RESEARCH CENTRE

Inria Centre at Université de Lorraine

IN PARTNERSHIP WITH:

Université de Lorraine, CNRS

2024

ACTIVITY REPORT

Project-Team

COAST

Web Scale Trustworthy Collaborative Service Systems

IN COLLABORATION WITH: Laboratoire lorrain de recherche en informatique et ses applications (LORIA)

DOMAIN

Networks, Systems and Services, Distributed Computing

THEME

Distributed Systems and middleware

Inria

Contents

Project-Team COAST

Creation of the Project-Team: 2015 July 01

Keywords

Computer sciences and digital sciences

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1 Team members, visitors, external collaborators

Research Scientists

- Claudia-Lavinia Ignat [Team leader, INRIA, Researcher, until Sep 2024]
- Claudia-Lavinia Ignat [Team leader, INRIA, Senior Researcher, from Oct 2024]

Faculty Members

- Khalid Benali [UL, Associate Professor]
- Gérôme Canals [UL, Associate Professor]
- François Charoy [UL, Professor]
- Thomas Lambert [UL, Associate Professor]
- Gerald Oster [UL, Associate Professor]
- Olivier Perrin [UL, Professor]

PhD Students

- Quentin Acher [INRIA]
- Clélie Amiot [INRIA]
- Victor Henrique De Moura Netto [INRIA, from Oct 2024]
- Lisa Formentini [INRIA]
- Hua Junrui [Hivenet, CIFRE, from Oct 2024]
- Ludovic Paillat [Hivenet, CIFRE]
- Pierre-Antoine Rault [INRIA]
- Mohammad Rizk [INRIA]

Technical Staff

- Adrien Ludwig [INRIA, Engineer, from Nov 2024]

Interns and Apprentices

- Victor Henrique De Moura Netto [Hivenet, Intern, from Mar 2024 until Aug 2024]
- Hua Junrui [Hivenet, Intern, until May 2024]

Administrative Assistants

- Sophie Drouot [INRIA]
- Delphine Hubert [UL]

2 Overall objectives

The advent of the Cloud, smart mobile devices and service-based architecture has opened a field of possibilities as wide as the invention of the Web 30 years ago. Software companies now deliver applications and services using the Web as a platform. From text to video editing, from data analytics to process management, they distribute business applications to users within their web browser or on some mobile appliance. These services are deployed on sophisticated infrastructures that can cope with very demanding loads. The Software as a Service approach (SaaS) highlights their cooperative nature, by enabling the storage of data in cloud infrastructures that can be easily shared among users.

Clients consume applications through service APIs (web services), available on delivery platforms, called stores or markets. This approach of software distribution outstrips the traditional software distribution channels, in scale and opportunity. Scale has different dimensions: the number of users (communities rather than groups), the size of data produced and managed (billions of documents), the number of services and of organizations (tens of thousands). Opportunity refers to the infinite number of combinations between these services and the many ways to consume and use them.

This fast-paced evolution challenges research because the creation of applications from the composition of services must incorporate new content and context based constraints. From a socio-technical perspective, the behaviour of users is evolving constantly as they get acculturated to new services and ways to cooperate. Mere enhancement of current existing solutions to cope with these challenges is insufficient.

We conduct a dedicated research effort to tackle the problems arising from the evolution of contemporary technologies and of those we can anticipate. We explore three directions: large scale collaborative data management, data centred service composition and above all, a foundation for the construction of trustworthy collaborative systems.

Large scale collaborative data management concerns mostly the problem of allowing people to collaborate on shared data, synchronously or not, on a central server or on a peer to peer network. This research has a long history referring back to a paper by Ellis and Gibbs [21]. User acculturation to online collaboration triggers new challenges. These refer to the number of participants in a collaboration (a crowd), to the number of different organizations and to the nature of the documents that are shared and produced. The problem is to design new algorithms and to evaluate them under different usage conditions and constraints and for different kinds of data.

Data centred service composition deals with the challenge of creating applications by composing services from different providers. Service composition has been studied for some time now but the technical evolution and the growing availability of public APIs require us to reconsider the problem [20]. Our objective is to develop models, methods, and tools that support developers in safely and efficiently composing these services, considering the widespread use of public APIs built on the REST (Representational State Transfer) architecture.

Based on the work that we do on the two first topics, our main research direction aims at providing support to build **trustworthy collaborative applications.** We base it on the knowledge that we can gather from the underlying algorithms, the composition of services and the quality of services that we can deduce and monitor. The complexity of the context in which applications are executed does not allow us to provide proven guarantees. Our goal is to base our work on a contractual and monitored approach to provide users with confidence in the service they use. Surprisingly, people rely today on services with very little knowledge about the amount of confidence they can put in these services. They are based on composition of other unknown services. Thus, it becomes very difficult to understand the consequences of the failure of a component of the composition. We follow a path that portrays a ruptured continuum, to underscore both the endurance of the common questions along with the challenge of accommodating a new scale. We regard collaborative systems as a combination of supportive services, encompassing safe data management and data sharing. Trustworthy data centred services are an essential support for collaboration at the scale of communities and organizations. We will combine our results and expertise to achieve a new leap forward toward the design of methods and techniques to enable the construction of usable large scale collaborative systems.

3 Research program

3.1 Introduction

Our scientific foundations are grounded on distributed collaborative systems supported by sophisticated data sharing mechanisms and on service oriented computing with an emphasis on orchestration and on non-functional properties. Distributed collaborative systems enable distributed group work supported by computer technologies. Designing such systems requires an expertise in Distributed Systems and in Computer-Supported Collaborative Work. Besides theoretical and technical aspects of distributed systems, the design of distributed collaborative systems must take into account the human factor to offer solutions suitable for users and groups.

The COAST team vision is to move away from a centralized authority based collaboration toward a decentralized collaboration. Users will have full control over their data. They can store them locally and decide with whom to share them. The COAST team investigates the issues related to the management of distributed shared data and coordination between users and groups.

