2012). Indeed, in the last decade, collaborative systems shifted towards new kinds of large-scale and interconnected infrastructures that transcend workplaces and organizations. While the term 'infrastructure' has traditionally been used mainly to refer to developing layers of hardware and software technology, CSCW research emphasizes the interactional and organizational features that influenced the evolution of infrastructures (Blomberg & Karasti, 2013) (Klokmose et al. 2015). One of the major characteristics of infrastructuring as a technology development methodology is the "Point of Infrastructuring" (PoI), which is the moment at which a group of practitioners understands that the current use of a technological infrastructure needs to be reconsidered (Pipek and Wulf, 2009) (Ludwig et al, 2018).

Current collaboration tools are heavily limited in terms of capability, openness and level of integration. They trap users in « private walled gardens » and information silos, creating de facto monopolies (Karger et Jones, 2006) (Ravasio et al. 2004) (Oleksik et al. 2012). Users of these collaborative tools have to place personal information in the hands of a single large corporation which is a perceived privacy threat. Large collaborative service providers such as Dropbox, iCloud and GoogleDrive adopted encryption solutions in order to store only the encrypted version of shared documents. However, for facilitating the usage of their services, encryption keys are stored by the service providers which gives them the possibility of decrypting data and being subject to different attacks.

PILOT proposes interoperable, secure and sovereign collaborative infrastructures that will allow : (1) to safely share a document in a peer-to-peer manner without moving it to a proprietary cloud service so that any of the participants can use their preferred editing tool when writing collaboratively in real-time; (2) to end-to-end encrypt communication messages and where servers do not need to decrypt data; (3) to represent an entire collaborative project as a full-fledged shareable digital object that can be enriched over time, record its history, and serve as shared context when creating on-the-spot collaborative sessions; (3) enabling community members to reconfigure the platforms they use to match their organizational structures and practices as they evolve over time.

## 1.2. Main previous achievements

The project will benefit from the previous experience and contributions of the different research groups of the consortium in the different required fields: Computer-Supported Cooperative Work, Human Computer Interaction and Collaborative Infrastructures.

*Computer-Supported Cooperative Work*. UTT has been involved in many projects in the healthcare, crisis management, and industry areas, adopting a practice-centered computing approach, aiming at defining design principles for collaborative systems that are grounded on existing practices. In particular, UTT has studied cooperation across boundaries, and defined how to design systems supporting knotworking (Abou Amsha et al., 2021), and reflected on software design and information system management practices in order to identify how to transfer past and current CSCW findings in current ecologies of artifacts (Lewkowicz & Liron, 2019) (Cormi, 2022). Inria did field studies in the domain of crisis management (Linot et al. 2018) and collaborative editing (Ignat et al. 2015). UGA has a longstanding experience in the study of very diverse forms of collaboration between experts in the industrial domain and particularly the collaboration of heterogenous actors in the design process. UGA also focussed on long term collaboration among virtual and distributed communities of makers that develop open-source hardware (ANR OPEN!, H2020 OPENNEXT) (Boujut et al., 2019), (Bonvoisin et al. 2021) (Dai et al. 2020) . UGA also has an expertise on the appropriation of technologies (why and how people appropriate technologies, how to design 'for' appropriation) and, in particular, on Computer Supported Collaborative Learning.

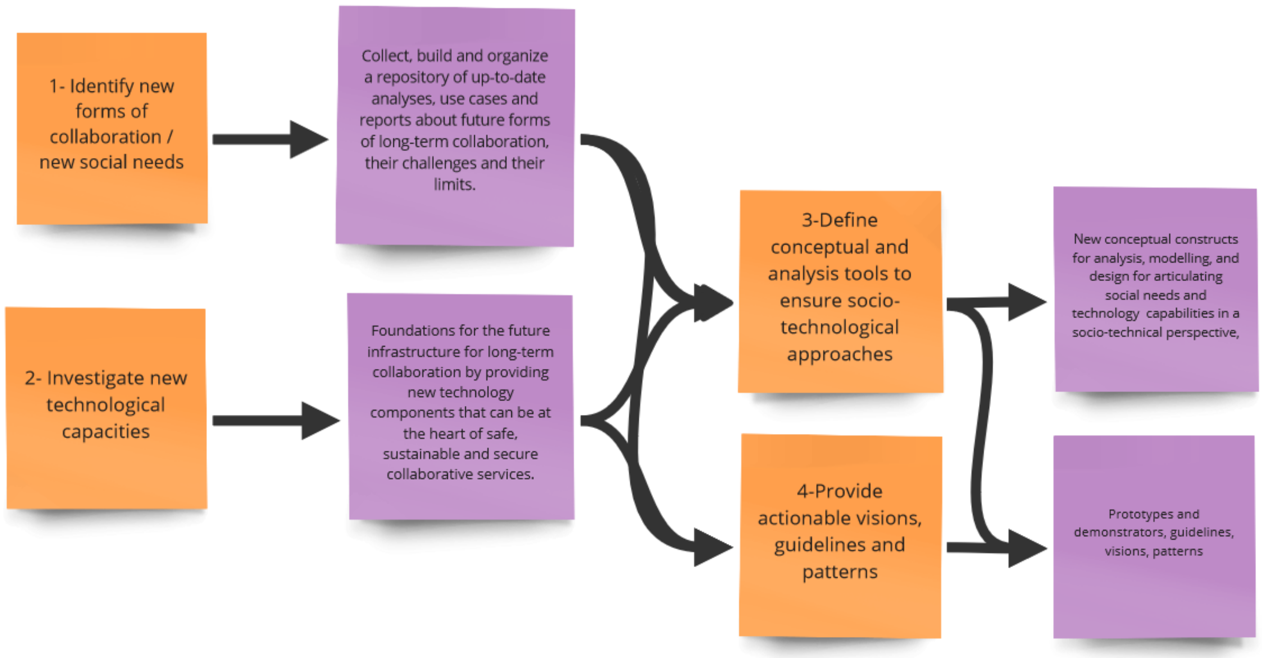
*Human Computer Interaction.* Inria produced original ideas, fundamental knowledge and practical tools to inspire, inform and support the design of human-computer interactions. Their research interests cover the design of novel interactive systems (Alvina et al., 2020) (Masson et al., 2020) and graphical user interfaces (Giannisakis et al., 2017) (Malacria et al., 2017) that facilitate how interaction is communicated (Mackamul, 2022). They have studied how users build expertise with interactive systems based on how interaction is communicated by systems to users (Goguey et al., 2018) (Fennedy et al., 2022) and how interaction could be better communicated between users (Masson et al., 2020). Simultaneously, they have built expertise in the production of advanced command histories to foster experimentation, reuse and sharing of work processes (Nancel and Cockburn, 2014). IMT partner expertise is at the intersection of human-machine interaction and data visualization and is organized around three themes: increasing the malleability and appropriability of digital tools, in particular for experienced users or groups of users; data visualization to better help users make sense of the masses of data (production of meaning, "sensemaking"), and improve the expressiveness of digital tools. Their research on Webstrates reinvents the way we create interactive software, with collaboration, composition, and malleability as fundamental principles.

