

2025 Activity Report

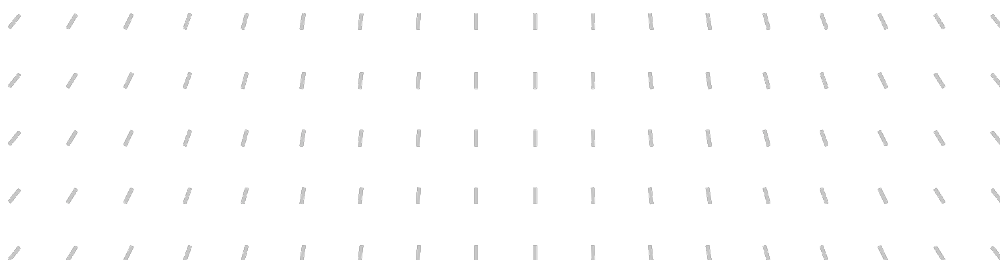
RESEARCH CENTRE: Inria Centre at the University of Lille
IN PARTNERSHIP WITH: Université de Lille, CNRS

Project-Team

SPIRALS

Self-adaptation for distributed services and large software systems

In collaboration with Centre de Recherche en Informatique, Signal et Automatique de Lille



Project-Team SPIRALS

Creation of the Project-Team: 2015 January 01

Each year, Inria research teams publish an Activity Report presenting their work and results over the reporting period. These reports follow a common structure, with some optional sections depending on the specific team. They typically begin by outlining the overall objectives and research programme, including the main research themes, goals, and methodological approaches. They also describe the application domains targeted by the team, highlighting the scientific or societal contexts in which their work is situated. The reports then present the highlights of the year, covering major scientific achievements, software developments, or teaching contributions. When relevant, they include sections on software, platforms, and open data, detailing the tools developed and how they are shared. A substantial part is dedicated to new results, where scientific contributions are described in detail, often with subsections specifying participants and associated keywords. Finally, the Activity Report addresses funding, contracts, partnerships, and collaborations at various levels, from industrial agreements to international cooperations. It also covers dissemination and teaching activities, such as participation in scientific events, outreach, and supervision. The document concludes with a presentation of scientific production, including major publications and those produced during the year.

Keywords

Computer sciences and digital sciences

- A1.3.3. – Blockchain
- A1.3.5. – Cloud
- A1.6. – Green Computing
- A2.3.1. – Embedded systems
- A2.3.2. – Cyber-physical systems
- A2.5. – Software engineering
- A2.5.2. – Component-based Design
- A2.5.3. – Empirical Software Engineering
- A2.5.4. – Software Maintenance & Evolution
- A2.6.2. – Middleware
- A3.1.3. – Distributed data
- A3.1.4. – Uncertain data
- A3.1.5. – Control access, privacy
- A3.1.9. – Database
- A3.2.1. – Knowledge bases
- A3.2.4. – Semantic Web
- A3.2.5. – Ontologies
- A4.4. – Security of equipment and software
- A4.5.2. – Model-checking
- A4.8. – Privacy-enhancing technologies
- A7.2. – Logic in Computer Science
- A9.1. – Knowledge

Other research topics and application domains

- B6.1. – Software industry
- B6.4. – Internet of things
- B6.5. – Information systems
- B6.6. – Embedded systems
- B8.5.2. – Crowd sourcing
- B9.5.1. – Computer science
- B9.5.6. – Data science
- B9.10. – Privacy

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1 Team members, visitors, external collaborators

Research Scientists

- Simon Blyudze [INRIA, Researcher, HDR]
- Pierre Bourhis [CNRS, Senior Researcher, from Oct 2025, HDR]
- Pierre Bourhis [CNRS, Researcher, until Sep 2025, HDR]
- Sophie Cerf [INRIA, ISFP, until Jul 2025]
- Francescomaria Faticanti [INRIA, ISFP, from Oct 2025]
- Pierre Laperdrix [CNRS, Researcher, HDR]
- Clémentine Maurice [CNRS, Researcher, HDR]
- Philippe Merle [INRIA, Senior Researcher, HDR]

Faculty Members

- Lionel Seinturier [Team leader, UNIV LILLE, Professor, HDR]
- Laurence Duchien [UNIV LILLE, Professor, HDR]
- Adrien Luxey-Bitri [UNIV LILLE, Associate Professor]
- Clément Quinton [UNIV LILLE, Associate Professor, HDR]
- Romain Rouvoy [UNIV LILLE, Professor, HDR]
- Juliette Senechal [UNIV LILLE, Professor Delegation, HDR]

Post-Doctoral Fellows

- Anderson Andrei Da Silva [INRIA, Post-Doctoral Fellow, from Jul 2025]
- Imane Fouad [INRIA, Post-Doctoral Fellow, until Jan 2025]

PhD Students

- Virginie Amand [INRIA]
- Elodie Bernard [INRIA, from Oct 2025]
- Alexandre Bonvoisin [UNIV LILLE, ATER, from Sep 2025]
- Alexandre Bonvoisin [INRIA, until Aug 2025]
- Sihem Bouhenniche [UNIV LILLE]
- Thibaud Cartegnie [INRIA, from Oct 2025]
- Tristan Coignon [INRIA, until Nov 2025]
- Thomas Collignon [QARNOT COMPUTING, CIFRE]
- Boubacar Diarra [ORANGE, CIFRE]
- Belkis Djefal [INRIA]
- Samuel Dubuisson [INRIA, from Oct 2025]

- Nusrat Jahan Farin [INRIA]
- Iliana Fayolle [UNIV LILLE]
- Gaëlle Fret [INRIA, from Oct 2025]
- Antoine Geimer [UNIV RENNES I]
- Maxime Huyghe [UNIV LILLE, until Sep 2025]
- Jean Intumwayase [UNIV LILLE, ATER, until Aug 2025]
- Louay Khrouf [BERGER-LEVRAULT, CIFRE, from Mar 2025]
- Jamile Lima Leite [ORANGE, CIFRE, from Mar 2025]
- Hugo Monfleur [INRIA, until Sep 2025]
- Clément Médart [UNIV LILLE]
- Remy Raes [INRIA]
- Brell Peclard Sanwouo Chekam [INRIA]
- Yifan Wang [ORANGE, CIFRE, until Nov 2025]
- Jeremy Woirhayé [INRIA, from Oct 2025]
- Brice Arleon Zemtsop Ndadjé [UNIV LILLE, from Oct 2025]
- Nada Zine [INRIA]

Technical Staff

- Noé Chachignot [INRIA, Engineer]
- Tanguy Chatelain [INRIA, Engineer, from Nov 2025]
- Guillaume Fieni [INRIA, Engineer]
- Gaëlle Fret [INRIA, Engineer, until Aug 2025]
- Nathan Leblond [INRIA, Engineer]
- Kellian Leveque [INRIA, Engineer, from Sep 2025]
- Daniel Romero Acero [INRIA, Engineer]
- Brice Arleon Zemtsop Ndadjé [INRIA, Engineer, until Sep 2025]

Interns and Apprentices

- Nomintuul Batbaatar [INRIA, Intern, from Apr 2025 until Aug 2025]
- Elodie Bernard [INRIA, Intern, from Apr 2025 until Aug 2025]
- Lucas Deloison [INRIA, Apprentice]
- Samuel Dubuisson [INRIA, Apprentice, until Aug 2025]
- Kellian Leveque [INRIA, Apprentice, until Aug 2025]
- Samir Sadallah [INRIA, Apprentice, from Sep 2025]
- Amaranta Salas Villarroel [INRIA, Intern, from Mar 2025 until May 2025]
- Jeremy Woirhayé [INRIA, Apprentice, until Aug 2025]

Administrative Assistant

- Isabelle Aslani [INRIA]

2 Overall objectives

2.1 Introduction

Our research is based on two complementary fields: distributed systems and software engineering. We aim at introducing more automation in the adaptation processes of software systems, that is, transitioning from the study of adaptive systems to self-adaptive systems.