Service-oriented Computing [23] is an established domain on which the ECOO, Score and now the COAST teams have been contributing for a long time. It refers to the general discipline that studies the development of computer applications on the web. A service is an independent software program with a specific functional context and capabilities published as a service contract (or more traditionally an API). A service composition aggregates a set of services and coordinates their interactions. The scale, the autonomy of services, the heterogeneity and some design principles underlying Service-oriented Computing open new research questions that are at the basis of our research. They span the disciplines of **Distributed Computing**, **Software Engineering** and **Computer- Supported Collaborative Work** (CSCW). Our approach to contribute to the general vision of Service-oriented Computing is to focus on the issue of the efficient and flexible construction of reliable and secure high-level services. We aim to achieve it through the coordination/orchestration/composition of other services provided by distributed organizations or people.

3.2 Consistency Models for Distributed Collaborative Systems

Collaborative systems are distributed systems that allow users to share data. One important issue is to manage the consistency of shared data according to concurrent access. Traditional consistency criteria such as serializability, linearizability are not adequate for collaborative systems. Causality, Convergence and Intention preservation (CCI) [26] are more suitable for developing middleware for collaborative applications. We develop algorithms for ensuring CCI properties on collaborative distributed systems. Constraints on the algorithms are different according to the kind of distributed system and to the data structure. The distributed system can be centralized, decentralized or peer-to-peer. The type of data can include strings, growable arrays, ordered trees, semantic graphs and multimedia data.

3.3 Optimistic Replication

Replication of data among different nodes of a network promotes reliability, fault tolerance, and availability. When data are mutable, consistency among the different replicas must be ensured. Pessimistic replication is based on the principle of single-copy consistency while optimistic replication allows the replicas to diverge during a short time period. The consistency model for optimistic replication [25] is called eventual consistency, meaning that replicas are guaranteed to converge to the same value when the system is idle. Our research focuses on the two most promising families of optimistic replication algorithms for ensuring CCI:

- operational transformation (OT) algorithms [21]
- algorithms based on conflict-free replicated data types (CRDT) [24].

Operational transformation algorithms are based on the application of a transformation function when a remote modification is integrated into the local document. Integration algorithms are generic, being parametrised by operational transformation functions which depend on replicated document types. The advantage of these algorithms is their genericity. These algorithms can be applied to any data type

and they can merge heterogeneous data in a uniform manner. Commutative replicated data types are a new class of algorithms initiated by WooT [22], the first algorithm designed WithOut Operational Transformations. They ensure consistency of highly dynamic content on peer-to-peer networks. Unlike traditional optimistic replication algorithms, they can ensure consistency without concurrency control. CRDT algorithms rely on natively commutative operations defined on abstract data types such as lists or ordered trees. Thus, they do not require a merge algorithm or an integration procedure.

3.4 Process Orchestration and Management

Process Orchestration and Management is considered as a core discipline behind Service Management and Computing. It includes the analysis, the modelling, the execution, the monitoring and the continuous improvement of enterprise processes and is for us a central domain of study. Many efforts have been devoted to establishing standard business process models founded on well-grounded theories (e.g. Petri Nets) that meet the needs of business analysts, software engineers and software integrators. This has led to heated debate in the Business Process Management (BPM) community as the two points of view are very difficult to reconcile. On one side, business people in general require models that are easy to use and understand and that can be quickly adapted to exceptional situations. On the other side, IT people need models with an operational semantics in order to be able to transform them into executable artifacts. Part of our work has been an attempt to reconcile these points of view. This resulted in the development of the Bonita BPM system. It also resulted more recently in our work on crisis management where the same people are designing, executing and monitoring the process as it executes. More generally, and at a larger scale, we have been considering the problem of processes spanning the barriers of organizations. This leads to the more general problem of service composition as a way to coordinate inter organizational construction of applications. These applications provide value, based on the composition of lower level services [19].

4 Application domains

4.1 Crisis Management

Crisis management research investigates all the dimensions regarding the management of unexpected catastrophic events like floods, earthquakes, terrorist attacks or pandemics. All the phases of a crisis, from preparedness to recovery require collaboration between people from many organizations. This provides opportunities to study inter-organizational collaboration at a large scale and to propose and evaluate mechanisms that ensure secure and safe collaboration. The PhD thesis of Béatrice Linot supervised by François Charoy and Jérôme Dinet and defended in 2021 provided us with a deep understanding of the factors that encourage collaboration and help to maintain trustworthy collaboration between stakeholders. This work is continued by the PhD thesis of Clélie Amiot who studies the effects of human chat-bot collaboration in this kind of setting [8] and with the PhD thesis of Lisa Formentini who studies the impact of the Covid lockdown on firefighters work practices and ecology of artefacts [12].

4.2 Collaborative Editing

Collaborative editing is a common application of optimistic replication in distributed settings. The goal of collaborative editors, irrespective of the kind of document, is to allow a group of users to update a document concurrently while ensuring that they eventually get all the same copy at the end. Our algorithm allows us to implement a collaborative editor in a peer-to-peer way. It avoids the need for a central server ensuring a higher level of privacy among collaborators. The domain of collaborative editing requires us to consider the problem of access control of participants and group key management [9].

4.3 Peer-to-peer storage

Peer-to-peer storage systems use the combined capacity of the peers to provide storage functionality to end users. Peer-to-peer storage systems are designed to provide persistence and availability of the stored content despite unreliability of the individual autonomous peers in a decentralised environment. We

started to apply our work on data replication [18], Erasure Coding (EC) [17] and group key management [9] for IPFS (InterPlanetary File System) peer-to-peer storage and we will transfer it to Hivenet.

5 Social and environmental responsibility

The team is deeply aware of the environmental impact of its practices and research activities, with a shared commitment to reducing it.

5.1 Footprint of research activities

In terms of practices, since the Covid-19 pandemic, the number of flights for team members has significantly decreased. Remote participation is prioritized when appropriate, and train travel is favored whenever feasible. Additionally, we prioritize conferences within Europe and have shifted away from systematically accompanying PhD students presenting their work. Regarding hardware purchases, each team member uses a low-power consumption laptop as their primary device, which remains in use for at least the duration of its warranty (five years) and often beyond.