*Collaborative Infrastructures.* Sorbonne Université has already proposed distributed protocols for dynamic systems such as mobile networks. It has already designed new algorithms to publish or broadcast ordered information (Wilhelm et al, 2022), (De Aranjo et al., 2019), (De Aranjo et al., 2018) or to schedule tasks in uncertain distributed environments (Arantes 2018). Inria partner is expert on peer-to-peer infrastructures and developed a peer-to-peer collaborative editor MUTE (Nicolas et al., 2017) in the context of the OpenPaaS::NG project financed by BPI France. They are pioneers on CRDTs (Conflict-free Replicated Data Types), i.e. replication algorithms where merging of concurrent changes can be done locally without any coordination mechanisms (Oster et al., 2006). MUTE relies on LogootSplit (André et al., 2013), an efficient replication mechanism for sequences. UGA partner developed the VISION-R platform which is a unique infrastructure that allows the development and the test of AR/VR based technologies dedicated to expert collaboration (EQUIPEX CONTINUUM, ANR Collaboration 4.0, H2020 SPARK) (Ezoji et al, 2021). INSA Lyon partner has an expertise on large scale distributed systems applied to dynamic environments such as IoT, mobile, edge/fog. The CNRS/UPSaclay partner developed a tool called FileWeaver (Gori et al. 2020), which augments traditional file management tools with automatic tracking and interactive visualization of file dependencies and histories. The prototype combines synchronized views of the folder structure, the graph of dependencies for a particular file as well as its history.

# 2. Detailed project description

## 2.1. Project outline, scientific strategy

PILOT is organized around four related scientific axes (Figure 1). (1) First, we need to better understand current and future forms of long-term collaboration. We will investigate the current forms of collaboration disseminated around multiple technology artifacts, especially in domains that are currently inventing new ways of working together with technology (Industry 4.0, software engineering, digital learning, crisis management, and healthcare), while taking into account the evolution of legal and regulatory frameworks for digital technology (addressed in Projet ciblé 5). (2) Second, at a technology level, we will develop new interoperable capabilities for software and networking that will be key for the future of long-term collaboration. We will share these advanced components within the program for identifying use cases. (3) Third, we will develop new conceptual and analysis tools for articulating social needs and technology capabilities, adopting a sociotechnical perspective. (4) Finally, we will develop frameworks for translating these analyses into actionable visions and propositions that will guide research and industry for the future of long-term collaboration.




A global description of the axes is presented below.

## Axis 1 - Understanding current and future forms of long-term collaboration

Long-term collaboration typically involves multiple technological artifacts, especially in domains that are inventing new ways of working with technology. This axis investigates existing innovative research projects in order to highlight the forms, stakes, and limits of these new forms of collaboration. The legal landscape is also changing with new frameworks emerging at the EU and states' scales that require better account for the location, privacy, ownership, and transferability of data that is not yet dealt with by existing digital tools and platforms, and could even prevent current services from continuing to exist. This axis therefore studies emerging forms of collaboration, in particular in the following areas: industry, software engineering, hybrid and distance learning, crisis management, and healthcare. These domains have been key in the emergence of technology-based collaborative practices. In connection with the TRANSVERSE project of eNSEMBLE, we will also study the evolution of legal and regulatory frameworks for digital technology that affect long-term collaboration. All these elements will allow us to collect, build and organize a repository of up-to-date analyses, use cases and reports about future forms of long-term collaboration, their challenges and their limits.

### Axis 2 - Open technical frameworks and protocols for long-term collaboration

The next generation of long-term collaboration technology will require fluid distributed infrastructure that can be partly owned and shared among participants. Interoperability, sustainability, trust, reliability, and security will be at the heart of the capabilities of this new infrastructure. We will investigate new algorithms and infrastructure to manage shared and replicated data while keeping track of user intention, dependencies and change histories between shared artifacts and across organizational barriers. We will also develop an interoperability framework that can be used as the basis for collaborative services integration in an heterogeneous environment. Finally we will develop security models and protocols adapted to long-term collaboration that do not require a central authority. All these capabilities will create the foundations for the future infrastructure for long-term collaboration by providing new technology components that can be at the heart of safe, sustainable and secure collaborative services.

### Axis 3 - Conceptual frameworks for long-term collaboration

As collaborative activities spread across multiple software and devices, breakdowns in the way information is shared, and group coordinated become increasingly frequent and problematic. New conceptual frameworks are needed to account for the organizational evolutions (e.g. people increasingly collaborating across teams and organizations), the constant evolution of software (e.g. constant updates, or switch from one platform to another), and emerging collaborative practices. We will develop new conceptual and analysis tools for articulating social needs and technology capabilities in a sociotechnical perspective, therefore developing new practices for software engineering and design. These frameworks will account for the asymmetries of roles, goals and preferences when collaborating on a shared artifact, and for the recording and browsing of collaborative interaction histories. Such conceptual frameworks for long-term collaboration will allow an appropriate modeling of coordination mechanisms to ensure the appropriation of technology by end-users, which is challenged by the complexity of the ecologies of artifacts at stake. This axis will produce theoretical constructs for analysis, modeling and design that match new forms of long-term collaboration (as identified in Axis 1) with technology capabilities (in particular those developed in Axis 2).