2.2 Scientific Foundations

Self-adaptation is a property of software systems that are able to modify their behavior and structure in response to their perception of the environment, of the system itself, and of their requirements [82, 85, 108]. The research community around self-adaptation has delivered many results, e.g. in terms of design-time issues for engineering self-adaptive systems [112], and in terms of run-time issues for managing these systems [103]. Certainly, many of the proposed *Self-Adaptive Systems* have been designed to operate in highly dynamic socio-technical ecosystems where requirements, models, and contexts change at runtime [82, 111]. Since the domain takes some roots in autonomic computing [97], *Feedback Control Loops* (FCL) are, in many cases, the promoted solution for designing and implementing these systems [81]. In addition, self-adaptation for distributed systems is closely associated with service orientation [115].

3 Research program

In the general context of self-adaptation, our research program addresses: models and components for self-adaptation seen as foundational elements for self-adaptation, frugal distributed systems where energy is considered as a major lever to trigger adaptation in software systems, cybersecurity and privacy where we study how the detection of leakages and vulnerabilities and their associated countermeasures can be automated as much as possible.

Models and Components for Self-Adaptation We aim at defining formal and rigorous foundations for self-adaptive software systems. As opposed to simple programs that compute a function, software systems are *structured assemblies* of interacting components that *coordinate their behavior* to perform a function based on continuous observation of *data*—both their internal state and the data provided by their environment. Our originality is to tackle the consolidation of the foundations of self-adaptation from different complementary angles, especially formal methods, machine learning, database theory, and feature models.

Frugal Distributed Systems Frugal computing is an emerging paradigm that emphasizes the efficient use of environmental resources in distributed systems, particularly in cloud computing environments. The Spirals project-team is recognized as a leading research group in the domain of energy-efficient cloud computing infrastructures. Based on the expertise we developed over the past decade, we contribute to design and implement new distributed systems that are efficient, sustainable, and cost-effective. Our work is characterized by a strong emphasis on resource optimization, energy efficiency, and the development of novel algorithms and architectures that can operate effectively in resource-constrained environments, from edge devices to the cloud.

Cybersecurity and Privacy The research conducted within this axis aims to improve system security and user privacy by identifying where vulnerabilities emerge, in order to better anticipate and mitigate them. Information leakage, in particular, is a pervasive security risk that affects all layers of modern computing systems, from high-level data representations to microarchitectural execution. This research axis addresses it through a multi-layered perspective, combining formal, empirical, and experimental approaches. At the logical level, we are interested on explanation on accessibility of data through queries. At the web layer,

we explore fingerprinting and tracking techniques leveraging both software interfaces and, increasingly, hardware features exposed via browsers. At the microarchitectural level, we design side-channel primitives – some exploitable remotely through JavaScript or WebGL – and evaluate detection tools. Together, these contributions provide a comprehensive view of how information can leak across abstraction layers and highlight our team’s ability to bridge distinct areas of expertise to tackle complex, real-world leakage scenarios.

4 Application domains

Our research activities are general enough to encompass a wide range of application domains in relation with distributed systems and software engineering. We currently focus on sustainability, safety, and cybersecurity, that are three crosscutting properties of software systems.

From an industrial perspective, the application domains of our research activities include cloud and telecom operators, IT services companies and software editors, cybersecurity agencies and companies. Examples of companies we are working with include the OVHcloud, Scalair and Qarnot Computing cloud operators, the Orange telecom company, the Davidson consulting company.

In terms of sustainability, we aim at better understanding how computing and software activities can better take into account the physical limits imposed by the environmental constraints of our world. Instead of measuring a posteriori the impact of digitalization, we aim at taking into account the environmental limits of our world in the very first stage of the design of software systems and services.

In terms of safety, we aim at building better and safer digital services and systems that can be proven safe by construction. We also want to study the tradeoff between safety and self-adaptation that are too often contradictory properties.

In terms of cybersecurity, we aim at improving privacy and preventing vulnerabilities. We are studying tracking techniques with a focus on fingerprinting to better understand how users can be identified on the Internet and how one can protect against such mechanisms. In terms of vulnerabilities, we especially apply our research to microarchitectural components and study how one can automate as much as possible countermeasures to these vulnerabilities.

5 Social and environmental responsibility

5.1 Impact of research results

Some parts of our research activities deal with green and power efficient computing. We are especially working on **PowerAPI** that is a middleware toolkit for building software-defined power meters. The results from this research activity have a potential high impact to go towards more sustainable software systems. The impact is important for the IT industry, from software editors to consulting company to telco and cloud operators. We aim at being able to issue recommendations for a greener design and development of software systems and to enable a finer measurement of energy consumption in modern distributed systems that can unlock important power savings.

In 2025, the defended PhD theses of Tristan Coignion [60] and Alexandre Bonvoisin [59] contribute to this objective. They proposed, respectively, an empirical evaluation of the energy impact of large language models for code generation and optimization (see Section 8.2), and the trade-offs between service quality and energy consumption in distributed systems (see Section 8.6). The ongoing CIFRE PhD thesis of Thomas Collignon with the Qarnot Computing company (see Section 9), the ANR projects Distiller and ObsoMobile, the PEPR Cloud CARECloud project, the Inria Défi Towards a More Frugal Cloud with the OVHcloud company, and the Inria Défi PULSE with the Qarnot Computing company (see Section 10), also contribute to this objective.

6 Highlights of the year

Simon Bliudze and his team of co-organizers from Spirals organized the **20th International Federated Conference on Distributed Computing Techniques** (DisCoTec) in Lille from 16 to 20 June 2025. DisCoTec is a major event in the research domain of distributed computing. In addition to the usual recurring tracks,

the 2025 edition hosted the **CORSE workshop** on Components Operationally: Reversibility and System Engineering to celebrate the 65th birthday of Jean-Bernard Stefani from the Inria Spades project-team.

6.1 Awards

Clémentine Maurice has been awarded the "**prix Inria - Académie des sciences jeunes chercheuses et jeunes chercheurs**" for her work on cybersecurity and more especially on microarchitectural vulnerabilities.

7 Latest software developments, platforms, open data

7.1 Latest software developments

7.1.1 amiunique

Name: amiunique

Keywords: Privacy, Browser fingerprinting

Scientific Description: The amiunique web site has been deployed in 2014 in the context of the DiverSE team research activities on browser fingerprinting to understand how software diversity can be leveraged to mitigate the impact of fingerprinting on the privacy of users. In 2018, it was migrated to the Spirals team where the research on browser fingerprinting still continues to this day. In 2024, a novel mobile app was deployed to investigate the fingerprintability of mobile devices.

The web site has yielded multiple datasets of genuine fingerprints to understand the multiple facets of browser fingerprinting and how they can be used on the web to reinforce security. The web site presents regular updates to include the latest development in web technology and understand their impact of users' privacy.

The whole source code of amiunique is open source and is distributed under the terms of the MIT license.

Main innovative features:

- canvas fingerprinting
- WebGL fingerprinting
- advanced JS features (platform, DNT, etc.)

Impact: The website has been visited by more than 3,000,000 unique visitors since its creation and it has been showcased in several professional forums and tutorial sessions over the years. It produced multiple datasets over the years that were used in articles published in top-tier conferences. Amiunique has received in 2018 the prize "**Protection de la vie privée**" granted by Inria and the CNIL. The research around fingerprints in amiunique has also been a **source of influence for the Brave web browser**.