5.2 Impact of research results

Our research on large-scale distributed collaborative systems focuses on enabling remote work, thereby supporting the reduction of office space requirements. It also examines the social dimensions of remote collaboration and home-office setups, which can contribute to decreased energy consumption. These potential benefits are emphasized in the Intergovernmental Panel on Climate Change (IPCC)'s Sixth Assessment Report – Working Group III: Mitigation of Climate Change. Our work on distributed collaborative systems can be used to exploit the underused computer resources and thus reduce the energy overhead of datacenters, such as cooling whose costs represent about 40% of the total energy consumption of a datacenter.

6 Highlights of the year

COAST team coordinates for Inria the IPCEI Cloud DXP (Data Exchange Platform) project which started in September 2024 and involves Amadeus and three Inria teams (CEDAR, COAST and Magellan).

7 New software, platforms, open data

7.1 New software

7.1.1 Discreet

Name: Distributed delivery service with context-aware cooperation

Keywords: Distributed systems, Group key agreement, Consensus protocols, Reliable broadcast

Scientific Description: MLS Protocol (Messaging Layer Security) relies on a Group Key Agreement Protocol called TreeKEM allowing members of a group to derive a common secret called group key which serves as a basis to secure group communications. The MLS Protocol offers an efficient solution to guarantee the confidentiality and integrity of communication. However, the availability of the protocol depends on the Delivery-Service component, which remains centralized most of the time. DiSCreet (Distributed delIvery Service with Context-awaRE coopEraTion) offers a distributed Delivery Service. It combines two distributed communication mechanisms adapted to the need of the messages exchanged by the protocol. It uses a Probabilistic Reliable Broadcast mechanism to reliably deliver messages allowing users to propose changes to the group (i.e. Proposal messages) and the Cascade Consensus Protocol to deliver the messages that actually modify the group (i.e. Commit messages) and thus require an agreement between members.

Functional Description: MLS Protocol (Messaging Layer Security), the latest IETF standard for Secure Group Communication, currently relies on a centralized component for message delivery, called the Delivery Service. The centralization of the Delivery Service makes it an ideal target for attackers and threatens the availability of any protocol relying on MLS. In order to overcome this issue, DiSCreet (Distributed delIvery Service with Context-awaRE coopEraTion) allows clients to exchange protocol messages efficiently and without any intermediary. It uses a Probabilistic Reliable-Broadcast mechanism to efficiently deliver messages and the Cascade Consensus Protocol to handle messages requiring an agreement.

URL: https://github.com/HiveNetCode/distributed-mls

Publications: hal-04829916, hal-04337821

Contact: Claudia-Lavinia Ignat

Partner: Hivenet

8 New results

8.1 CRDTs for Replicated Relational Databases with Integrity Constraints

Participants: Victorien Elvinger, Ba Habibatou, Claudia-Lavinia Ignat.

Many offline-first applications use an embedded relational database, such as SQLite, to manage their data. The replication of the database eases the addition of collaborative features to its applications. Most of the approaches for replicating a relational database require coordination at some extent. A few approaches propose a coordination-less replication to allow offline work. These approaches are limited in two ways: (i) They do not respect Strong Eventual Consistency that states that two replicas converge as soon as they integrate the same set of modifications; (ii) They fail to preserve the combined effect of operations' intent in complex scenarios.

In [11] we proposed a new CRDT for replicating relations and maintaining integrity constraints in face of concurrent modifications. In contrast to previous approaches, our proposal enforces Strong Eventual Consistency and respects combined effect of operations' intent in complex scenarios. Its replicated state consists of the composition of CRDT primitives. The state of the database is computed from the replicated state by deterministically resolving all integrity violations. Local modifications are compensated in a way that ensures the preservation of combined effect of operations' intent.

8.2 Distributed Delivery Service for Group Key Agreement Protocols

Participants: Davide Frey *(WIDE team)*, Claudia-Lavinia Ignat, Ludovic Paillat *(Hivenet)*, Mathieu Turuani *(PESTO team)*.

End-to-end encrypted messaging applications such as Signal and Whatsapp became widely popular thanks to their capability to ensure the confidentiality and integrity of online communication. While the highest security guarantees were long reserved to two-party communication, solutions for n-party communication remained either inefficient or less secure until the standardization of the MLS Protocol (Messaging Layer Security). The MLS protocol relies on a Group Key Agreement Protocol that allows members of a group to derive a common secret called group key which serves as a basis to secure group communications. It is scalable in terms of the number of operations modifying the group such as adding/removing members and it supports periodic group-key renewals preventing compromised communication. The MLS Protocol offers an efficient solution to guarantee the confidentiality and integrity of communication. However, the availability of the protocol depends on the centralized Delivery-Service component. The centralization of this component makes it an ideal target for attackers who wish

to disrupt communication. Notably, with the help of a compromised Delivery Service, an attacker can prevent group members from refreshing their keys and resolving the compromise.

In order to overcome these limitations we proposed DiSCreet (Distributed delIvery Service with Context-awaRE coopEraTion), a fully distributed Delivery Service [9]. It combines two distributed communication mechanisms adapted to the need of the messages exchanged by the protocol. We used a Probabilistic Reliable Broadcast mechanism to reliably deliver messages allowing users to propose changes to the group (i.e. Proposal messages) and a Cascade Consensus Protocol to deliver the messages that actually modify the group (i.e. Commit messages) and thus require an agreement between members. Our solution strengthens the availability of the MLS Protocol without compromising its security. We showed that our approach is relevant in the context of dynamic groups by conducting a theoretical study comparing DiSCreet with DCGKA, another distributed group key agreement protocol. We implementated DiSCreet based on an open source implementation of MLS.

8.3 Attacks and Defenses on the DHT of the InterPlanetary File System

Participants: Thibault Cholez *(Resist team)*, Victor de Moura Netto, Claudia-Lavinia Ignat.

The InterPlanetary File System (IPFS), the largest decentralized peer-to-peer file system, is experiencing growing adoption with an increasing number of contributors and users. IPFS relies on Kademlia Distributed Hash Table (DHT) for publishing and fetching content. We showed that IPFS did not implement any protection mechanism proposed for Kademlia against the Sybil attacks that deny access to a given content on the network.