### Axis 4 - Actionable visions for future forms of long-term collaboration

The goal of this research axis is to develop actionable visions and guidelines to facilitate the implementation of new, technology-supported forms of long-term collaboration between research and industry. Accomplishing this requires the expertise of engineers and designers, who will need new frameworks, patterns, and artifacts to realize these visions. In order to ensure the impact of this project is long-lasting and practical, the axis will produce guidelines and visions for long-term cooperation across organizations. This will encompass various forms of collaboration, which will have been analyzed in other axes from a socio-technical perspective, including distributed collaboration, purpose-driven collaboration, open collaboration, and adaptive collaboration. To promote engagement and foster a community around these outcomes, the axis will create a platform that can receive and distribute contributions.

## 2.2. Scientific and technical description of the project

In this section we provide a detailed description of the four axes of the project introduced in the previous section.

### Axis 1 - Understanding current and future forms of long-term collaboration

**Leaders: Myriam Lewkowicz, François Charoy**

Following a practice-centered approach for the development of computing technologies (Schmidt, 2018), which assumes that ‘to design technology that supports collaborative practices requires that we uncover the largely unarticulated detail of what people actually do when they work together’ (Suchman & Trigg, 1986, p. 221), this axis aims at discovering, describing, and analyzing, the emerging and the future forms of collaboration in what we consider the most important domains of our society: healthcare, hybrid and distance learning, industry, software engineering, and crisis management. Crises happen, the market and the society change, so as the national or EU legal and regulatory landscape. These evolutions trigger new practices in all the aforementioned domains that need to be investigated to highlight the forms of collaboration they mobilize, their stakes, and their limits. The studies conducted in this axis will feed a repository of up-to-date analyses, use cases and reports about emerging forms of long-term collaboration, their challenges and their limits. Documenting these practices in a repository will offer opportunities for reflexivity, comparison, and concept building (Li et al., 2021) therefore supporting the axis 3.

**WP1.1 Long-term collaborative practices for the future of the healthcare sector**
From in-hospital coordination and collaboration, at-home management of chronic illnesses, to data-driven practices that connect the whole ecosystem of healthcare stakeholders, collaborative practices increasingly influence and impact individuals’ everyday lived health experiences, the work practices of healthcare professionals, and the interaction between multiple stakeholders of healthcare in a variety of settings, such as home, community, organization, and society. This work package takes the opportunity of studying this shifting environment where collaborative work is characterized by contingent fluctuations between the stability of cooperators and normal intensity of work, and unexpected and pressing situations, where cooperation between new actors has to be established immediately.

**WP1.2 Long-term collaborative practices for the future of crisis management**
Crisis management requires collaboration between practitioners from different organizations at all its phases. Each of these organizations (e.g. police, firefighters, ER, NGO) has a strong organizational culture and well-defined practices and is used to collaborate. The new form of communication and information sharing impact them. This WP offers case studies of long-term collaborative practices to gather the knowledge for understanding the challenges for technology, organization, and regulation in the future of long-term collaboration for crisis management.

**WP1.3 Long-term collaborative practices for the future of digital and hybrid learning**
Digital learning is a domain with decades of application in different contexts (eLearning, smart cities and serious games) that has even intensified in the recent COVID-19 context. This WP contributes to the definition of an ecosystem for collaboration with a common functional reference system capable of adapting to different situations.

**WP1.4 Long-term collaborative practices for the future of industry**
The industry of the future is an information system of great complexity that produces a large amount of digital data that must be treated in an “intelligent” way. This intelligent treatment raises issues that have mainly been tackled from a technical and economical point of view, whereas the social and human dimensions that play an essential role in the complexity have been neglected so far. This WP studies how new infrastructure built on the Industrial Internet of Things, and digital twins are used and could be used to improve productivity, safety, and a better quality of life at work.

**WP1.5 Long-term collaborative practices for the future of software engineering**
Software systems have risen to an unprecedented complexity involving diverse and distributed teams across different expertise (for instance, planning, security, integration, development) that coordinate around the concept of software architecture. Current software engineering exemplifies the future stakes of long-term collaboration in relation with dealing with software platform evolution, integration, validation, and decision making.

**Deliverable of Axis 1**
**D1**: a repository of up-to-date analyses, use cases and reports about future forms of long-term collaboration, their challenges and their limits

## Axis 2 - Open technical frameworks and protocols for long-term collaboration

**Leaders: Claudia-Lavinia Ignat, Matthieu Tixier**

Current research demonstrates the possibility to share the history of digital action across software, to decentralize cooperation spaces, or to build and monitor networks for ensuring a better collaboration. The future of long-term collaboration will be made of these existing resources and infrastructure, but also of capacities that are not yet available. This axis aims at supporting the development of cutting edge network and software components for the future of long-term collaboration.

**WP 2.1 Sustainable and safe infrastructure for future forms of collaboration** Collaboration involves exchanging and sharing data and information among users and services distributed in time and space. The nature of information and data and their structure impose different kinds of constraints on the way they are shared and replicated. It is important to keep track of user intention, of dependencies and histories of change between shared artifacts even across organizational barriers. Despite the important progress made in the last 20 years regarding replication and diffusion algorithms, the goal of this WP is to investigate new algorithms and infrastructure that will be the basis for future collaborative systems.

Most of the platforms hosting collaboration services rely on a central authority and place personal information in the hands of a single large corporation which is a perceived privacy threat. Users must provide their data to the vendors of these services and trust them to preserve the privacy of their data, but they have little control over the usage of their data after sharing it with other users. Moreover, the centralisation of the platforms hosting these services makes their scalability and reliability very costly. They often limit the number of persons that can simultaneously modify shared data, they generally rely on costly infrastructures and do not allow sharing of infrastructure and administration costs, and centralisation is not suitable for collaboration among a federation of organizations that want to keep control over their data and do not want to store their data at a third party.

This WP proposes to investigate peer-to-peer collaboration where control over the data is given to users who can decide with whom to share their data. The risk of privacy breaches is decreased in this peer-to-peer collaboration. These systems feature high scalability, resilience to faults and attacks, low deployment barriers for new services and shared costs for system administration.

