2022
ACTIVITY REPORT

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

DOMAIN

Networks, Systems and Services, Distributed Computing

THEME

Distributed Systems and middleware

Inria

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Project-Team SPIRALS

Creation of the Project-Team: 2015 January 01

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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. In particular, we target the two key properties of *self-optimization* and *self-protection*, and we study some *foundational elements for self-adaptation*.

2.2 Scientific Foundations

Distributed software services and systems are central to many human activities, such as communication, commerce, education, defense, etc. Distributed software services consist of an ever growing number of devices, often highly heterogeneous, from cloud platforms, sensor networks, to application servers, desktop machines, and mobile devices, such as smartphones. The future of this huge number of interconnected software services has been called the Internet of Services, a vision *"where everything that is needed to use software applications is available as a service on the Internet, such as the software itself, the tools to develop the software, the platform servers, storage and communication to run the software."* [1] This pervasiveness continuously leads to new usages that in turn foster the emergence of novel requirements and concepts for new software services. Hence, it is necessary to establish new paradigms to design and execute software programs in these highly interconnected and heterogeneous environments, and it is necessary to ensure not only that these software systems can be adapted to new usages, new infrastructures, and new execution environments in the long term, but also that after the adaptation process the services still perform as expected.

This research project focuses on defining *self-adaptive* software services and middleware. From the perspective of the Internet of Services, this project fits in the vision sketched by e.g. the FP8 Expert Group Services in the Future Internet [77], the NESSI Research Priorities for the next Framework Programme for Research and Technological Development FP8 [82], the Roadmap for Advanced Cloud Technologies under H2020 [78], and research roadmaps, such as [60, 63, 76].

3 Research program

Our research program is organized around three axes: self-optimization, self-protection, and foundational elements for self-adaptation. These three axes are detailed below.

3.1 Self-optimization

This research axis aims to tackle the challenges we can observe with the growing adoption of software services in the wild.

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[1] Available from the CORDIS FP7 ICT SSAI web page version archived on 28/11/2015

Monitoring software in the wild.   Software systems are now widely distributed by design, being natively deployed in the very-large scale across several countries and continents. This infrastructure scale and geographical coverage call for the development of novel software monitoring techniques and algorithms that can follow *key performance indictors* (KPI) and report on critical situations where optimizations would be required. Given this context, collecting and processing such data flows to build a holistic view of the distributed system is a key challenge to deliver timely and targeted adaptations. Beyond the middleware challenge of distributed monitoring in the wild, we can also observe the rise of novel KPI aiming to balance performance and environmental metrics to better control the consumption of limited resources for the purpose of a given business. This evolution demonstrates that software developers and operators miss more global indicators of the impact of their software on their environment at large to take more optimal decisions.

Collaborative decision-making approaches.   To support the above decisions, we believe that very-large-scale distributed systems require to adopt decentralized and collaborative decision-making strategies to implement from local and quick reactions to more global and long-term planning. With this objective in mind, the combination of multiple decision-making techniques, such as control theory, reinforcement learning, constraint solvers, or rule-based approaches, will offer more flexibility to deal with domain-specific adaptations to be performed. Furthermore, our experience on *software product lines* (SPL) will also bring interesting venues to structure and control the control plane of such distributed systems, hence offering some layer of reflexivity for self-adaptive software systems.

3.2   Self-protection

In this axis, our research activities deal with security and privacy especially web privacy. Even if software is a major source of privacy and security threats, hardware and micro-architectural components can also raise some threats that have major consequences in distributed environments, as exemplified by the well-known Spectre and Meltdown vulnerabilities disclosed in 2018. We will then also work on research questions associated with hardware and micro-architectural components. More specifically, we will work at three levels: at the level of web applications, at the level of web browsers, and at the level of hardware and micro-architectural components.

Web and mobile applications.   We work on two topics: improving privacy on the web, and protecting users from software vulnerabilities. On the first topic on privacy, we will work on identifying harmful content related to privacy leakage, and on generating automatic shims to replace this harmful content with benign one. The ultimate goal is to have a browser, or an operating system, that does not send identifying information online, can decide which elements in a page are harmful to block, and can repair/augment webpages to assure their proper functioning. The second topic is on debloating which is related to the fact that modern web and mobile applications rely on an impressive list of dependent libraries. While using external libraries eases the development, this is known to be a major source of problems as a package can present a vulnerability or be downright malicious, affecting the integrity of the whole program. The goal here is to design methods and develop tools to have programs that can still benefit from the wealth of existing dependencies that exist in ecosystems, like NPM or Gradle, without the security problems that come with it.