We evaluated the time needed to pre-compute Sybils' cryptographic identities to target any content on IPFS. We also described and evaluated the success ratio of a localized Sybil attack denying content access on IPFS. Our experimental results [10] demonstrate unequivocally that deploying just 20 Sybils from a single IP address effectively denies content access in IPFS, revealing a critical vulnerability in its lookup process. We proposed simple yet efficient defenses that should be implemented by IPFS developers from what was proposed in the scientific literature and what was successfully implemented in similar Kademlia-based DHTs.

8.4 Distributed Access Control using CRDTs

Participants: Claudia-Lavinia Ignat, Olivier Perrin, Pierre-Antoine Rault.

Collaborative editing applications are a popular family of distributed systems that enable simultaneous document editing with other users. Their use peaked during the lockdown periods of the Covid pandemic. This highlighted their utility but also their limitations when managing large-scale collaboration. In this context, centralized systems are not suitable for several reasons. Centralized servers are vulnerable to server failures and the need for scaling. Users may then be affected by the unavailability of the applications. Nevertheless, centralized systems offer significant advantages, such as easier maintenance of consistency for shared resources. Another important aspect concerns the governance of security policies to manage different types of users and their access or modification rights for documents. In a centralized system, the single point of access simplifies this task but raises issues of censorship (a single administrator), data sovereignty (who has access to the server), and confidentiality (who has access to the data). To improve scalability, fault and attack tolerance, service transparency, and even user privacy, systems are increasingly turning to distributed architectures. In these systems, both data and security policies are replicated. Certain document modifications may conflict with changes to the policies. Conflicts are thus likely to occur, as in any distributed system—particularly given the dynamic nature of policy modifications. Conflict-free Replicated Data Types (CRDTs) are mechanisms that provide rules for resolving such conflicts.

In the context of the PhD thesis of Pierre-Antoine Rault defended on December 2024, we proposed a replication mechanism for access control that manages collaborative documents with multiple dynamic administrators. In addition to maintaining the consistency of the replicated document state and access rights, the proposed mechanism preserves the integrity of the document and prevents unauthorized modifications. We designed a CRDT to maintain consistency of data and policies in the presence of multiple administrators, without a central server. We proposed a CRDT for an access control policy based on independent rights. The use of independent rights ensures the absence of interaction between policy changes for two different rights. Our CRDT model guarantees that simultaneous policy modifications are reconciled and that replicas eventually converge. Our mechanism also ensures the correction of the document state retrospectively by compensating for the effects of unauthorized modifications that have already been applied. Our solution adds metadata to operations related to both documents and policies, allowing the evaluation of the list of document modifications that need to be reverted or applied. We proposed a validator that catalogs possible scenarios and the results of the developed algorithms.

8.5 Impact of Chatbots on Virtual Teamwork Dynamics and Performance

Participants: Clélie Amiot, François Charoy.

We studied the role of chatbots as a pivotal element in enhancing virtual teamwork. We delved into the effects of chatbots on group dynamics and performance within an online collaborative setting. To this end, a unique collaborative online activity was developed, completed with an integrated platform and a custom-designed chatbot assistant. The study involved 72 participants, systematically arranged into teams of four. These teams were further allocated into four distinct experimental conditions based on the nature of chatbot assistance provided: no assistance, private chat assistance, group chat assistance, or a combination of both.

The core findings of this investigation revealed a pronounced enhancement in team performance metrics attributable to the chatbot intervention. Teams with chatbot assistance exhibited not only improved performance but also experienced a notable reduction in response times for information requests during the collaborative activity. This improvement underscores the efficacy of chatbots in streamlining communication and information dissemination within team settings.

A particularly compelling aspect of our findings was the significant correlation observed between the chatbot's communication capabilities and the cognitive workload of team members. Teams interacting with chatbots demonstrating higher communication proficiency reported reduced cognitive strain, suggesting that the quality of chatbot interaction plays a crucial role in the overall team experience [8].

8.6 The dynamic of ecology of artefacts for cooperation since the Covid Crisis - the case of civil security

Participants: François Charoy, Lisa Formentini.

This work explores how the artifact ecologies of civil security organizations, specifically tools and practices, evolved during and after the Covid-19 pandemic. It focuses on the shift from traditional practices to ones adapted for hybrid and remote configurations, particularly in the context of organizations like firefighters and other emergency services. It aims at understanding what remains from these new practices four years after the end and the event and what lead to this new stage in the evolution of practices. The research uses the SDIS 57 (firefighters of Moselle) as a case study to document these transformations through qualitative methods, including interviews and observational studies. While the focus is on civil security, the research aspires to benefit other long-term cooperative organizations and improve the design of collaborative tools [12].

8.7 Quantifying the Performance of Erasure Codes in P2P Storage Systems

Participants: Shadi Ibrahim *(Magellan team)*, Thomas Lambert, Mohammad Rizk.

Traditionally, in distributed systems, the main solution to provide both availability and robustness for stored data is replication. However, one of the consequences of such a solution is the storage overhead it incurs, which is becoming increasingly problematic as the amount of stored data continues to grow each year. An alternative to replication is Erasure Coding (EC), which can provide comparable or even better robustness and availability with significantly lower storage overhead. The trade-off is that it requires additional computation for encoding and, in some cases, decoding the data.

In [17], we presented preliminary results evaluating EC within IPFS (InterPlanetary File System), a widely used peer-to-peer storage system. While the implementation is still ongoing, initial findings indicate that a naive implementation of EC in this context results in lower throughput compared to replication when adding files.

9 Bilateral contracts and grants with industry

9.1 Bilateral contracts with industry

Hivenet - Hive Computing Services SAS (Cannes, France)

Participants: Alexandru Dobrila *(Hivenet)*, Davide Frey *(WIDE team)*, Claudia-Lavinia Ignat *(contact)*, Hua Junrui *(Hivenet)*, Gérald Oster, Ludovic Paillat *(Hivenet)*, François Taiani *(WIDE team)*, Mathieu Turuani *(PESTO team)*.