A long-term collaboration has to support several collaboration modes:

(1) **connected,** where user modifications are immediately shared and visible to the other users;

(2) **disconnected,** where users are not connected to the network. User modifications will be transmitted to the other users at the reconnection;

(3) **ad-hoc collaboration,** where subgroups of users can work together and synchronize at a later time with other members of the group;

(4) **inter-organizational work mode,** where groups of users from different organizations work and share data during a collaborative activity. This mode has to guarantee the privacy of shared data during the collaborative activity, i.e. only the necessary data will be accessible to the other organizations.

We propose investigating the use of peer-to-peer infrastructures such as IPFS (https://ipfs.io/) on which we can plug replication mechanisms for data synchronization. Data replication algorithms have to be reliable (i.e. after the reception of all modifications the replicas have to converge) and explainable (i.e., the decisions taken by these algorithms have to be understood by users and their intentions have to be respected). These algorithms have to be suitable for a large community of users that produces a large number of modifications with a high frequency. Depending on the applications to be supported by the infrastructure we propose developing the suitable data replication mechanisms. Existing collaborative systems such as GoogleDocs do not support the different modes of collaboration proposed and seamless switch from one mode to the others.

**WP2.2 Interoperability for long-term collaboration.**
Setting up a collaborative network requires combining different tools and services in order to support the main functions of collaborative work. However, the diversity of these services, their heterogeneity, and their constant evolution in time makes it difficult to integrate properly. The goal of this work package is to develop an interoperability framework that can be used as the basis for collaborative services integration. This includes open and extensible formats and ontological approaches such that different applications could function on the same shared objects as well as software models and infrastructures capable of fostering collaboration among heterogeneous actors and artifacts.

**WP2.3 Security for distributed collaborative systems**
A challenging issue is how to balance collaboration with security of shared objects. Interaction is aimed at making shared objects available to all who need them, whereas security seeks to ensure this availability only to users with proper authorisation. In large scale collaboration, we need to keep up with the same performances that we can achieve at a small scale. We need also to ensure that the infrastructure that supports data sharing and collaboration is resilient and trustworthy.

Existing access control mechanisms mainly based on a central authority feature several difficulties in the context of collaborative systems. In the case of a federation of organizations, agreeing on an authority that manages access rights is almost impossible. Lack of a central authority raises issues of group management such as joining and leaving the group as well as rights revocation. Indeed, it should be possible for a partner to revoke granted rights without contacting an external authority.

This WP proposes an easy to use security mechanism adapted for distributed collaborative systems without a central authority. The security mechanism has to deal with user access rights to the shared documents as well as with end-to-end encryption of data with key management suitable for dynamic user groups.

**WP 2.4 Collaborative interaction histories**
This WP investigates how collaborative interaction history, i.e. the recording of the actions performed on a shared object and of its intermediate states, could be distributed between collaborators and browsed on demand in order to learn how collaborators performed certain actions. While

professionals may work in the same domain and use similar tools, their skills and expertise with these tools may differ significantly, for instance knowledge of shortcuts or advanced features, efficient work habits. Thus, a significant opportunity of expertise transfer is lost among collaborators while working on collaborative projects. Software capacities should be created with the goal of better supporting the sharing of computing skills between collaborators.

**Deliverable of Axis 2**
**D2:** algorithms and technology components for the foundation of an infrastructure for long-term collaboration

## - Axis 3 - Conceptual frameworks for long-term collaboration

**Leaders: Matthieu Tixier, Claudia-Lavinia Ignat**

The current distribution of collaboration over multiple software, devices and apps poses new challenges to the analysis of computer-supported cooperation (Rossito et al., 2014) (Wolf & Blomberg, 2020) as well as current and future artifact ecologies that evolves with time (Bødker et al, 2016). The future forms of collaboration, the network and the software capacities that will be available in the near future, will be beneficial only with the support of proper conceptual framework to account for these evolutions.

The main outcomes of this axis will be conceptual frameworks and systematic approaches for dealing with the specific challenges of long-term and cooperation. We will address the question of incorporating the knowledge gained from the observation and the analysis of existing practices into new software engineering practices and toolboxes. In other words, this axis aims at linking the needs and challenges for long-term cooperation highlighted in axis 1, and the yet and future capabilities, developed in axis 2.

**WP 3.1 An online library crossing cases and technologies**
Cross-analysis and comparisons between research cases is a key method in CSCW and practice based research (Wulf et al., 2011) for the development of new theoretical constructs and dimensions of analysis in computer supported cooperative practices (Wulf et al., 2018). This WP aims to build and maintain a comprehensive online library for the purpose of the project members and the endeavor to develop new conceptual frameworks for long term collaboration. This online library will gather the case studies developed in axis 1 and a collection of open technical components and protocols developed in axis 2. The discussion and analysis of the material made available within this library will support the development of actionable guidelines and demonstrators (axis 4) as well as the sharing of the project results.

**WP 3.2 Long-term collaboration across organizations**
Coordination mechanisms (CM) is a central conceptual framework from CSCW research that proved resourceful for understanding and designing for cooperative work practices (Schmidt & Bannon 1992, Cabitza & Simone, 2013). By setting at the forefront the relationship between a coordinate

protocol, collectively defined and normalized , and a coordinative artifact that inscribes it and often keeps track of users' actions, a CM account for both the social and the technical dimensions of collaboration. CM have successfully been used for analyzing collaboration at the scale of one organization and for inspiring the design of technology with a proper level of flexibility. However, when ecologies of artefacts are challenging the boundaries of an organization (Wolf & Blomberg, 2020) and allow inter-organizational and lightweight collaborations, new studies and cases are needed to better understand the specific challenges for CM analysis: How can protocols be negotiated and updated in an evolving collaboration over time? How can these evolutions be consistently reflected in a coordinative artifact? How can the heterogeneity of the artifacts brought by participants be tackled? We propose to develop a new analysis framework in terms of coordination mechanisms for the design and deployment of technologies for collaboration at the boundaries of organizations.