Functional Description: This web site aims at informing visitors about browser fingerprinting and possible tools to mitigate its effect, as well as at collecting data about the fingerprints that can be found on the web. It collects browser fingerprints with the explicit agreement of the users (they have to click on a button on the home page). Fingerprints are composed of 17 attributes, which include regular HTTP headers as well as the most recent state of the art techniques (canvas fingerprinting, WebGL information).

URL: <https://amiunique.org/>

Contact: Pierre Laperdrix

Partners: INSA Rennes, Université de Lille

7.1.2 KubeDiagrams

Name: KubeDiagrams

Keywords: Kubernetes, Helm, Architecture diagram

Scientific Description: Generate Kubernetes architecture diagrams from Kubernetes manifest files, customization files, Helm charts, and actual cluster state.

KubeDiagrams supports most of all Kubernetes built-in resources, any custom resources, label-based resource clustering, and declarative custom diagrams.

KubeDiagrams is available as a Python package in PyPI and a container image in DockerHub.

Functional Description: KubeDiagrams supports most of all Kubernetes built-in resources, any custom resources, label-based resource clustering, and declarative custom diagrams.

KubeDiagrams is available as a Python package in PyPI and a container image in DockerHub.

URL: <https://github.com/philippemerle/KubeDiagrams>

Contact: Philippe Merle

Participant: Philippe Merle

7.1.3 PowerAPI

Keywords: Energy efficiency, Energy management

Functional Description: PowerAPI is a library for monitoring the energy consumption of software systems.

PowerAPI differs from existing energy process-level monitoring tools in its software orientation, with a fully customizable and modular solution that lets the user precisely define what he/she wants to monitor. PowerAPI is based on a modular and asynchronous event-driven architecture using the Akka library. PowerAPI offers an API which can be used to define requests about energy spent by a process, following its hardware resource utilization (in term of CPU, memory, disk, network, etc.).

URL: <https://powerapi.org/>

Publications: [hal-01069142v1](#), [hal-00912996v2](#), [hal-00772454v1](#), [hal-00912613v1](#), [hal-00681560v3](#), [hal-00715331v1](#), [hal-01827132v2](#), [hal-01439889v1](#), [hal-01403486v1](#), [hal-01130030v1](#), [hal-03173410v1](#), [hal-02470128v1](#), [hal-02904300v1](#)

Contact: Romain Rouvoy

Participants: Adel Nouredine, Loic Huertas, Maxime Colmant, Romain Rouvoy, Mohammed Chakib Belgaid, Arthur D'azemar, Guillaume Fieni, Daniel Romero Acero

8 New results

In 2025, we obtained new results in the domains of frugal distributed systems (see Sections 8.1, 8.2, and 8.6), cybersecurity and privacy (see Sections 8.3, and 8.5), and models and components for self-adaptation (see Section 8.4).

8.1 Automation in database management system administration

Participants: Pierre Bourhis (*contact person*), Romain Rouvoy, Yifan Wang.

In the context of his PhD defended in November, Yifan Wang obtained new results in the domain of the automation of database management system administration [64].

We introduce a qualitative study of Database Administrator (DBA) workflows that surfaces persistent issues: resource over-allocation, sub-optimal tuning routines, and limited uptake of automation tools. From these findings, we concentrate on two pressing pain points: the need for more practical DBMS auto-tuning and excessive memory provisioning. Building on this, we propose DOT, a lightweight knob selection and optimization framework. DOT combines recursive feature elimination with cross-validation and Bayesian optimization to quickly identify the most impactful configuration knobs. By narrowing the search space without lengthy warm-up phases, DOT enables more efficient and cost effective DBMS tuning compared to traditional auto-tuners. To address inefficient memory use, we introduce MicroTune, an adaptive reinforcement learning driven buffer manager that continuously adjusts memory allocation in real time. By rightsizing buffers to match workload demands, MicroTune cuts waste and meets SLA requirements, showcasing a hands-on approach to resource optimization in production.

These results have been obtained in the context of a collaboration with Orange that funded the Cifre PhD thesis of Yifan Wang. Results have been published in [113].

8.2 Empirical evaluation of the energy impact of large language models for code generation and optimization

Participants: Tristan Coignon, Clément Quinton, Romain Rouvoy (*contact person*).

In the context of his PhD defended in November, Tristan Coignon obtained new results in the domain of the empirical evaluation of the energy impact of large language models for code generation and optimization [60].

First, we evaluate the runtime performance of LLM-generated code on over 200 Leetcode problems, revealing that while LLMs can outperform human-written solutions in some cases, their efficiency is highly sensitive to model parameters and problem familiarity. Second, we quantify the energy consumption of code assistants like GitHub Copilot through a user study and server instrumentation. The results show significant energy waste due to unsolicited suggestions and highlight how inference server configuration and usage modes can reduce energy consumption. Third, we analyze the net energy impact of LLM-based code optimization techniques across 118 problems. Our findings show that while optimizations can reduce energy usage, they are only environmentally profitable if the optimized code is run frequently enough to offset the cost of generating the optimization. Together, these three contributions provide a detailed examination of the trade-offs in using LLMs for code generation and optimization, with a focus on energy consumption. By empirically assessing both the costs and potential savings of code assistants and LLM-based optimizers, this thesis highlights a critical dimension of sustainable software engineering. While LLMs can improve code efficiency and accelerate development, their environmental impact depends heavily on usage patterns, deployment conditions, and application context. As ICT's footprint grows, understanding these trade-offs is essential. This thesis offers actionable insights for aligning software development with ecological constraints.

This thesis has been conducted in the context of the ANR Distiller project (see Section 10). Results have been published in [24] and in [83].

8.3 Automated exploration of the impact of configuration parameters on browser fingerprints

Participants: Maxime Huyghe, Clément Quinton, Lionel Seinturier (*contact person*).

In the context of his PhD defended in November, Maxime Huyghe obtained new results in the automated exploration of the impact of configuration parameters on browser fingerprints [61].

We present three main contributions offering comprehensive insights into browser configurations and fingerprint characteristics. First, FP-Rainbow, an automated methodology for analyzing how browser

configuration parameters affect fingerprint characteristics. Through extensive experimentation across 1,748 configuration parameters and 18 versions of Chromium browser, we generated 61,559 browser fingerprints representing the most comprehensive systematic study of browser configuration impact to date. Our analysis identified 32 to 56 impactful parameters on the Browser Object Model and achieved 78.15% success in identifying configuration parameters from fingerprints, quantitatively proving configuration choices directly impact fingerprints. Second, we present a novel formal representation using feature modeling from Software Product Line Engineering to capture browser fingerprint variability. Our method transforms flat attribute-value pairs into hierarchical trees, preserving relationships and constraints. This approach enables advanced analysis of browser fingerprint variability, like fingerprint sampling, evolution tracking, and configuration space exploration, it also has a side effect of reducing the size by up to 59,000 times without loss of information. Third, we propose extending these feature modeling techniques to configuration parameters and environmental attributes (OS, Hardware, Software). By unifying all data, we introduce a query language and a method to extract minimal fingerprints that maintain high identification rates. These contributions have implications across multiple domains. For privacy, our findings offer quantitative evidence for informed user decisions on browser configurations. Browser developers can use our tools to assess new features privacy impact and implement privacy-preserving default configurations. All datasets, tools, and methodologies are open-source to ensure reproducible research and community validation. The comprehensive datasets include detailed hardware and software configuration information alongside browser fingerprints, facilitating diverse research applications. This commitment fosters a broader understanding of browser fingerprinting and supports developing effective privacy-enhancing technologies. This work opens promising future directions: extending to other browsers/platforms, longitudinal studies of fingerprint evolution, integrating machine learning for improved analysis, and developing next-generation privacy-enhancing technologies. Our methodologies provide a foundation for ongoing privacy assessment as web technologies evolve.

Results have been published in [32, 31, 71] and in [92].