- Ludovic Paillat, CIFRE PhD Student, is supervised by Claudia-Lavinia Ignat, Davide Frey (WIDE team), Mathieu Turuani (PESTO team) and Alexandru Dobrila (Hivenet) on *Security for peer-to-peer cloud storage without central authority* since October 2023.
- Hua Junrui, CIFRE PhD Student, is supervised by Gérald Oster, François Taiani (WIDE team), and Alexandru Dobrila (Hivenet) on *Advanced techniques for efficient DHT with fault tolerance against Byzantine faults in large-scale distributed systems* since October 2024.

10 Partnerships and cooperations

10.1 International research visitors

10.1.1 Visits of international scientists

Other international visits to the team

Mohammed Riyadh Abdmeziem

Status Associate Professor

Institution of origin: Ecole nationale Supérieure d'Informatique (ESI), Alger

Country: Algeria

Dates: February 26, 2024 - March 1, 2024

Context of the visit: Presentation of his work on asynchronous and distributed group key management protocols, along with the challenges associated with establishing trust in federated learning environments and discussion on possible collaborations with COAST team.

Type of mobility: Research stay

Amina Ahmed Nacer

Status Associate Professor

Institution of origin: M'hamed Bougara University, Bourmedes

Country: Algeria

Dates: November 18, 2024 - November 22, 2024

Context of the visit: Presentation of her work on malicious clouds coalition management for business processes deployment and discussion on possible collaborations with COAST team.

Type of mobility: Research stay

10.1.2 Visits to international teams

Research stays abroad

Ignat Claudia-Lavinia

Visited institution: Technical University of Cluj-Napoca, Faculty of Automation and Computer Science, Computer Science Department

Country: Romania

Dates: October 21, 2024 - October 31, 2024

Context of the visit: Presentation of the work of COAST team on distributed collaborative systems in order to establish future collaborations.

Type of mobility: Research stay

10.2 European initiatives

10.2.1 Other european programs/initiatives

IPCEI-CIS (Important Project of Common European Interest – Next Generation Cloud Infrastructure and Services) DXP between Inria and Amadeus

Title: Data Exchange Platform

Dates: 2024-2029

Inria coordinator: Claudia-Lavinia Ignat

Inria teams: Cedar, COAST, Magellan

Participants: François Charoy, Claudia-Lavinia Ignat *(contact)*, Thomas Lambert, Gérald Oster.

This project aims to design and develop an open-source management solution for a federated and distributed data exchange platform (DXP), operating in an open, scalable, and massively distributed environment (cloud-edge continuum). In collaboration with Amadeus and the Cedar and Magellan teams, we will contribute to the design of solutions for data interoperability, access, and usage control, as well as to the development of a decentralized public/private key infrastructure and mechanisms for data placement and replication.

10.3 National initiatives

10.3.1 Inria Challenge

Alvearium between Inria and Hivenet

Title: Large Scale Secure and Reliable Peer-to-Peer Cloud Storage

Dates: 2022-2026

Inria coordinator: Claudia-Lavinia Ignat

Inria teams: COAST, Coati, Magellan, Pesto, Wide

Participants: Claudia-Lavinia Ignat *(contact)*, Thomas Lambert, Gérald Oster.

The project aims to propose an alternative peer-to-peer cloud which provides both computing and data storage via a peer-to-peer network rather than from a centralised set of data centers. Hivenet proposes to exploit the unused capacity of computers and to incentivize users to contribute their computer resources to the network in exchange for similar capacity from the network and/or monetary compensation. By exchanging similar computer resources and network capacity users can benefit from all cloud services. Peers store encrypted fragments of the data of other peers. This proposed peer-to-peer cloud solution addresses users concerns about the privacy of their data and the dependency on centralised cloud providers. In this collaboration with Hivenet we will apply our work on data replication and placement, Byzantine fault tolerance and security mechanisms in peer-to-peer environments.

10.3.2 PEPR

PILOT project of PEPR eNSEMBLE (Future of digital collaboration)

Title: Practices and infrastructure lor Long-term collaboration

Dates: 2023-2030

Coordinators: François Charoy (Université de Lorraine), Claudia-Lavinia Ignat (Inria), Myriam Lewkowicz (Université de Technologie de Troyes)

Partners: Inria (coordinator), CNRS, Université Grenoble Alpes, Université Paris-Saclay, Sorbonne Université, IMT, Université de Technologie de Troyes, INSA Lyon, Université Claude Bernard, Nantes Université, ENSAM, Université de Lille, Université de Toulouse III

Participants: François Charoy, Claudia-Lavinia Ignat *(contact)*, Gérald Oster, Olivier Perrin.

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.

TRUSTINCloudS project of PEPR Cloud

Title: Cybersecurity of cloud infrastructures

Dates: 2023-2030

Coordinator: CEA (Aymen Boudguiga)

Partners: AMU, IMT, UL, EURECOM, UT3, CEA, INRIA

Participants: Claudia-Lavinia Ignat *(contact)*.

TRUSTINCloudS project develops solutions for the major cybersecurity challenges specific to Cloud environments, in order to ensure the confidentiality, integrity and availability of data, applications and services. The work carried out in this project aims at adapting traditional security mechanisms to the characteristics of the Cloud in order to address the specific threats of the different types of Clouds (IaaS, PaaS,...). The main objective of TRUSTINCloudS is to study and develop new methodologies to strengthen Cloud security and implement them in platforms in order to build a sovereign and trusted Cloud. In the context of this project, COAST team will work on the security of peer-to-peer clouds for storage.

11 Dissemination

Participants: Quentin Acher, Clélie Amiot, Khalid Benali, Gérôme Canals, François Charoy, Lisa Formentini, Claudia-Lavinia Ignat, Thomas Lambert, Gérald Oster, Olivier Perrin.

11.1 Promoting scientific activities

11.1.1 Scientific events: organisation

General chair, scientific chair

- Khalid Benali was chairman of the organizing committee of INFORSID'2024 organised in Nancy.

11.1.2 Scientific events: selection

Member of the conference steering committees

- Claudia-Lavinia Ignat was a member of the Steering Committee for the International Conference on Intelligent Computer Communication and Processing (ICCP) in 2024.