**WP 3.3 Asymmetries and heterogeneity in asynchronous collaboration**
The gold standard of actual collaborative tools remains the Google suite: synchronized documents where every user sees the same representation of the same document, synchronized in real-time and produced along a long-term collaboration. However, these tools do not consider the richness of people's differences: even when collaborating on a shared artifact, different people have different goals, different ways of thinking, different preferences, and different roles in the collaboration, but they must all use the same tools and representations. This WP aims at better understanding and characterizing the nature of these asymmetries as multiple users collaborate on shared documents, how do they evolve in time, and to recommend software and infrastructure supporting asymmetric collaborations.

**WP 3.4 New models for software engineering and design**
The renewed perspectives on long-term collaboration should include an evolution of software engineering practices that ensure a central place of human work in approaches and methods. Such a software design approach should depart from a centralized information perspective and be able to cope with an information system as an evolving infrastructure (Elligsen & Røed, 2010) (Pipek & Wulf, 2009). Another key aspect is to recognize the role of human work in achieving forms of interoperability through data work (Bossen et al., 2019), and the importance of maintenance work as well as the redundancy and co-existence of multiple practices (Cormi et al. 2022). The stakes are to provide new design and modeling tools that help software engineering to account for the specific challenges of future forms of long-term collaboration.

**Deliverable of Axis 3**
**D3**: conceptual constructs for the analysis, modeling and design for articulating social needs and technology capabilities in a sociotechnical perspective

## Axis 4 - Actionable guidelines and demonstrators for long-term collaboration

**Leaders: François Charoy, Myriam Lewkowicz**

In his influential conference "A Research Center for Augmenting Human Intellect" (Engelbart and English, 1968) from over 50 years ago, Douglas Engelbart outlined a vision for humans and machines working together as a collective to tackle "big problems". This vision is now a reality. Still, it introduces new unforeseen challenges. It does not consider the complexity of long-term collaboration among people and organizations. The evolving acculturation of stakeholders to methods and technologies impacts the way people work together, so as the evolution of technology itself. Building on the outcomes and results of axis 1,2, and 3, and of other PCs, this work package aims at building a shared statement on ways to achieve common goals through collective efforts and shared resources from different organizations with different backgrounds and cultures and a long duration scope (months, years). We call it an actionable vision for long-term collaboration. In addition to the platform produced by axis 1, the output of this WP will be a living repository of guidelines, patterns, best practices, and technical artifacts (4.1). Its goal is to lower the barriers to effective long-term inter-organizational collaboration. It will be declined for specific domains (4.2) according to their peculiarities. The results of the studies conducted in the other axis, as long as a broad state of the art, will help to produce a collection of patterns and practices (4.3) that will complement the guidelines and visions. They will be recognized for innovative and well-documented solutions to recurrent collaboration issues. These issues can relate to all dimensions of the life cycle of a collaboration: goal alignment, roles and responsibilities, trust, transparency, flexibility and adaptability, improvement, and technology support.

**WP 4.1: Actionable guidelines and visions for long-term collaboration across organizations.** The outcome of this WP will be the definition of instructions and recommendations for steps or actions that users can follow to achieve sustainable collaboration in the long run between organizations that have different cultures and practices. These recommendations include the communication protocols, the process, the definition of the goals, and the common framework to measure progress, usually required with the objective to sustain long-term and effective collaboration. It also includes more general governance rules and tools to recognize the evolution of the practices and the incorporation of new technologies and systems. They are all part of the ecology of artifacts that constitutes the collaborative environment of the stakeholders.

**WP 4.2 Derive and design actionable guidelines and visions for different domains** Long-term collaboration has different meanings depending on the domain that we consider. The outcome of this WP will be actionable guidelines and visions depending on different application domains that are studied in the other axes (starting with axis 1). For each of these domains, the work done in the previous WP will be used to devise specific instructions and recommendations that can be generalized to other domains. This will involve a nuanced examination of the concept of "long-term collaboration", which may differ in interpretation among practitioners. The guidelines will also consider the different natures of tools and practices that are domain dependent.

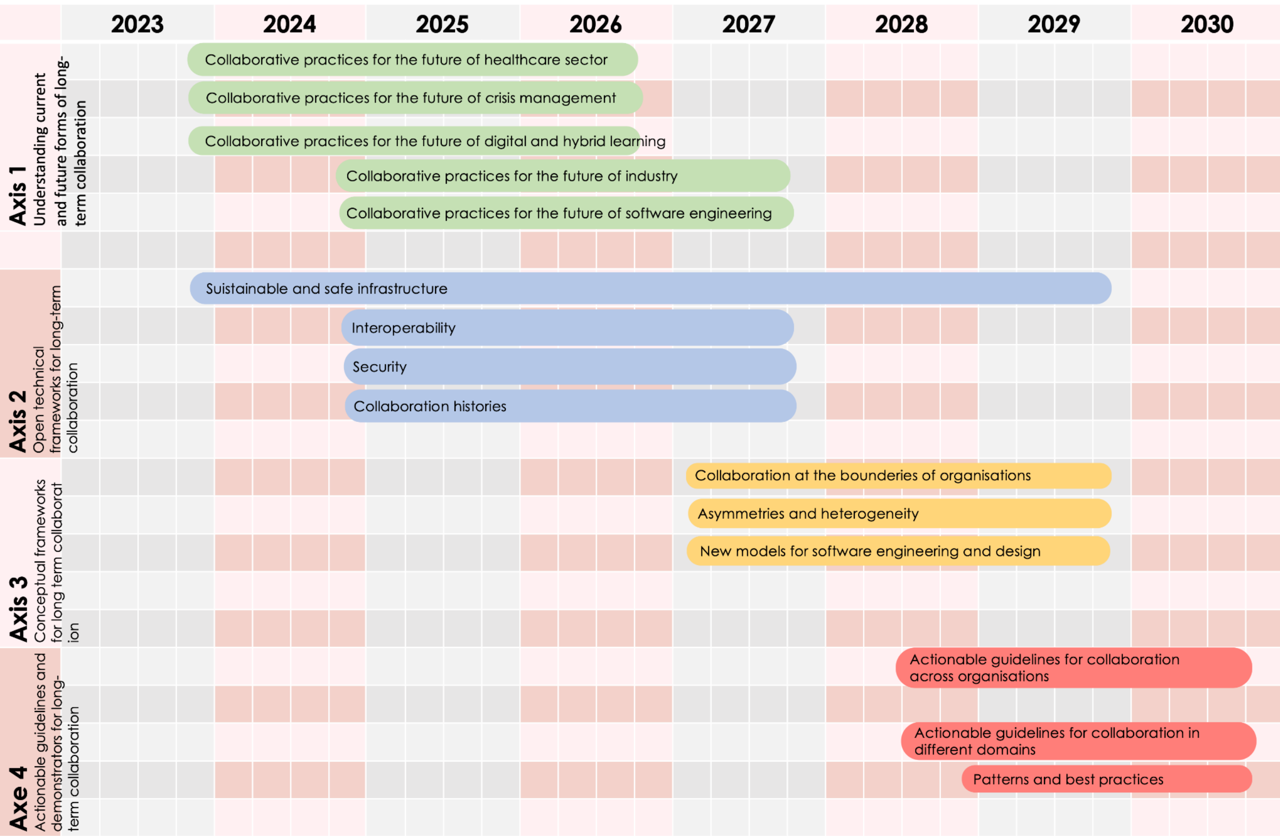
**WP 4.3. Patterns and best practices for effective long-term inter-organizational collaboration** In the fields of design, engineering, and work organization, patterns offer generic solutions to recurring problems. When seeking to enhance collaboration between organizations, especially during long-term endeavors, referring to a catalog of patterns can be incredibly beneficial. These patterns describe common problems faced by users and provide solutions, such as adjusting a communication framework or removing a partner from a collaboration. Patterns can be seen as informal processes and techniques for accomplishing specific goals, and can be adapted to various situations. The patterns also document the benefits and drawbacks associated with their use. Compiling, analyzing, and organizing this knowledge is a substantial long-term effort that will be conducted in this task. It will use the results from tasks within other work packages and possibly other axes.