Browsers and hardware.   We investigate hardware and software fingerprinting and their associated defenses. While so far we mostly look at fingerprinting the browser, it remains to be seen how much can be fingerprinted on both the software and hardware side. With the arrivals of new APIs like WebGPU, WebUSB or WebXR that rely much more on the hardware, there is a need to understand the privacy problems that can be caused by these APIs to protect users online. The goal is also to infer hardware characteristics through auxiliary time-related channels and micro-benchmarks instead of relying on attributes sent by the browser.

Hardware and micro-architectural components.   We work on analyzing attack surface and on improving the reproducibility of micro-architectural attacks. For that, given the lack of documentation of hard-

ware components by the manufacturers, we will work on the reverse-engineering of micro-architectural components. Recent work by Vila et al. [84] shows that it is possible to use automata learning and program synthesis techniques to reverse engineer cache replacement policies from measurements made with performance counters. This approach could be extended to model hardware prefetchers, and perhaps to refine the models proposed on branch prediction units. Concerning reproducibility, it is not uncommon for code that works on one machine to give other results on another machine – and identifying the root cause can be quite complex. We propose the use of the gem5 simulator to overcome some of these problems, and in particular improving visualization techniques, creating a reference benchmark of attacks available to the community, and study countermeasures.

3.3 Foundational elements for self-adaptation

In this axis, our research activities deal with the definition of 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. We will leverage formal methods, machine learning, database theory, and knowledge representation to consolidate the foundations of self-adaptation. Thus, we plan to work on developing and consolidating the formal foundations of self-adaptation in three complementary directions: structure, behaviour, and data. This will enable a holistic coverage of the different facets of self-adaptive software systems. Of course, these facets are not isolated from each other with connections having to be established among them. This axis is transversal and applies both to self-optimization and self-protection.

Structure. Software systems are commonly assembled from numerous components, each narrowly focused on its provided functionality. Among others, this allows structural variability—often offering a myriad of configuration options—which is crucial for these systems and must be handled from design-to run-time. Two fundamental aspects to be addressed here are the specification, analysis and implementation (1) of the interaction among the components and (2) of the *(re-)configuration* of component assemblies. W.r.t. configuration specifications, we particularly focus on approaches where these features are described in a so-called feature model [62]. We will continue exploring theoretical and implementation aspects of the underlying interaction and reconfiguration mechanisms to provide developers with appropriate modelling abstractions. Since it is not always possible to entirely explore the whole configuration space relating each configuration to the proper non-functional and functional requirements, we will apply machine learning techniques to predict the properties of configurations, identify influential options, ensure non-regression and select the "best" configuration. Furthermore, since the configuration space of the system is likely to evolve over time and due to external factors, the model will have to be learned again anyway to stay consistent with the system and its functional and performance properties. The learning process can therefore be considered itself as a configurable system, which can thus be fine-tuned with respect to what can be learned, how it can be learned and when it can be learned. We will thus investigate solutions for the self-adaptative learning of configuration spaces.

Behaviour. The ability to provide satisfaction guarantees of behavioural properties, such as deadlock-freedom, safety, some aspects of security and privacy, is rapidly becoming crucial for modern software systems due to increasing societal awareness, as attested by the growing use of formal methods by software giants such as Amazon [71] and Facebook [52] and to legislative evolution, e.g., GDPR. This requires precise and formal behavioural models allowing reasoning for proof and analysis of such properties. In particular, the Rigorous System Design (RSD) approach [80] strives for correctness by construction through enforcing multiple levels of separation of concerns. We plan to work on (1) transforming high-level models commonly defined by a "user", such as feature models mentioned above (in relation with the structural modelling) or requirements into (Java)BIP [46, 50] behavioural models, (2) learning behavioural models of existing software by static (source code) or dynamic (execution traces) analysis, (3) maintaining coherency between models and code in presence of evolutions and adaptations, and (4) formalisation of domain-specific knowledge to generate efficient distributed code while respecting the behavioural semantics of the system and taking into account its structural constraints.

Data. The self-adaptation mechanisms that are studied in the team are always triggered by data: either data gathered online in distributed systems, or data mined offline from repositories of metadata associated with software systems. In this context, being able to reason, query, and manage data and metadata associated with software systems is a central, yet complex and difficult task that raises many challenges. In relation with our expertise in database theory, we want to focus on two main challenges: (1) how data management and knowledge representation techniques can be used for improving the self-adaptation of software systems, and (2) how to take into account the data management concern along the development of self-adaptive software systems.