Member of the conference program committees

- Khalid Benali was a PC member of the International Conference on Computational Collective Intelligence (ICCCI) 2024 and the ACM International Conference on Management of Digital EcoSystems (MEDES) 2024.
- François Charoy was a PC Member of the International Conference on Service Oriented Computing (ICSOC) 2024, BIS 2024 and Inforsid 2024.
- Claudia-Lavinia Ignat was an associate chair at the ACM Conference on Computer-Supported Cooperative Work and Social Computing (CSCW) in 2024. She was a PC member of the ACM/IFIP International Middleware Conference (Middleware) 2024, the European Conference on Computer-Supported Cooperative Work (ECSCW) 2024, the International Conference on Collaboration Technologies and Social Computing (CollabTech) 2024 and the International Conference on Intelligent Computer Communication and Processing (ICCP) 2024.

- Thomas Lambert was a PC member of IEEE BigData'24 and CHEOP24 (workshop at EuroSys'24).
- Gérald Oster was a PC member of the International Conference on Collaboration Technologies and Social Computing (CollabTech) 2024 and the International Conference on Intelligent Computer Communication and Processing (ICCP) 2024.

Reviewer

- Claudia-Lavinia Ignat was reviewer for GROUP 2025 conference.

11.1.3 Journal

Member of the editorial boards

- Claudia-Lavinia Ignat is an associate editor of Computer Supported Cooperative Work (CSCW): The Journal of Collaborative Computing and Work Practices.
- François Charoy is a member of the editorial board of Service Oriented Computing and Applications (Springer).

Reviewer - reviewing activities

- Thomas Lambert was reviewer for FGCS and IEEE Internet Computing.

11.1.4 Invited talks

- Claudia-Lavinia Ignat gave a keynote on "Large-scale trustworthy distributed collaborative systems - challenges and prospective solutions" at INFORSID (INFormatique des ORganisations et Systèmes d'Information et de Décision) on May 2024 in Nancy, France.
- Claudia-Lavinia Ignat was invited to present her work on "Large-scale trustworthy distributed collaborative systems" on October 2024 at the Technical University of Cluj-Napoca, Romania

11.1.5 Leadership within the scientific community

- Claudia-Lavinia Ignat and François Charoy organized monthly online animation seminars in the context of PILOT project of PEPR eNSEMBLE.

11.1.6 Scientific expertise

- Claudia-Lavinia Ignat was member of the HCERES evaluation committee of SAMOVAR.
- Gérald Oster took part in the evaluation process of AAPG 2024 as a Scientific Expert for the scientific panel CE25 (Software sciences and engineering - Multi-purpose communication networks, digital infrastructure).

11.1.7 Research administration

- François Charoy was co-head of the Computer Science mention of the IAEM Doctoral School (Université de Lorraine). He was the president of a hiring committee for an associate professor position at Télécom Nancy. He served on the hiring committee for an associate professor position at IMT Télécom Sud Paris and on the promotion committee for a professor position at Université Grenoble Alpes.
- Claudia-Lavinia Ignat is member of the Scientific Committee of GDR Réseaux et Systèmes Distribués (RSD). She is member of "Bureau du Comité de Projets" (BCP) for Inria Centre at Université de Lorraine. In 2024, she was a member of the hiring committees for Junior Research Scientists (CRCN/ISFP) at Inria Grenoble and Inria Lille.

- Thomas Lambert is scientific deputy for Nancy for SLICES-FR platform. He is also a member of user's committee for Abaca platform and Abaca coordinator for the CPER GENI. He was a member of a hiring committee for two associate professor positions at Université de Lorraine.
- Quentin Acher and Lisa Formentini are members of "Bureau des Doctorants" for Loria in charge of the organisation of students' integration weekend and Coffee Time and Beer Time events.
- Gérald Oster was the president of a hiring committee for a *Professeur Agrégé* (PRAG) position at Télécom Nancy. He served on the hiring committee of an associate professor position at Université de Lorraine.

11.2 Teaching - Supervision - Juries

11.2.1 Teaching

Permanent members of the COAST project-team are leading teachers in their respective institutions. They are responsible of lectures in disciplines like software engineering, database systems, object oriented programming and design, distributed systems, service computing and more advanced topics at all levels and in different departments in the University. Most PhD Students have also teaching duties in the same institutions. Claudia-Lavinia Ignat teaches a course on data replication and consistency at Master level (M2 SIRAV) at Université de Lorraine. As a whole, the COAST team accounts for more than 2,500 hours of teaching. Members of the COAST team are also deeply involved in the pedagogical and administrative life of their departments.

- Khalid Benali is responsible for the professional Master degree speciality "Distributed Information Systems" of MIAGE (Université de Lorraine).
- Gérôme Canals is the deputy director of IUT Nancy-Charlemagne of Université de Lorraine.
- François Charoy is responsible for the Software Engineering specialisation at the TELECOM Nancy Engineering School of Université de Lorraine.
- Gérald Oster is the deputy director of TELECOM Nancy Engineering School of Université de Lorraine. He is responsible for the 3rd (last) year of study and President of the jury of the Diploma at TELECOM Nancy.

11.2.2 Supervision

- PhD defended: Pierre-Antoine Rault, Security mechanisms for decentralised collaborative systems, defended in December 2024, supervised by Claudia-Lavinia Ignat and Olivier Perrin
- PhD in progress: Clélie Amiot, Trust and Human/Chatbot collaboration, started in October 2019, supervised by Jérome Dinet and François Charoy
- PhD in progress: Quentin Acher, Management of mutable data over P2P storage, started in September 2023, supervised by Claudia-Lavinia Ignat and Shadi Ibrahim (Magellan team)
- PhD in progress: Ludovic Paillat (Hivenet), Security for peer-to-peer cloud storage without central authority, started in October 2023, supervised by Claudia-Lavinia Ignat, Davide Frey (WIDE team) and Mathieu Turuani (PESTO team)
- PhD in progress: Lisa Formentini, Evolution of Ecology of Artefacts for Cooperation, the case for Civil Security, started in October 2023, supervised by François Charoy and Matthieu Tixier (UTT)
- PhD in progress: Mohammad Rizk (Magellan team), Reliable and cost-efficient data placement and repair in P2P storage over immutable data, started in November 2023, supervised by Shadi Ibrahim (Magellan team) and Thomas Lambert
- PhD in progress: Victor Henrique De Moura Netto, Improving security and performance of IPFS's DHT, started in October 2024, supervised by Claudia-Lavinia Ignat and Thibault Cholez (Resist team)