**Deliverable of Axis 4**

**D4**: prototypes and demonstrators, guidelines and patterns to facilitate the implementation of new, technology-supported forms of long-term collaboration

## 2.3. Planning, KPI and milestones

The timeline of the PILOT project is presented in the figure below.




The project will produce the following KPIs to measure its success:

| KPI | | Risk | Corrective measures |
|---|---|---|---|
| **Scientific KPI** | | | |
| 1 | Number of publications in major venues | Low | • Increase the communication of deadlines of conferences and journals relevant to the PEPR eNSEMBLE |
| 2 | Number of Interdisciplinary publications | Medium | • Increase the ratio of funded PhD thesis involving interdisciplinary co-advising<br>• offer dedicated training to value the work in different disciplines<br>• Increasing the ratio of funding dedicated interdisciplinary micro-projects |
| **Valorization KPI** | | | |
| 3 | Number of links / projects with industry partners | Medium | • Participate to industrial events<br>• Increase communication towards industrials |
| **Training KPI** | | | |
| 4 | Number of co-advised PhD thesis | Low | • Favor open-call projects proposing PhD co-advising |
| 5 | Number of co-advised PhD thesis with advisors from different fields | High | • Favor open-call projects proposing PhD co-advising with advisers from different fields |
| 6 | Number of Master Internships | Medium | • Dedicate more funding of master grants |
| 7 | Seminars, summer/winter schools | Medium | • Dedicate more funding to the animation<br>• Work in close collaboration with the pilot institutions and partners |
| **Technical KPI** | | | |
| 8 | Number of functional demonstrators | Medium | • Dedicate more funding to the technical committee |
| 9 | Number of specifications | Medium | • Create a working group managed by the technical committee<br>• Provide support for building specifications |
| **Communication and Dissemination KPI** | | | |
| 10 | Number of dissemination actions | Low | • Encourage the community to communicate |

| | | | |
|---|---|---|---|
| 11 | Number of articles in the press | High | Reinforce the dissemination actions with the Communications Board |
| 12 | Use Case/Guidelines Reach | High | Increase communication towards users communities |
| 13 | Feedback from the users communities | Medium | Increase communication towards users communities |
| **International KPI** | | | |
| 13 | Number of international actions (visitors, events - workshops, schools, masters, …) | High | Encourage the organization of workshops in international events (conferences, schools, etc.) |
| **Human KPI** | | | |
| 14 | Gender diversity | Medium | • At equal level, choose women and non-binary persons<br>• Encourage women and non-binary to apply |
| **Leverage KPI** | | | |
| 15 | Number of awards (ERC, IUF, Best papers, etc.) | Low | • Encourage members of the program to apply<br>• Develop a program to mentor applicants |
| 16 | Number of funded projects (local, national, international) | High | • Encourage the members of the program to apply<br>• Develop a program to mentor applicants |
| **Specific KPI** | | | |
| 17 | Impact of the use case/vision platform (contribution, reuse, feedback updates) | High | • Increase communication towards partners and academic communities<br>• Provide support to potential contributors |
| 18 | Diversity of terrains (number of domains, places, actors involved in studies) | Medium | • Dedicate specific calls to increase diversity with PhD funding |

# 3. Project organisation and management

## 3.1. Project manager

Claudia-Lavinia Ignat (https://members.loria.fr/CIgnat/) is a tenured research scientist (chargée de recherche) at Inria Nancy-Grand Est and head of the Coast team. She obtained a PhD in Computer

Science from ETH Zurich, Switzerland in 2006 and an habilitation (HDR) from Lorraine University. Her research domain is distributed collaborative systems that enable distributed group work using computer technologies. Designing such systems requires an expertise in distributed systems and computer-supported cooperative work. Besides theoretical and technical aspects of distributed systems, design of distributed collaborative systems must take into account the human factor to offer suitable solutions for users. Her work is organized around two axes of research: collaborative data management referring to the design and evaluation of various approaches related to the management of distributed shared data including data replication and group awareness; and trustworthy collaboration referring to the design of easy to use security models and on mechanisms for assessing trust in collaborators.

She developed several replication algorithms for maintaining consistency over textual, hierarchical and graphical documents and wiki pages. She evaluated optimistic replication algorithms from a theoretical point of view, but also from a practical point of view by using simulations and real traces of collaboration. By means of user studies she evaluated real-time constraints in collaborative editing. She proposed several metrics for trust assessment in collaborative systems and a validation methodology based on user studies and game theory. She studied collaborative user behavior and conflicts in several collaborative systems.