4 Application domains

4.1 Introduction

Although our research is general enough to be applied to many application domains, we currently focus on applications and distributed services for the retail industry and for the digital home. These two application domains are supported by a strong expertise in mobile computing and in cloud computing that are the two main target environments on which our research prototypes are built, for which we are recognized, and for which we have already established strong collaborations with the industrial ecosystem.

4.2 Distributed software services for the retail industry

This application domain is developed in relation with the PICOM (*Pôle de compétitivité Industries du Commerce*) cluster. We have established strong collaborations with local companies in the context of former funded projects, such as Cappucino and Macchiato, which focused on the development of a new generation of mobile computing platforms for e-commerce. We are also involved in the Datalyse and OCCIware funded projects that define cloud computing environments with applications for the retail industry. Finally, our activities in terms of crowd-sensing and data gathering on mobile devices with the APISENSE® platform share also applications for the retail industry.

4.3 Distributed software services for the digital home

We are developing new middleware solutions for the digital home, in particular through our long standing collaboration with Orange Labs. We are especially interested in developing energy management and saving solutions with the POWERAPI software library for distributed environments such the ones that equip digital homes. We are also working to bridge the gap between distributed services hosted on home gateways and distributed services hosted on the cloud to be able to smoothly transition between both environments. This work is especially conducted with the SALOON platform.

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 another line of research, the ongoing PhD thesis of Romain Fouquet contributes to limit what is currently running in a modern browser. By correctly identifying what is truly needed on a web page to guarantee its core functionality, it becomes possible to block unneeded scripts like superficial third-party

libraries, trackers or unwanted ads on the web. This leads to direct power savings as less data will be downloaded and less computing resources will be used to render a page.

6 Highlights of the year

One highlight of the year is our activity around the PowerAPI software library. PowerAPI is a middleware toolkit for building software-defined power meters and that Romain Rouvoy and others in the team are now developing for almost 10 years. The research activity around PowerAPI reached another level of increase in 2022: one ANR project (Distiller), two Inria Défi (one with Qarnot Computing, one with OVHcloud), and one industrial consortium started in 2022; two PhD theses (Chakib Belgaid [33] and Guillaume Fieni [36]) have been defended in 2022, and two new PhD theses begun (Alexandre Bonvoisin and Tristan Coignion); this activity is also supported by industrial collaborations with several companies such as Davidson Computing, Qarnot Computing, Orange, OVHcloud.

6.1 Awards

- Laurence Duchien and her co-authors won a 10-year most influential paper at the 17th Symposium on Software Engineering for Adaptive and Self-Managing Systems (SEAMS 2022) for her paper on a framework for evaluating quality-driven self-adaptive software systems [85]. SEAMS is the reference international research conference on self-adaptive software systems.

- Walter Rudametkin, now Professor at University Rennes 1, was awarded a 5-year IUF Junior position.

- Clémentine Maurice received the "Trophée de la femme cyber chercheuse" awarded by the CEFSYS (Cercle des femmes de la cybersécurité) that aims at animating the community of women working or wishing to contribute to the domain of cybersecurity.

- Naif Mehanna won the Best Paper award in the CSAW 2022 Applied Research Competition MENA region for his work on the impact of GPU in fingerprinting for device identification. The work has been initially published in the 29th Annual Network and Distributed System Security Symposium (NDSS 2022) [24].

7 New software and platforms

7.1 New software

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.

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/

Authors: Pierre Laperdrix, Antonin Durey, Walter Rudametkin Ivey

Contact: Benoit Baudry

Partners: INSA Rennes, Université de Lille

7.1.2   APISENSE

Keywords: Mobile sensing, Crowd-sensing, Mobile application, Crowd-sourcing, Android

Functional Description: APISENSE platform is a software solution to collect various contextual information from Android devices (client application) and automatically upload collected data to a server (deployed as a SaaS). APISENSE is based on a Cloud computing infrastructure to facilitate datasets collection from significant populations of mobile users for research purposes.

URL: https://github.com/APISENSE

Authors: Antoine Veuiller, Christophe Ribeiro, Julien Duribreux, Romain Rouvoy, Nicolas Haderer, Romain Sommerard, Lakhdar Meftah

Contact: Romain Rouvoy

Partner: Université de Lille

7.1.3   cloudnet

Name: Cloudnet

Keywords: Cloud configuration, Tosca, Docker Compose, Heat Orchestration Template, Alloy

Scientific Description: The multiplication of models, languages, APIs and tools for cloud and network configuration management raises heterogeneity issues that can be tackled by introducing a reference model. A reference model provides a common basis for interpretation for various models and languages, and for bridging different APIs and tools. The Cloudnet Computational Model formally specifies, in the Alloy specification language, a reference model for cloud configuration management. The Cloudnet software formally interprets several configuration languages in it, including the TOSCA configuration language, the OpenStack Heat Orchestration Template and the Docker Compose configuration language.