- PhD in progress: Hua Junrui (Hivenet), Advanced techniques for efficient DHT with fault tolerance against Byzantine faults in large-scale distributed systems, started in October 2024, supervised by François Taiani (Wide team) and Gérald Oster

11.2.3 Juries

- Nawal Guermouche, HDR defense jury, "Vers une gestion proactive et intelligente des systèmes cyber-physiques orientés services", Université de Toulouse, June 2024 (François Charoy, Rapporteur)
- Runbo Su, PhD defense jury, "Trust management in service-oriented Internet of Things (SO-IoT)", Université de Lorraine, July 2024 (Claudia-Lavinia Ignat, Examiner)
- Nouha Laamech, PhD defense jury, "Towards a secure data sharing management approach for IoT environments", Université de Pau des Pays de l'Adour, September 2024 (Khalid Benali, Examiner)

11.3 Popularization

11.3.1 Specific official responsibilities in science outreach structures

- Lisa Formentini was member of Orion club on "Human Interact" and organised a pinte of science and several lab visits

11.3.2 Productions (articles, videos, podcasts, serious games, ...)

- Clélie Amiot gave an interview about her research work on human-chatbot interaction (see article)

11.3.3 Participation in Live events

- Clélie Amiot participated to game design for video games exposition at Féru des Sciences where she also ran a booth
- In September 2024 Clélie Amiot ran the VirtualSociety (the start-up to which she contributes) booth, and the "Inside" booth (Inria's VR mediation booth) at Vandoeuvre In Game
- In October 2024 Clélie Amiot ran a booth at Cité des Sciences for Fête de la Science for schoolchildren and general public
- In November 2024 Clélie Amiot ran a booth at Blainville-sur-l'Eau together with Inria and Loria
- In June 2024 Claudia-Lavinia Ignat supervised Dina Bitam, a tenth-grade student (élève en seconde) at Henri Loritz highschool for a two-weeks internship at Inria Centre at Université de Lorraine, in COAST team
- In December 2024 Claudia-Lavinia Ignat presented her research works to several ninth-grade students (élèves en 3ème) while they were doing an internship at Inria Centre at Université de Lorraine
- In October 2024 Quentin Acher presented his research work on "Data management in peer-to-peer systems" during Pizza time event at Loria/Inria Centre at Université de Lorraine dedicated for an exchange between young researchers around their research topics

12 Scientific production

12.1 Major publications

[1] C. Amiot, F. Charoy and J. Dinet. 'Chatbots in Collaborative Settings and their Impact on Virtual Teamwork'. In: *Proceedings of the ACM on Human-Computer Interaction* (2024). URL: https://hal.science/hal-04841009. In press.

[2] C.-L. Ignat, L. André and G. Oster. 'Enhancing rich content wikis with real-time collaboration'. In: *Concurrency and Computation: Practice and Experience* 33.8 (25th Apr. 2021). DOI: 10.1002/cpe.4110. URL: https://hal.inria.fr/hal-01404024.

[3] C.-L. Ignat, Q.-V. Dang and V. Shalin. 'The Influence of Trust Score on Cooperative Behavior'. In: *ACM Transactions on Internet Technology* 19.4 (19th Sept. 2019), pp. 1–22. DOI: 10.1145/3329250. URL: https://hal.inria.fr/hal-02307981.

[4] Q. Laporte-Chabasse, R. S. Stoica, M. Clausel, F. Charoy and G. Oster. 'Morpho-statistical description of networks through graph modelling and Bayesian inference'. In: *IEEE Transactions on Network Science and Engineering* 9.4 (2022), pp. 2123–2138. DOI: 10.1109/TNSE.2022.3155359. URL: https://hal.science/hal-03744409.

[5] H. Le Nguyen and C.-L. Ignat. 'An Analysis of Merge Conflicts and Resolutions in Git-based Open Source Projects'. In: *Computer Supported Cooperative Work* 27.3-6 (June 2018), pp. 741–765. DOI: 10.1007/s10606-018-9323-3. URL: https://hal.science/hal-01917249.

[6] M. Nicolas, G. Oster and O. Perrin. 'Efficient Renaming in Sequence CRDTs'. In: *IEEE Transactions on Parallel and Distributed Systems* 33.12 (1st Dec. 2022), pp. 3870–3885. DOI: 10.1109/TPDS.2022.3172570. URL: https://hal.inria.fr/hal-03772633.

[7] L. Paillat, C.-L. Ignat, D. Frey, M. Turuani and A. Ismail. 'Discreet: distributed delivery service with context-aware cooperation'. In: *Annals of Telecommunications - annales des télécommunications* (11th July 2024), pp. 1–23. DOI: 10.1007/s12243-024-01053-1. URL: https://inria.hal.science/hal-04829916.

12.2 Publications of the year

International journals

[8] C. Amiot, F. Charoy and J. Dinet. 'Chatbots in Collaborative Settings and their Impact on Virtual Teamwork'. In: *Proceedings of the ACM on Human-Computer Interaction* (2024). URL: https://hal.science/hal-04841009. In press (cit. on pp. 5, 9).

[9] L. Paillat, C.-L. Ignat, D. Frey, M. Turuani and A. Ismail. 'Discreet: distributed delivery service with context-aware cooperation'. In: *Annals of Telecommunications - annales des télécommunications* (11th July 2024), pp. 1–23. DOI: 10.1007/s12243-024-01053-1. URL: https://inria.hal.science/hal-04829916 (cit. on pp. 5, 6, 8).

International peer-reviewed conferences

[10] T. Cholez and C.-L. Ignat. 'Sybil Attack Strikes Again: Denying Content Access in IPFS with a Single Computer'. In: *Proceedings of the 19th International Conference on Availability, Reliability and Security*. ARES 2024: The 19th International Conference on Availability, Reliability and Security. Vienna, Austria: ACM, 30th July 2024, pp. 1–7. DOI: 10.1145/3664476.3664482. URL: https://inria.hal.science/hal-04666290 (cit. on p. 8).