She was general co-chair and PC member co-chair of ECSCW 2018 international conference. She is an associate editor of Journal of Computer Supported Cooperative Work, a regular PC member of the CHI, CSCW, ECSCW, GROUP, CollabTech and CDVE conferences and organizer of the International Workshop on Collaborative Editing. She was the principal investigator for Inria partner for several research and technological transfer projects such as the DGCIS Wiki 3.0 project, two projects financed by Région Lorraine with TVPaint enterprise and a Deeptech project financed by BPI with Fair&Smart enterprise. She is the coordinator of an Inria challenge project with HIVE enterprise that involves four Inria teams. She was the coordinator of the USCOAST associated Inria team in collaboration with the Department of Psychology from Wright State University. She also participated to BPI OpenPaaS::NG, ANR STREAMS and ConcoRDanT projects.

Myriam Lewkowicz is Professor at Troyes University of Technology where she heads the pluridisciplinary research group Tech-CICO and the master program. She is interested in defining digital technologies to support existing collective practices or to design new collective activities. This interdisciplinary research proposes reflections and approaches for the analysis and the design of new products and services to support cooperative work. The main application domains for this research for the last fifteen years have been healthcare (social support, coordination, telemedicine) and the industry (digital transformation, maintenance). She is a member of the program committees of the main conferences in Cooperative Work, Social Software, and Human-Machine Interaction, chairs the European scientific association EUSSET, and is deputy editor-in-chief of the CSCW journal, « The Journal of Collaborative Computing and Work Practices ».

François Charoy is a Professor of Computer Science at the University of Lorraine in France. From 2011 to 2022, he led the Coast team funded by Inria and the University of Lorraine to research large-scale trustworthy collaborative systems. His research interests range from distributed systems and service-oriented computing to business process management and collaborative approaches, both from a technical and user perspective. He was one of the creators of Bonita BPM, the BPM engine now developed by the Bonitasoft company. Recently, he was co-chair of the ECSCW 2018 conference. He was invited to IBM Almaden in 2019 and to Wright State University in 2015 and 2018. He was PI or contributed to several projects (OpenPaaS-NG, Open, FP7 InterOp, EIT ICT CityCrowdSource) on interoperability, collaboration or service computing. The main focus of his research is the ability to support collaboration and coordination among people and machines in a secure and trustworthy way without the control of a central authority. This includes studying computer-mediated collaboration and its effect on people's behavior, especially in crisis management and, more recently, people's trust in cognitive services in collaborative discussions.

## 3.2. Organization of the partnership

The table below presents the expertise of the main partners of the project.

| Partner | Expertise | Highlights |
|---|---|---|
| Inria | HCI, CSCW, Distributed Systems, Security | - Expertise on the design of novel interactive systems and graphical user interfaces that facilitate how interaction is communicated<br>- 1 ERC - Advanced Grant CREATIV (Creating Co-Adaptive Human-Computer Interfaces )<br>- Expertise on different aspects of CSCW, Distributed Systems and Security<br>- Collaboration with industrial partners : Linagora, XWiki, HIVE<br>- Participation to OpenPaaS::NG project<br>- Coordination of Inria Alvearium challenge on peer-to-peer clouds involving several Inria projects and HIVE |
| CNRS /UPSaclay | HCI | - Expertise on design of open and flexible interactive environments<br>- 1 ERC Advanced Grant “ONE - Unified Principles of Interaction”<br>- 1 ERC POC (Proof-of-Concept) OnePub<br>- Leader of the Continuum project |
| UGA | CSCW, CSCL | - expertise on the integration of technological solutions (AR or VR) in industrial scenarios<br>- methodological expertise in the implementation of observation protocols and analysis of the activity of designers.<br>- expertise on the appropriation of technologies and Computer Supported Collaborative Learning (CSCL). |

| | | |
|---|---|---|
| IMT | HCI | - Expertise on new forms of interaction, mobile and wearable interaction, augmented reality; data visualization and meaningful representations; design, physical artifacts and tangible interaction; new interaction and design paradigms; behavioral models and the novice/expert transition<br>- contribution on Webstrates platform (https://webstrates.net) |
| SU | Distributed systems | - Many best paper awards in distributed systems conferences<br>- Expertise in addresses both theoretical and practical issues of distributed systems for supporting large-scale collaboration<br>- It has access to different platforms to deploy, test and evaluate distributed algorithms: OMNET++/Inet (https://omnetpp.org/) tools to simulated different user mobility patterns, the national grid'5000 platform to deploy protocols on geo-distributed clusters (https://www.grid5000.fr/w/Grid5000:Home), and Google Cloud Platform (https://cloud.google.com/gcp) to test protocols on real clouds. |
| UTT | CSCW | - more than 20 years of experience of pluridisciplinary research<br>- recognized in the international CSCW community, through several publications on practice-centered computing.<br>- development of the Hypertopic platform (http://hypertopic.org) that supports collective interpretation of collections of items.<br>- participation to the program committees of the main conferences of the domain (ACM CSCW, ACM GROUP, ACM CHI, ECSCW, C&T).<br>- involvement in EUSSET (the European Society of Socially-Embedded Technologies) and the CSCW Journal. |
| INSA Lyon | Distributed systems | - Expertise on large scale distributed systems applied to dynamic environments such as IoT, mobile, edge/fog<br>- Leader of a chair with SPIE ICS on the analysis of flows at the edge of the network to develop AI at low energy cost. |

## 3.3. Management framework

To ensure effective project management, the following actions will be taken:

1. Regular meetings will be held every two weeks via videoconference, lasting for at least one hour, between project coordinators, axis leaders, and main partners to review progress, discuss challenges, and ensure that all partners share the same goals. Priority themes for PhD calls will also be decided during these meetings in line with the research strategy.

2. Quarterly coordination meetings will be scheduled between coordinators and partners to discuss the preparation of PhD calls, review the budget, provide a general update on the project, plan for

the future (including publications, travels, exchanges, and upcoming events), and identify risks according to KPIs. Mitigation plans will also be developed to address these risks.

3. An annual scientific workshop will be organized, including PhD progress presentations, keynotes from invited external experts, and workshops/brainstorming sessions to encourage collaboration and generate new ideas.