The use of the software shoes, for examples, how the Alloy formalization allowed us to discover several classes of errors in the OpenStack HOT specification.

Functional Description: Application of the Cloudnet model developed by Inria to software network deployment and reconfiguration description languages.

The Cloudnet model allows syntax and type checking for cloud configuration templates as well as their visualization (network diagram, UML deployment diagram). Three languages are addressed for the moment with the modules:

* Cloudnet TOSCA toolbox for TOSCA inncluding NFV description * cloudnet-hot for HOT (Heat Orchestration Template) from OpenStack * cloudnet-compose for Docker Compose

We can use directly the software from an Orange web portal: https://toscatoolbox.orange.com

URL: https://github.com/Orange-OpenSource/Cloudnet-TOSCA-toolbox

Publication: hal-02940938v1

Contact: Philippe Merle

Participants: Philippe Merle, Jean-Bernard Stefani, Roger Pissard-Gibollet, Souha Ben Rayana, Karine Guillouard, Meryem Ouzzif, Frédéric Klamm, Jean-Luc Coulin

Partner: Orange Labs

7.1.4 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: http://powerapi.org

Contact: Romain Rouvoy

Participants: Adel Noureddine, Loïc Huertas, Maxime Colmant, Romain Rouvoy, Mohammed Chakib Belgaid, Arthur D'azemar

8 New results

We highlight below five new major results that we obtained in 2022 in the domains of software engineering, energy management for software systems, and security.

8.1 Leveraging Browser Fingerprinting to Strengthen Web Authentication

In the context of his PhD defended in January, Antonin Durey obtained new result in the domain of browser fingerprinting to strengthen web authentication [35]. Browser fingerprinting is a stateless and permission-less technique that collects information about the user's device, OS, browser and configuration to form an identifier. While it has mainly been studied from a tracking perspective, its properties make it interesting for security, and more specifically, for Web authentication. Antonin obtained three main contributions. He evaluates the resilience of websites against two types of attack, stolen credentials and cookie hijacking, and shows that fingerprinting, despite its potential, is barely used to protect against these attacks. He designs and implements a fingerprints linking algorithm for Web authentication and evaluates it on a dataset of 952,828 fingerprints collected from 64,235 browser instances, and show the

algorithm is reliable and relevant to link fingerprints. He designs and implements an authentication scheme that strengthens web authentication by using browser fingerprinting. This work led to the following publications: [24, 25] [54].

8.2   Side Channels in Web Browsers

In the context of his PhD defended in November, Thomas Rokicki obtained new results in the domain of side channels in Web browsers. Thomas' first research direction was to redefine the scope of timing attacks in JavaScript. In particular, he studied the impact of widespread countermeasures to timing attacks: suppressing access to high-resolution timers. The second category of contributions concerns a specific type of side channel: CPU port contention. In a first contribution, he showed, for the first time, the implementation of port contention in the browser sandbox. In a second contribution, he extends the scope of port contention to completely change its threat model, i.e., a threat model that does not require simultaneous multi-threading. He also showed how this new side channel can be used for browser fingerprinting purposes. This work led to the following publications: [26, 27, 75].

8.3   Towards Understanding Web Applications: Automated Abstraction Inference and its Applications

In the context of his PhD defended in December, Sacha Brisset obtained new results in the domain of the automatic repair of web applications [34]. Sacha work explores web application structure through a variety of lenses: web testing, data extraction and web analytics. The study shows that many web related research, regardless of the domain, suffer greatly from the lack of a generic fully unsupervised web application abstraction inference solution. He develops such a solution iteratively with three main contributions: SFTM, a new algorithm allowing to match two web pages with computation times several orders of magnitude smaller than the existing algorithms in the state-of-the-art; ERRATUM an approach allowing to repair locators on web applications; and APPSTRACT an approach to automatically generate an abstraction of a web application. This work led to the following publications: [12, 13].

8.4   Green Coding: an Empirical Approach to Harness the Energy Consumption of Software Services

In the context of his PhD defended in December, Chakib Belgaid obtained new results in the domain of the eco-design of software systems [33]. Chakib conducted a large empirical study to measure and estimate the energy consumption of software systems. This study led to the contribution of several toolsets that can serve to reproduce the measures he did, and to extent these measures to other programming contexts. In the detail, he started by contributing a benchmarking protocol. He then studied the energy efficiency of three of the most currently popular programming ecosystems: the Python programming language, the Java programming language, and microservice-based web applications. This work led to the following publications: [72, 73].