8.4 Concern-oriented microservice architecture: language, library, toolkit, and evaluation

Participants: Hugo Monfleur, Philippe Merle (*contact person*).

In the context of his PhD defended in November, Hugo Monfleur obtained new results in the domain of architecture description languages (ADL) for distributed systems [63].

The microservices architecture style has become a major focus in the design of distributed applications and services. This goes hand in hand with the development of cloud computing and its associated properties in terms of scalability, flexibility, and resource efficiency. In this context, we have designed a new metamodel for microservices-based ADLs and a language implementing it called Concern Oriented Microservice Architecture (COMSA), along with a toolkit. We thus propose a new way of designing the description of microservices applications, using the concept of concern to semantically anchor a syntactic structure, making architectural description a design necessity. This proposition is supported by compilers that produce executable code without modification, making COMSA a fully executable language. By rewriting a dataset of applications described using Docker Compose in COMSA, we establish that an application written in COMSA requires, on average, three times fewer properties for an equivalent description. This result immediately indicates a considerable gain in consistency and corroborates the qualitative improvements in intelligibility, error tolerance and maintenance efforts.

This thesis has been conducted in the context of the ANR SCALER project (see Section 10). Results have been published in [102, 99].

8.5 Binary code analysis for microarchitectural security

Participants: Antoine Geimer, Clémentine Maurice (*contact person*).

In the context of his PhD defended in December, Antoine Geimer obtained new results in the domain of cybersecurity.

Microarchitectural attacks threaten isolation in cloud environments, allowing a malicious VM or the cloud provider to access sensitive data. To protect against this, developers use constant-time programming techniques and enclave mechanisms like Intel SGX, but these approaches remain imperfect. In this work, we strengthen microarchitectural security through three contributions. First, we provide a retrospective of side-channel vulnerability detection tools, using a multi-criteria classification. We design a common benchmark to properly compare these tools and evaluate them against known vulnerabilities. We then identify missing features and formulate recommendations for future detection tools. We extend this benchmark to create a differential testing approach, identifying side-channel vulnerabilities introduced during compilation. We manually analyze these vulnerabilities to precisely identify problematic optimizations. Our results show that targeted disabling of these features significantly improves resilience to this type of attack, without any noticeable performance degradation. Finally, we extend a symbolic execution tool dedicated to SGX binaries to detect Spectre vulnerabilities. Our approach is inspired by previous work but adapted to the specific memory model used. It significantly improves the scalability of SGX enclave analysis, thus making the exploration of large programs practically feasible.

Results have been published in [90].

8.6 Reconciling performance and efficient use of hardware resources: the case of configurable software services

Participants: Alexandre Bonvoisin, Clément Quinton (*contact person*), Romain Rouvoy.

In the context of his PhD defended in December, Alexandre Bonvoisin obtained new results in the domain of the energy measurement of distributed software systems [59].

The first contribution examines different data access library and their configurations to understand the trade-offs between targeted service quality and energy consumption. Building on that work, the second contribution explores how application-framework selection, runtime configuration, and compilation strategy decisions shapes energy consumption, memory footprint, and raw performance of the designed system. Finally, the third contribution analyzes the interrelationships among software indicators, such as execution time and energy consumption to identify and facilitate software evaluation, which remains a challenging task in the light of the growing complexity of software systems.

This thesis has been conducted in the context of the ANR Distiller project (see Section 10). Results have been published in [28] and in [79].

9 Bilateral contracts and grants with industry

Berger-Levrault

Participants: Louay Khrouf, Romain Rouvoy (*contact person*).

This collaboration (2025–28) aims at working on the optimization of the energy consumption of software systems through code transformation by analyzing the impact of code changes on software energy usage.

The ongoing CIFRE PhD thesis of Louay Khrouf takes place in the context of this collaboration.

Orange #1

Participants: Yifan Wang, Pierre Bourhis (*contact person*), Romain Rouvoy.

This collaboration (2022–25) aims at working on the self-optimization of database management systems.

The CIFRE PhD thesis of Yifan Wang [64] has been defended in December in the context of this collaboration. Results have been published in [113].

Orange #2

Participants: Boubacar Diarra, Philippe Merle (*contact person*).

This collaboration (2023–26) aims at working on the formal verification of cloud native applications.

The ongoing CIFRE PhD thesis of Boubacar Diarra takes place in the context of this collaboration. First results have been published in [86] and [26].

Orange #3

Participants: Jamile Lima Leite, Philippe Merle (*contact person*).

This collaboration (2025–28) aims at working on the auto-scaling of 5G+/6G network functions in large scale edge computing infrastructures.

The ongoing CIFRE PhD thesis of Jamile Lima Leite takes place in the context of this collaboration.

Qarnot Computing

Participants: Sophie Cerf (*contact person*), Thomas Collignon, Lionel Seinturier.

This collaboration (2023–26) aims at working on the control of high performance computing tasks emissions. In tomorrow’s computing services, users will have objectives in terms of quality of service and cost, to which will be added new objectives related to the energy impact and environmental footprint of their calculations. As these objectives are contradictory, there will necessarily be a compromise to ensure. This collaboration focuses on the realization of this trade-off at the level of a computational task, or a cluster of computational tasks of a same user, the user deciding on the relative importance to be brought to the parameters mentioned above.

The ongoing CIFRE PhD thesis of Thomas Collignon and the Inria Défi PULSE take place in the context of this collaboration. First results have been published in [84] and in [25].

10 Partnerships and cooperations

10.1 International research visitors

10.1.1 Visits of international scientists

Participant: Romain Rouvoy.

Tomé Maseda, PhD student from the University of Coruña, visited the team from April to June to work on the management of CPU power consumption in container-based environments.

Participant: Pierre Bourhis.

Michael Benedikt, professor of computer science at the University of Oxford, visited the team for a short stay (4 days) in October to work with Pierre Bourhis and other members of the team on databases and computational logic.

Participant: Sophie Cerf.

Ruslan Shaiakhmetov, PhD student from the University of Bologna, visited the team from April to July to work on the data-driven control policy optimization for cloud resource management and racecar simulation.

10.1.2 Visits to international teams

Research stays abroad

Tristan Coignon

Visited institution: CWI Amsterdam

Country: Netherlands

Dates: November 2025

Context of the visit: Joint work with Ivano Malavolta and Vincenzo Stoico on the energy consumption of LLM.

Mobility program/type of mobility: research stay funded by the University of Lille in the context of the mobility program for PhD students.

10.2 European initiatives

10.2.1 Other european programs/initiatives

ANR France-Germany FACADES

Participants: Iliana Fayolle, Sihem Bouhenniche, Pierre Laperdrix (*contact person*), Clémentine Maurice, Romain Rouvoy.

FACADES is a 42-month European project (2022–26) with CISPA and Saarland University funded in the context of the German-French ANR joint call. The project investigates fingerprinting and CPU attack and defense exploration from browser scripts. The aim is to analyze the security implications of new features in web browsers (WebAssembly, WebGPU, WebUSB, etc.) that provide direct or indirect access to low-level hardware features.

The PhD theses of Sihem Bouhenniche and Iliana Fayolle take place in the context of this project. First results have been published in [32, 31] and in [107, 100, 87, 101].

IPCEI CIS Cloud Carbon Tower

Participants: Noé Chachignot, Gaëlle Fret, Nathan Leblond, Daniel Romero, Romain Rouvoy (*contact person*), Lionel Seinturier.

Cloud Carbon Tower is a 36-month European project funded by 7 member states of the EU to develop the next generation of cloud infrastructure and services. The French side of the project is coordinated by Orange. The Cloud Carbon Tower Project proposes end-to-end monitoring of the energy consumption and carbon emissions of a cloud computing infrastructure. Based on established and recognized software solutions, such as PowerAPI and Cloud-Joule, the project targets an integrated and robust solution allowing a cloud operator and its ecosystem to monitor the environmental impact of their activities.