[11] C.-L. Ignat, V. Elvinger and H. Ba. 'Synql: A CRDT-based Approach for Replicated Relational Databases with Integrity Constraints'. In: *Proceedings of DisCoTec 2024 - 19th International Federated Conference on Distributed Computing Techniques*. DAIS 2024 - 24th International Conference on Distributed Applications and Interoperable Systems. Groningen, Netherlands, 17th June 2024. URL: https://inria.hal.science/hal-04580135 (cit. on p. 7).

Conferences without proceedings

[12] L. Formentini. 'What remains of containment? Evolution of artifact ecologies in civil security organizations'. In: *Formentini, Lisa (2024): What remains of lockdown? Evolution of artifact ecologies in civil security organizations. In: Proceedings of the 22nd European Conference onComputer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Doctoral Colloquium Contributions, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_dc03*. ECSCW2024. Rimini, Italie, Italy: European Society for Socially Embedded Technologies (EUSSET), 2024. DOI: 10.48340/ecscw2024_dc03. URL: https://sciencespo.hal.science/hal-04772248 (cit. on pp. 5, 9).

[13] C.-L. Ignat. 'Keynote: Large-scale trustworthy distributed collaborative systems - challenges and prospective solutions'. In: INFORSID (INFormatique des ORganisations et Systèmes d'Information et de Décision) 2024. Nancy, France, 28th May 2024. URL: https://inria.hal.science/hal-04595294.

Reports & preprints

[14] T. Lambert, T. Jain and S. Ibrahim. *On the (In)Accuracy of Stragglers' Detection in Big Data Analytic Systems*. 13th Apr. 2024. URL: https://inria.hal.science/hal-04545304.

Other scientific publications

[15] F. Charoy, M. Sellami, W. Gaaloul and S. Assar. *Busines process management : fondamentaux de la gestion des processus métier*. 1st June 2024. URL: https://cnrs.hal.science/hal-04717752.

[16] L. Formentini, M. Tixier and F. Charoy. 'What remains of containment? Evolution of artifact ecologies in civil security organizations'. In: ECSCW2024. Rimini, Italie, Italy, 17th June 2024. URL: https://sciencespo.hal.science/hal-04772255.

[17] M. Rizk, S. Ibrahim and T. Lambert. 'Quantifying the Performance of Erasure Codes in P2P Storage Systems'. In: SSDBM 2024 - 36th International Conference on Scientific and Statistical Database Management. Rennes, France, 2024. URL: https://inria.hal.science/hal-04857465 (cit. on pp. 6, 10).

12.3 Cited publications

[18] Q. Acher, C.-L. Ignat and S. Ibrahim. 'Quantifying the Performance of Conflict-free Replicated Data Types in InterPlanetary File System'. In: *Middleware 2023 Companion Proceedings*. Bologna, Italy, Dec. 2023, pp. 1–6. DOI: 10.1145/3631310.3633488. URL: https://inria.hal.science/hal-04337761 (cit. on p. 6).

[19] S. Bhiri, O. Perrin, W. Gaaloul and C. Godart. 'An Object-Oriented Metamodel For Inter-Enterprises Cooperative Processes Based on Web Services'. Anglais. In: *Journal of Integrated Design and Process Science* 8 (2004), pp. 37–55. URL: http://hal.inria.fr/inria-00099953/en/ (cit. on p. 5).

[20] F. Casati. 'Promises and Failures of Research in Dynamic Service Composition'. English. In: *Seminal Contributions to Information Systems Engineering*. Ed. by J. Bubenko, J. Krogstie, O. Pastor, B. Pernici, C. Rolland and A. Sølvberg. Springer Berlin Heidelberg, 2013, pp. 235–239. URL: http://dx.doi.org/10.1007/978-3-642-36926-1_18 (cit. on p. 3).

[21] C. A. Ellis and S. J. Gibbs. 'Concurrency Control in Groupware Systems'. In: *Proceedings of the ACM SIGMOD Conference on the Management of Data - SIGMOD 89*. Portland, Oregon, USA, May 1989, pp. 399–407. URL: http://doi.acm.org/10.1145/67544.66963 (cit. on pp. 3, 4).

[22] G. Oster, P. Urso, P. Molli and A. Imine. 'Data Consistency for P2P Collaborative Editing'. Anglais. In: *ACM Conference on Computer-Supported Cooperative Work - CSCW 2006*. Banff, Alberta, Canada: ACM Press, Nov. 2006, pp. 259–268. URL: http://hal.inria.fr/inria-00108523/en/ (cit. on p. 5).

[23] M. P. Papazoglou, P. Traverso, S. Dustdar and F. Leymann. 'Service-Oriented Computing: State of the Art and Research Challenges'. In: *Computer* 40 (2007), pp. 38–45 (cit. on p. 4).

[24] N. Preguiça, J. M. Marquès, M. Shapiro and M. Letia. 'A commutative replicated data type for cooperative editing'. Anglais. In: *29th IEEE International Conference on Distributed Computing Systems (ICDCS 2009)*. Montreal, Québec Canada: IEEE Computer Society, 2009, pp. 395–403. DOI: 10.1109/ICDCS.2009.20. URL: http://hal.inria.fr/inria-00445975/en/ (cit. on p. 4).

[25] Y. Saito and M. Shapiro. 'Optimistic Replication'. In: *Computing Surveys* 37.1 (Mar. 2005), pp. 42–81. URL: http://doi.acm.org/10.1145/1057977.1057980 (cit. on p. 4).

[26] C. Sun, X. Jia, Y. Zhang, Y. Yang and D. Chen. 'Achieving Convergence, Causality Preservation, and Intention Preservation in Real-Time Cooperative Editing Systems'. In: *ACM Transactions on Computer-Human Interaction* 5.1 (Mar. 1998), pp. 63–108. URL: http://doi.acm.org/10.1145/274444.274447 (cit. on p. 4).