4. Intermediate discussions and meetings will be held on a regular basis to ensure that progress is being made.

5. Monthly short meetings will be scheduled with people funded by the project, such as PhD students, on demand depending on their needs, to provide the support they need to make progress on their research.

An annual report will be generated and shared with all stakeholders after the scientific workshop. This report will provide a comprehensive overview of the project's progress, including key achievements, milestones, and challenges. The report will also include a summary of financial performance, upcoming activities, and any risks and mitigation plans identified.

People will be assigned to the surveillance of KPI and milestones outcomes and will report during the quarterly meetings. Identification of risks and mitigation plans will be discussed during these meetings. Actions to be taken when a risk probability increases or materializes will be proposed during these meetings to avoid it or mitigate the impact.They will be validated by the project management.

## 3.4. Institutional strategy

The partner institutions are major actors in research fields related to digital tools for collaboration such as Human-Computer Interaction, Distributed Systems and Computer Supported Cooperative Work. In particular, University Grenoble-Alpes and University Paris-Saclay are historical and pioneering centers of Human-Computer Interaction in France and in Europe. They also provide skills through their LabEX, EquipEX+ CONTINUUM, AI institutes and scientific clusters essential for the PILOT project. For UGA partner, PILOT project falls within the general 'Smart and Efficient Systems for a Responsible Society' strategic orientation of the LIG Lab and, in particular, the Interactive and Cognitive Systems axis.

Inria and the INS2I institute of CNRS are recognized for their scientific excellence in computer and digital sciences. Their strategies involve strong partnerships with French players in the field (telephony/communication, cloud, software publishers and digital services) and already collaborate closely through numerous joint research teams and national initiatives. The partner institutions support and promote interdisciplinarity which is at the center of human collaboration with digital tools.

In order to put in place a solid and ambitious organizational foundation for research over the next few years, UTT partner defined objectives for the coming years based on the following three points (feuille de route pour la stratégie recherche, 2022): Strengthen the visibility of UTT and its scientific signature, with a desire to build relations with other universities ; Work on an articulation between the different scientific disciplines and societal challenges ; Encourage innovative research projects ; Allow researchers to flourish and reaffirm their place within UTT. The participation of UTT in PILOT is obviously aligned with the university strategy.

# 4. Expected outcomes of the project

## 4.1. Expected scientific outcomes

The convergence of collaborative practices and technologies profoundly impact how we collaborate as groups and organizations. The dynamic evolution of the field calls for informed and validated guidelines and technologies to ensure effective organization of collaborative efforts while respecting the participants' diverse cultures and practices. The ultimate goal of this project is to provide users with a comprehensive set of tools and methodologies to facilitate large-scale and sustainable collaborations.

At present, managers face significant challenges in selecting the best socio-technical stack for their projects. Furthermore, incorporating new solutions or validating new practices in long-term collaborative initiatives is daunting. Maintaining participants' sovereignty over the technologies and data they share can be almost impossible when working with partners in multi-organizational collaborations. Through this project, we will provide a comprehensive set of technologies, visions, and guidelines that will promote better collaboration in the long run while preserving participants' interests and enforcing their specific requirements. Given that there is no one-size-fits-all solution, the project will provide tailored approaches to meet different domains' specific constraints and requirements.

In addition to the valuable scientific results that will be produced through this project, the platform that will be developed represents a significant achievement in itself. Our ambition is for this platform to become a national and international reference point for individuals and organizations seeking resources to support long-term distributed collaboration.

The platform will encompass all dimensions of the collaborative socio-technical stack, including technology, use cases, demonstrators, guidelines, and visions. It will be a valuable resource for managers, end-users, and academics alike, providing a comprehensive and up-to-date overview of the latest developments in the field.

We anticipate that this platform will become a living and lasting resource, filling a significant gap in the current landscape of resources available to those seeking to better understand and benefit from long-term distributed collaboration. It will serve as a central hub for knowledge sharing and collaboration, facilitating greater cooperation and advancing the field as a whole. Ultimately, we hope that this platform will contribute to a more connected and collaborative world, enabling individuals and organizations to work together more effectively and achieve their goals more efficiently.

In addition, the project provides many opportunities to strengthen existing partnerships between the institutions involved in the PILOT project, and more broadly in the PEPR, as well as to establish and develop other partnerships through links with field use cases and other relevant entities like major equipment programs, e.g., Equipex+ CONTINUUM, research programs, e.g., PEPRs on Digital Education, on Cloud and on Cybersecurity. We also plan to set up collaborative projects involving industrial partners, e.g. Linagora, through the calls for projects program.

## 4.2. Dissemination strategy

From a scientific point of view, we will ensure the publication and dissemination of results in major journals and conferences in the relevant fields (e.g., by supporting the organization of workshops associated with the main conferences in the fields).
We will follow ANR's Open Science policy by requiring all funded research projects within the program to publish their data and outputs on national platforms: HAL open archive for publications, TGIR Huma-Num's Nakala for data. All the produced code will be released and maintained under open-source licenses and referenced in the Software Heritage database, with the support of the program's research engineers who will be specifically trained in these practices.
To ensure the visibility of the community beyond its scientific results, we will establish connections with national (AFIHM, AFIA, AFXR, ARPEGE) and international (ACM, EUSSET) learned societies, taking advantage of the fact that several Program Directors and members of the Executive Committee are strongly involved in them.
Regarding the general public, civil society and institutions, the Executive Committee will encourage the participation and presentation of the program's activities in annual national events such as Fête de la Science, or in outreach initiatives in high schools such as Chiche!. They will also work closely with local initiatives of pilot and partner institutions to bring the academic world closer to society, such as contributing to funding programs for artists' or designers' residencies in research laboratories (e.g. AIRlab at University of Lille). This will feed our research, but also produce artifacts adapted to communication towards the general public (interactive artworks, serious games, performances) that will be showcased e.g., during public sessions of the eNSEMBLE days.
Starting in year 2, the Executive Committee will organize the annual eNSEMBLE days, that could include: "Innov' eNSEMBLE", a forum and exhibition of demonstrations targeting users, companies and institutional representatives, which will foster connections with these actors and more generally with civil society (this session will take place once enough demonstrators have been developed).

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