10.3 National initiatives

10.3.1 ANR

ANR ADAPT

Participants: Simon Bliudze (*contact person*), Sophie Cerf, Adrien Luxey-Bitri, Daniel Romero, Lionel Seinturier.

ADAPT is a 48-month project (2024–28) funded by ANR. The project’s objective is to develop a formal framework and tools that support hierarchical modeling of self-adaptive systems and integrate adaptive control to allow dynamic reconfigurations. To this end, we intend to 1) extend component-based models with hierarchical motifs to allow specifying modular robots (MR) functions and constraints on resources; 2) define appropriate control mechanisms, based on hierarchical control motifs, for adapting and reconfiguring hierarchies of motifs, utilising aggregate measures over components; 3) implement control mechanisms over extended component-based models; and use them to 4) simulate and validate adaptations, before deploying them on the real MRs, such as Blinky Blocks.

First results have been published in [21, 27].

ANR Distiller

Participants: Alexandre Bonvoisin, Tristan Coignon, Clément Quinton, Romain Rouvoy (*contact person*), Lionel Seinturier.

Distiller is a 36-month project (2021–24) funded by ANR. The project intends to better assist practitioners by delivering software artifacts recommendations to promote sustainable cloud native software. Distiller will rely on a software sustainability index. The core idea is to evaluate the sustainability of different cloud-native services. Based on those evaluations and your project requirements, Distiller will recommend a more sustainable next technical stack.

The PhD theses of Alexandre Bonvoisin [59] and Tristan Coignon [60] have been defended in 2025 in the context of this project. In 2025, results obtained by the team in the context of this project have been published in [14, 24, 28, 33, 29].

ANR ObsoMobile

Participants: Gaëlle Fret, Adrien Luxey-Bitri (*contact person*), Romain Rouvoy.

ObsoMobile is a 54-month project (2025–30) funded by ANR in the context of the PRC program. The ambition of this project is to rethink smartphone obsolescence, that is to say, to drastically increase the lifespan of mobile phones—with the aim of reaching 50 years of lifespan. Partners are the University Lyon 1 and the University of Strasbourg.

The ongoing PhD thesis of Gaëlle Fret takes place in the context of this project.

ANR RAISIN

Participant: Sophie Cerf (*contact person*).

RAISIN is a 48-month project (2024–28) funded by ANR. The project intends to develop techniques enabling resource-aware conservative static analyses. Complexity evaluation of static analysis will allow to estimate the analysis time of a program, then the objective is to develop dynamic, control-based techniques that change the precision of a given analysis during the analysis itself. The project is led by Raphaël Monat from the Inria SyCoMoRES project-team.

ANR SCALER

Participants: Philippe Merle (*contact person*), Hugo Monfleur, Romain Rouvoy.

SCALER is a 42-month project (2022–26) funded by ANR. The project aims to optimize the scaling of microservice-based networked services while satisfying their stringent IT and telco requirements. Especially the objectives are to identify relevant metrics to characterize microservices, to define microservices integration patterns, and to design smart management strategies. Partners are the University of Grenoble, the Orange and Eolas companies.

The PhD thesis of Hugo Monfleur has been defended in November in the context of this project [63]. Results have been published in [99, 102].

ANR SmartCloud

Participants: Simon Bliudze (*contact person*), Philippe Merle, Arleon Zemtsop.

SmartCloud is a 42-month project (2024–27) funded by ANR. The project goal is to develop a flexible infrastructure for smart and coordinated dynamic reconfiguration of Cloud Computing systems. Formal Methods techniques will be used to allow explicit specification of the structural and behavioural constraints of the system to provide formal correctness guarantees and allow proactive adaptivity in a coordinated manner. Distributed monitoring and online optimisation techniques will be used for dynamic adaptation, aiming to optimise the efficiency of resource usage in a scalable manner. Partners are the Scalair company and the Inria OLAS project-team.

The ongoing PhD thesis of Arleon Zemtsop contributes to this project. First results have been published in [22, 49].

10.3.2 PEPR and PTCC

PEPR Cloud TARANIS

Participants: Philippe Merle (*contact person*), Clément Quinton, Brell Sanwouo, Lionel Seinturier, Romain Rouvoy, Sophie Cerf, Simon Bliudze, Pierre Bourhis.

TARANIS is a 7-year project (2023–29) funded in the context of PEPR Cloud Computing framework. New infrastructures, such as Edge Computing or the Cloud-Edge-IoT computing continuum, make cloud issues more complex as they add new challenges related to resource diversity and heterogeneity (from small sensor to data center/HPC, from low power network to core networks), geographical distribution, as well as increased dynamicity and security needs, all under energy consumption and regulatory constraints. In order to efficiently exploit new infrastructures, the project proposes a strategy based on a significant abstraction of the application structure description to further automate application and infrastructure management. Thus, it will be possible to globally optimize the resources used with respect to multi- criteria objectives (price, deadline, performance, energy, etc.) on both the user side (applications) and the provider side (infrastructures). This abstraction also includes the challenges related to the abstraction of application reconfiguration and to automatically adapt the use of resources.

The ongoing PhD thesis of Brell Sanwouo takes place in the context of this project. First results have been published in: [109] and in [37, 42, 43].

PEPR Cloud CARECloud

Participants: Djeflal Belkis, Pierre Bourhis, Sophie Cerf, Clément Quinton, Adrien Luxey-Bitri, Romain Rouvoy (*contact person*), Nada Zine.

CARECloud is a 7-year project (2023–29) funded in the context of PEPR Cloud Computing framework. The first objective of the project is to understand how cloud infrastructures consume energy in order to identify sources of waste and to design new models and metrics to qualify energy efficiency. The second objective focuses on the energy efficiency of cloud infrastructures, i.e., optimizing their consumption during the usage phase. In particular, this involves designing resource allocation and energy lever orchestration strategies: mechanisms that optimize energy consumption (sleep modes, dynamic adjustment of the size of virtual resources, optimization of processor frequency, etc.). Finally, the third objective targets digital sobriety in order to sustainably reduce the environmental impact of clouds and aims to design infrastructures that are more energy and IT resource efficient, resilient to electrical intermittency, adaptable to the production of electricity from renewable energy sources and tolerant of the disconnection of a highly decentralized part of the infrastructure.

The ongoing PhD theses of Djeflal Belkis and Nada Zine take place in the context of this project. First results have been published in [88, 94, 95, 110, 83, 96, 79] and in [14, 24, 35, 50, 28, 33, 29].

PEPR Cybersecurity IPoP

Participants: Pierre Bourhis, Imane Fouad, Clémentine Maurice, Pierre Laperdrix (*contact person*), Romain Rouvoy, Juliette Sénéchal.

IPoP is a 72-month project (2022–28) funded in the PEPR Cybersecurity framework. The objectives of the IPoP (Interdisciplinary Project on Privacy) project are to study the threats on privacy that have been introduced by these new digital technologies, and to conceive theoretical and technical privacy-preserving solutions that are compatible with French and European regulations, that preserve the quality of experience of the users. Spirals is leader of WP2 on new forms of personal data gathering and their associated threats for privacy.

First results have been published in [31] and in [89, 106, 80].

PEPR Cybersecurity REV

Participants: Nusrat Jahan Farin, Clémentine Maurice (*contact person*), Pierre Laperdrix.

REV is a 72-month project (2022–28) funded in the PEPR Cybersecurity framework. The objectives of the REV (Recherche et Exploitation de Vulnérabilités) project are to study the presence of vulnerabilities in modern devices by attacking multiple layers of a system at the same time from the software, hardware and its interfaces. This broad-spectrum analysis is key to understand how far an attack can go since the deployment of numerous protections prevents a device from being compromised through a single vector. The goals of the project are multiple from finding novel attacks to determining the best course for correction while considering how potential findings fit into the legal framework. Spirals is leader of WP2 focused on low level attacks with one task in WP4 being dedicated to web vulnerabilities.

The ongoing PhD thesis of Nusrat Jahan Farin takes place in the context of this project. First results have been published in [11] and in [78, 90].

PTCC SWHSec

Participants: Thibaud Cartegnie, Pierre Laperdrix (*contact person*), Clémentine Maurice, Lionel Seinturier.

SWHSec is a 36-month project (2023–26) funded in the context of the CampusCyber. The objective of the SWHSec project is to assess and control the software vulnerabilities that can be maliciously introduced in large code bases. The project leverages the existing massive Software Heritage archive. The purpose is to enrich the archive with security-relevant information.

The ongoing PhD thesis of Thibaud Cartegnie takes place in the context of this project.

10.4 Inria initiatives

Inria Défi Federated Machine Learning over the Internet

Participants: Adrien Luxey-Bitri, Luis Lugo Martinez, Rémy Raes, Romain Rouvoy (*contact person*), Lionel Seinturier.

Federated Machine Learning over the Internet (Fed-Malin) is a 48-month Défi (2021–25) funded by Inria. The goal of the project is to push federated learning research and to address a number of challenges that arise when it is deployed over the Internet, including privacy & fairness, energy consumption, personalization, and location/time dependencies. 10 Inria project-teams participate to this Défi with the support of the Groupe La Poste.

The PhD thesis of Rémy Raes takes place in the context of this project. First results have been published in [18, 29, 67] and in [105].

The post-doc of Luis Lugo Martinez takes place in the context of this project in collaboration with the Magnet project-team.

Inria Défi Towards a More Frugal Cloud

Participants: Romain Rouvoy (*contact person*), Lionel Seinturier.

Towards a More Frugal Cloud is a 48-month (2021–25) Défi funded by Inria. The goal is to investigate new solutions for designing cloud-based digital services that can be more frugal in terms of energy consumption and that can reduce the environment impact of these environments. 5 Inria project-teams participate to this Défi along with the OVHcloud company.

First results have been published in [94, 98, 93, 96, 95, 33].

Inria Défi Reliable and productive code assistants based on large language models

Participants: Clément Quinton (*contact person*).

Reliable and productive code assistants based on large language models (LLM4Code) is a 48-month (2024–27) Défi funded by Inria. The goal is to leverage LLM capabilities to build code assistants that can enhance both reliability and productivity. 12 Inria project-teams participate to this Défi along with Software Heritage and the Sopra Steria company.

First results have been published in [24, 40, 50].

Inria Défi Pushing carbon-neutral services towards the edge

Participants: Mohamed Chakib Belgaid, Thomas Collignon, Sophie Cerf, Daniel Romero, Romain Rouvoy (*contact person*), Lionel Seinturier.

Pushing carbon-neutral services towards the edge (PULSE) is a 48-month (2021–25) Défi funded by Inria. The goal is to develop and promote best practices in geo-repaired hardware and software infrastructures for more environmentally friendly intensive computing. 6 Inria project-teams participate to this Défi along with the Qarnot Computing company. This Défi is led by Romain Rouvoy for Inria and Rémi Bouzel for Qarnot Computing.

The ongoing CIFRE PhD thesis of Thomas Collignon takes place in the context of this context. First results have been published in [15, 25, 30, 51] and in [88, 104, 84, 91].

10.5 Public policy support

Under the coordination of Juliette Sénéchal, we contributed to a public consultation on E-Privacy and GDPR for the Digital Omnibus launched by the European Commission. This contribution has been published on the web site on the EU Commission¹.

11 Dissemination

11.1 Promoting scientific activities

11.1.1 Scientific events: organisation

General chair, scientific chair

Simon Bliudze was the General Chair of the **20th International Federated Conference on Distributed Computing Techniques** (DisCoTec) that was held in Lille from 16 to 20 June 2025.

Member of the organizing committees

Rémy Raes: 9th GDR RSD / ASF Winter School on Distributed Systems & Networks.

Romain Rouvoy: 9th GDR RSD / ASF Winter School on Distributed Systems & Networks.

Sophie Cerf: 9th GDR RSD / ASF Winter School on Distributed Systems & Networks.

11.1.2 Scientific events: selection

Member of steering committees

Simon Bliudze: International Federated Conference on Distributed Computing Techniques (DisCoTec), IFIP WG6.1 International Conference on Coordination Models and Languages (Coordination)

Clémentine Maurice: USENIX WOOT Conference on Offensive Technologies, Microarchitecture Security Conference (uASC).

Chair of conference program committees

Clément Quinton: International Working Conference on Variability Modelling of Software-Intensive Systems (VaMoS).

Member of the conference program committees

Simon Bliudze: International Conference on Fundamentals of Software Engineering (FSEN), IEEE/ACM International Conference on Formal Methods in Software Engineering (FormaliSE)

Sophie Cerf: International Conference for High Performance Computing, Networking, Storage, and Analysis (SC) Reproducibility Initiative, International Symposium on Reliable Distributed Systems (SRDS)

Francescomaria Faticanti: Annual IEEE International Conference on Sensing, Communication, and Networking (SECON), International Workshop on Edge Network Softwarization (ENS).

Clémentine Maurice: USENIX Security.

Philippe Merle: International Conference on Adaptive and Self-Adaptive Systems and Applications (ADAPTIVE), International Conference on Cloud Computing, GRIDs, and Virtualization (CLOUD COMPUTING), International Conference on Cooperative Information Systems (CoopIS), International Conference on Service-Oriented Computing (ICSOC), International Conference on Web Services (ICWS), International Conference on Evolving Internet (INTERNET), International Conference on Advanced Service Computing (SERVICE COMPUTATION), International Conference on Enabling Technologies: Infrastructure for Collaborative Enterprises (WETICE), Workshop on Adaptable Cloud Architectures (WACA).

Clément Quinton: ACM International Systems and Software Product Line Conference (SPLC).

Romain Rouvoy: International Conference on Software Engineering (ICSE) - Industry challenge track, ACM Symposium on Applied Technology (SAC) DADS track, International Middleware Conference.

Lionel Seinturier: European Conference on Software Architecture (ECSA), International Conference on Software Architecture (ICSA) NIER Track, International Conference on Service Computing (ICSOC),

¹https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14855-Simplification-digital-package-and-omnibus/F33089165_en

IEEE International Conference on Web Services (ICWS), ACM Symposium on Applied Technology (SAC) SA-TTA track.

Reviewer

Sophie Cerf: IEEE International Conference on Distributed Computing Systems (ICDCS)

11.1.3 Journal

Member of the editorial boards

Laurence Duchien: special issues co-editor for Journal of Systems and Software (JSS).

Reviewer - reviewing activities

Simon Bliudze: Journal of Software and Systems Modeling (SoSyM), Science of Computer Programming (SCICO).

Francescomaria Faticanti: IEEE Transactions on Network and Service Management (TNSM), Computer Communications, Performance Evaluation.

Clément Quinton: Empirical Software Engineering (EMSE), Transactions on Software Engineering and Methodology (TOSEM), Journal of Systems and Software (JSS).

11.1.4 Invited talks

Sophie Cerf

- Invited talk at the Sufficiency seminar at the IRIT laboratory in Toulouse
- Invited talk at the LCIS laboratory Scientific Day in Valence

Clémentine Maurice

- Invited talk at the MIS laboratory in Amiens
- Invited lecture at the ARCHI spring school in Sète
- Keynote speaker at the C&ESAR conference in Rennes

11.1.5 Leadership within the scientific community

Simon Bliudze

- Co-head of the YODA (trustworthY and Optimal Dynamic Adaptation) working group of the GDR GPL
- Member of the Formal Methods Europe (FMEurope) **Book Review Committee** (the aim of the committee is to provide the formal methods community, and the scientific community in general, with high-quality reviews of books on topics of interest to the community)

Sophie Cerf

- Elected member of the "bureau" of the French chapter of the ACM Special Interest Group in Operating Systems (SIGOPS / ASF)

Laurence Duchien

- President of the scientific council of IRT SystemX

Clémentine Maurice

- Member of the "Software and source codes college" of the Committee for Open Science of the Higher Education Ministry

- Member of the SSLR ("Sécurité des systèmes, des logiciels et des réseaux") working group of the GDR SI

Romain Rouvoy

- Elected member of CoNRS section 6 (until August 2025)
- President of the French chapter of the ACM Special Interest Group in Operating Systems (SIGOPS / ASF)
- Elected member of the administrative council of Specif Campus
- Co-head of the "Logiciel Eco-Responsable" working group of the GDR GPL

Pierre Laperdrix

- Assistant director of the GDR Sécurité Informatique (since September 2024)

11.1.6 Scientific expertise

Pierre Bourhis

- Member of the jury of agrégation of informatique

Sophie Cerf

- Member of the recruitment committee for an associate professor position at CentraleSupélec Rennes

Laurence Duchien

- Member of the scientific advisory board of Labex CIMI-Toulouse
- Member of the scientific advisory board of IMT Atlantique

Clémentine Maurice

- Member of the recruitment committee for an associate professor position at University of Lille
- Member of the recruitment committee for an associate professor position at Sorbonne Université

Philippe Merle

- Member of the recruitment committee for Inria senior researcher positions (DR2)
- Member of the recruitment committee for Inria young researcher positions at Inria Centre at Université de Lorraine
- Member of the recruitment committee for an associate professor position at INSA Toulouse

Romain Rouvoy

- Member of the jury of agrégation of informatique

Lionel Seinturier

- President of the recruitment committee for a professor position at INSA Rennes
- President of the promotion committee for a professor position at University Sorbonne Paris Nord
- Vice-president of the recruitment committee for an associate professor position at University of Lille
- Member of the recruitment committee for an associate professor position at Telecom SudParis

11.1.7 Research administration

Simon Bliudze

- Elected member of the Centre Committee of the Centre Inria de l'Université de Lille
- Leader of the CRISAL laboratory Software Engineering (*Génie Logiciel*) thematic group (GT GL)
- Member of the Scientific Council of the CRISAL laboratory
- Member of the Gender Parity committee of the CRISAL laboratory
- Co-organiser of the joint Inria/CRISAL Mentoring programme

Pierre Bourhis

- Referent for Communication of the CRISAL laboratory
- Animator of the communication committee of the CRISAL laboratory
- Member of the Gender Parity committee of the CRISAL laboratory

Sophie Cerf

- Member of the Gender Parity committee of the CRISAL laboratory
- Mediation scientific co-referent for Inria Centre of the University of Lille

Laurence Duchien

- Dean of the Faculty of science and technology at the University of Lille

Maxime Huyghe

- Elected member of the Council of the doctoral school MADIS

Clémentine Maurice

- Co-animator of the transverse axis "Cybersecurity" of the CRISAL laboratory

Philippe Merle

- Elected member of the Inria evaluation committee (CE)
- Elected member of the Inria social administration committee (CSA)
- Member of the Inria national committee on "hygiène, de sécurité et des conditions de travail" (FS CSA)
- Member of the "Comité Local d'Hygiène, de Sécurité et de Conditions de Travail" (FSS) of the Inria Centre of University of Lille
- Member of the centre committee for the Inria Centre of University of Lille

Clément Quinton

- Elected member of the CRISAL laboratory council

Lionel Seinturier

- ICT Panel Scientific Counselor for the Research Evaluation Department of Hcéres
- Member of the Scientific council of the University of Lille

11.2 Teaching - Supervision - Juries - Educational and pedagogical outreach

11.2.1 Supervision

- HDR defended: Pierre Laperdrix, Untangling the Web Tracking Ecosystem to Design Effective Defenses, defended on 13 October 2025, University of Lille, [62].
- PhD defended: Alexandre Bonvoisin, Reconciling performance and efficient use of hardware resources: the case of configurable software services, defended on 5 December 2025, University of Lille, supervised by Clément Quinton & Romain Rouvoy, [59].
- PhD defended: Tristan Coignon, Empirical Evaluation of the Energy Impact of Large Language Models for Code Generation and Optimization, defended on 13 November 2025, University of Lille, supervised by Romain Rouvoy & Clément Quinton, [60].
- PhD defended: Antoine Geimer, Binary code analysis for microarchitectural security, defended on 2 December 2025, University of Rennes, supervised by Clémentine Maurice & Sandrine Blazy (Inria Epicure project-team).
- PhD defended: Maxime Huyghe, Automated Exploration of the Impact of Configuration Parameters on Browser Fingerprints, defended on 26 November 2025, University of Lille, supervised by Lionel Seinturier, Clément Quinton & Walter Rudametkin (Inria Diverse project-team), [61].
- PhD defended: Hugo Monfleur, Concern-oriented microservice architecture: language, library, toolkit, and evaluation, defended on 28 November 2025, University of Lille, supervised by Philippe Merle, [63].
- PhD defended: Yifan Wang, Towards Adaptive and Practical Automation in DBMS Administration, defended on 12 November 2025, University of Lille, supervised by Romain Rouvoy & Pierre Bourhis, [64].
- PhD defended: Jiali Xu, Characterisation of Anomalous Behaviour for Security in Deep-Edge Wireless Systems, defended on 3 December 2025, supervised by Romain Rouvoy & Valéria Loscri (Inria Fun project-team), [114].
- PhD in progress: Virginie Amand, Designing Sustainable Software Services with Large Language Models, since October 2024, University of Lille, supervised by Romain Rouvoy & Clément Quinton.
- PhD in progress: Elodie Bernard, Analyse fine du comportement d'applications Android et identification des acteurs impliqués, since October 2025, University of Lille, supervised by Pierre Laperdrix.
- PhD in progress: Sihem Bouenniche, Security Analysis of Current and Future Web Standards, since January 2024, University of Lille, supervised by Clémentine Maurice & Walter Rudametkin.
- PhD in progress: Thibaud Cartegnie, Analyse des dépendances dans les gestionnaires des paquets, since October 2025, University of Lille, supervised by Clémentine Maurice & Pierre Laperdrix.
- PhD in progress: Thomas Collignon, Control of high performance computing tasks emissions, since November 2023, University of Lille, supervised by Sophie Cerf & Lionel Seinturier.
- PhD in progress: Belkis Dejffal, Optimization of Databases in Cloud Environments in a Context of Green Computing, since December 2023, University of Lille, supervised by Romain Rouvoy & Pierre Bourhis.
- PhD in progress: Boubacar Diarra, Formal modeling and reliability of cloud network configurations, since January 2023, University of Lille, supervised by Philippe Merle.
- PhD in progress: Samuel Dubuisson, Impact minéral du système productif numérique, since October 2025, University of Lille, supervised by Clément Quinton & Adrien Luxey-Bitri.
- PhD in progress: Nusrat Jahan Farin, since November 2024, University of Lille, supervised by Clémentine Maurice.

- PhD in progress: Iliana Fayolle, Side channel vulnerabilities in web environments, since 1 October 2023, University of Lille, supervised by Clémentine Maurice.
- PhD in progress: Gaëlle Fret, Anatomie logicielle des smartphones, since October 2025, University of Lille, supervised by Romain Rouvoy & Adrien Luxey-Bitri.
- PhD in progress: Louay Khrouf, Optimisation de la consommation énergétique des logiciels par la transformation, since March 2025, University of Lille, supervised by Romain Rouvoy.
- PhD in progress: Jamile Lima Leite, Optimisation du scaling des fonctions 5G+/6G sur les infras edge à large échelle, since March 2025, University of Lille, supervised by Philippe Merle.
- PhD in progress: Clément Médart, Detection and materially assisted mitigation of temporal side channels attacks, since October 2025, University of Lille, supervised by Clémentine Maurice, Gilles Grimaud & Pierre Graux (CRISAL 2XS team).
- PhD in progress: Govin PK, Energy-Efficient Data Stream Processing, University of Rennes, supervised by Romain Rouvoy & Guillaume Pierre (Inria Magellan project-team).
- PhD in progress: Rémy Raes, Distributed machine learning in ubiquitous environments using location dependant models, since 1 March 2023, University of Lille, supervised by Romain Rouvoy & Adrien Luxey-Bitri.
- PhD in progress: Brell Sanwouo, Artificial Intelligence applied to Self-Adaptive Systems, since March 2024, University of Lille, supervised by Clément Quinton & Paul Temple (Inria Diverse project-team).
- PhD in progress: Jérémy Woirhaye, Towards intelligent slicing of microservice applications in the cloud, since October 2025, University of Lille, supervised by Romain Rouvoy & Thomas Ledoux (Inria Stack project-team).
- PhD in progress: Arléon Zemtsop, Reconfiguration dynamique, sûre et optimisée de systèmes cloud computing, since October 2025, University of Lille, supervised by Simon Bliudze & Clément Quinton.
- PhD in progress: Nada Zine, Développement de services logiciels durables basé sur des modèles de langage (LLM), since November 2024, University of Lille, supervised by Clément Quinton & Romain Rouvoy.

11.2.2 Juries

Simon Bliudze

- Giuseppe De Palma (U Bologna), reviewer

Laurence Duchien

- HDR Hélène Coulon (IMT Atlantique), reviewer

Clémentine Maurice

- HDR Daniele Antonioli (EURECOM), examiner
- Nicolas Bailluet (U Rennes), examiner

Philippe Merle

- Gabriel Darbord (U Lille), president

Clément Quinton

- Antoine Gratia (U Namur), reviewer

Lionel Seinturier

- HDR Steven Costiou (U Lille), president
- Antoine Omond (U Tromso), opponent
- Mazzen Ezzeddine (U Côte d'Azur), reviewer
- Karim Ghallab (Sorbonne U), reviewer

11.2.3 Educational and pedagogical outreach

Simon Bliudze is, in addition to his tenure Junior Researcher position at Inria, part-time Associate Professor at École Polytechnique, Palaiseau, France, in the Department of Computer Sciences (DIX).

- CSC_2F002_EP: Design and Analysis of Algorithms, 28h, Bachelor Program
- CSC_3X061_EP: Introduction to Computer Science, 40h, Ingénieur Polytechnicien Program

Francescomaria Faticanti, as part of his Starting Faculty position at Inria, teaches at University of Lille in the FST faculty.

- Advanced distributed systems, 24h, Level M2, Master of Computer Science
- Operating Systems Architecture, 18h, Level M1, Master of Computer Science

Laurence Duchien teaches at the Université de Lille in the FST faculty.

- Software engineering project, 64h, Level M2, Master MIAGE FI/FC/FA

Adrien Luxey-Bitri teaches at the Université de Lille in the FST faculty.

- To build a web server, 24h, Level L1, Licence of Computer Science
- Computer networks, 20h, Level L3, Licence of Computer Science
- Distributed systems, 48h, Level M1, Master of Computer Science
- Architecture of Operating Systems, 18h, Level M1, Master of Computer Science
- Advanced distributed systems, 24h, Level M2, Master of Computer Science
- Suivi de stages, projets et mémoires, 30h, Licence and Master of Computer Science
- Enjeux Environnementaux du Numérique, 16h, Level M2, Master of Computer Science

Philippe Merle teaches at the Université de Lille in the FST faculty.

- Software Configuration, 12h, Level M2, Master of Computer Science

Clément Quinton teaches at the Université de Lille in the FST faculty.

- Object-oriented programming, 36h, Level L2, Licence of Computer Science
- Software project, 24h, Level L2, Licence of Computer Science
- Object-oriented design, 45h, Level L3, Licence of Computer Science
- Distributed systems, 24h, Level M1, Master of Computer Science
- Software product lines, 24h, Level M2, Master of Computer Science
- Suivi de stages et de projets, 30h, Licence and Master of Computer Science

Romain Rouvoy teaches at the Université de Lille in the FST faculty.

- Design of distributed applications, 12h, Level M1, Master of Computer Science

- Object-oriented design, 4h, Level L3, Licence of Computer Science
- Suivi de projets, 20h, Level M2, Master of Computer Science

Lionel Seinturier teaches at the Université de Lille in the FST faculty.

- Conception d'applications réparties, 48h, Level M1, Master MIAGE
- Systèmes répartis avancés 1, 24h, Level M2, Master of Computer Science

11.3 Popularization

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

Adrien Luxey-Bitri wrote an article for The Conversation on the consequences of IT on the mining of minerals [77].

11.3.2 Participation in Live events

Clémentine Maurice

- Popularization talk at “Bar des Sciences” of the Faculty of science and technology of the Université de Lille
- Popularization talk at INSA Rennes for students from first to fifth year

Juliette Sénéchal

- Participation to the live event organized by DGCCRF on 28 November 2025 on The legal framework for commercial practices in light of the exploitation of consumers' cognitive biases².

11.3.3 Others science outreach relevant activities

Clémentine Maurice

- Co-organization of a visit to the CRIStAL laboratory and Inria for L3 and M1 students of ENS Rennes, over 3 days and 44 students
- Member of the organizing committee of the conference Pass The SALT, that gathers industry, academics, government speakers, approximately 100 participants

12 Scientific production

12.1 Major publications

- [1] Y. Al-Dhuraibi, F. Paraiso, N. Djarallah and P. Merle. ‘Elasticity in Cloud Computing: State of the Art and Research Challenges’. In: *IEEE Transactions on Services Computing (TSC)* 11.2 (Mar. 2018), pp. 430–447. DOI: [10.1109/TSC.2017.2711009](https://doi.org/10.1109/TSC.2017.2711009). URL: <https://hal.inria.fr/hal-01529654>.
- [2] S. Farhat, S. Bliudze, L. Duchien and O. Kouchnarenko. ‘Composing Run-Time Variability Models’. In: *Software Engineering and Formal Methods. SEFM 2024*. Vol. 15280. Lecture Notes in Computer Science. Aveiro, Portugal: Springer Nature Switzerland, 26th Nov. 2024, pp. 234–252. DOI: [10.1007/978-3-031-77382-2_14](https://doi.org/10.1007/978-3-031-77382-2_14). URL: <https://hal.science/hal-04855648>.

²<https://www.economie.gouv.fr/dgccrf/actualites-dgccrf/matinale-la-protection-des-consommateurs-face-aux-nouvelles-formes-dinfluence-commerciale>

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12.2 Publications of the year

International journals

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International peer-reviewed conferences

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- [55] J. Sénéchal. ‘A l’origine de l’ineffectivité des règles juridiques de protection de l’humain interagissant avec des dispositifs numériques : processus « post-moderne » de destruction créatrice ou naissance balbutiante d’un droit des risques systémiques « non-moderne » ?’ In: « *Vers un droit neuro-éthique ? – Towards a Neuro-ethical Law, Réflexion à partir des pratiques numériques d’influence et de manipulation des consommateurs* ». Bibliothèque de l’Institut de Recherche Juridique de la Sorbonne – André Tunc. 28th May 2025. URL: <https://hal.science/hal-05400314>.
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