8.5   Towards Modeling the Power Usage Efficiency of Software-Defined Computing Infrastructures

In the context of his PhD defended in December, Guillaume Fieni obtained new results in the domain of the evaluation and estimation of the energy consumption of software infrastructures [36]. His three contributions follow. He first proposes SmartWatts, a software power meter to estimate the energy consumption of software containers such as Docker. In a second part, he proposes SelfWatts, a controller to automate the configuration of software power meters to facilitate their deployment in heterogeneous infrastructures. And finally, he proposes xPUE, a new metric to calculate the energy efficiency of software and hardware in real time at different levels of an infrastructure. This work led to the following publications: [56, 57, 55, 58].

9 Bilateral contracts and grants with industry

ip-label

> **Participants:** Romain Rouvoy *(contact person)*.

A software exploitation license (2014–ongoing) of the APISENSE® crowd-sensing platform has been sold to the ip-label company. They use this platform as a solution to monitor the quality of the GSM signal in the wild. The objective is to provide developers and stakeholders with a feedback on the quality of experience of GSM connection depending on their location.

Davidson Consulting

> **Participants:** Mohammed Chakib Belgaid, Romain Rouvoy *(contact person)*, Lionel Seinturier.

This collaboration (2017–22) aims at proposing new solutions for optimizing the energy footprint of ICT software infrastructures. We want to be able to measure and assess the energy footprint of ICT systems while preserving various quality of service parameters, such as performance and security. We aim at proposing a testbed for assessing the energy footprint of various programming languages. This testbed will also incorporate frameworks for web and mobile programming. Finally, we want to be able to issue recommendations to developers in order to assist them in improving the energy footprint of their programs. This collaboration will take advantage of the POWERAPI software library.

The defended PhD of Mohammed Chakib Belgaid [33] takes place in the context of this collaboration.

Orange # 1

> **Participants:** Philippe Merle *(contact person)*, Lionel Seinturier.

This collaboration (2017–22) aims at defining a computational model for software infrastructures layered on top of virtualized and interconnected cloud resources. This computational model provides application programming and management facilities to distributed applications and services [66, 81] and defines a pivot model that enables the interoperability of various existing and future standards for cloud systems such as OCCI and TOSCA. This pivot model is defined with the Alloy specification language [61]. This collaboration takes advantage of the expertise that we are developing since several years on reconfigurable component-based software systems [79], on cloud systems [74], and on the Alloy specification language [67].

This collaboration with Orange Labs is a joint project with Jean-Bernard Stefani from the Spades Inria project-team.

Orange # 2

> **Participants:** Thibault Simon, Romain Rouvoy *(contact person)*.

This collaboration (2021–24) aims at working on the sustainable design of software systems. The purpose is especially to characterize the quality of software components from an environmental point of view to go towards the production of low environment footprint software systems.

The CIFRE PhD thesis of Thibault Simon takes place in the context of this collaboration.

Amaris (now Mantu)

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

This collaboration (2018–22) aims at proposing new solutions for automatically spotting and fixing recurrent user experience issues in web applications. We are interested in developing an autonomic framework that learns and classifies the behaviors and figures out causality links between data such as web GUI events, support tickets and user feedback, source version management events (e.g. recent commits). The ultimate objective is to implement an AI-powered recommendation system to guide the maintenance and even to automatically predict and solve user issues.

The defended CIFRE PhD thesis of Sacha Brisset [34] took place in the context of this collaboration.

Berger-Levrault

> **Participants:**   Tetouhe Kilimou, Philippe Merle *(contact person)*.

This collaboration (2020–22) aims at proposing new solutions for steering, orchestrating, and maintaining the software development activities in the stages related to packaging, delivering, and deploying. The objective is to better control these stages and to make them more reliable. Based on several identified use cases, the envisioned solutions take advantage of our expertise and our recent advances in software metamodeling, smart monitoring, and knowledge based building.

10   Partnerships and cooperations

10.1   International initiatives

10.1.1   Associate Teams in the framework of an Inria International Lab or in the framework of an Inria International Program

SusAIn

Title: Towards a Sustainable Artificial Intelligence

Duration: 2021 -> 2023

Coordinator: Romain Rouvoy & Felipe Tobar

Partners:

- Inria Spirals
- Inria Chile
- Univ. Chile
- LNCC Brazil

Inria contact: Romain Rouvoy

Summary: The SusAIn associate-team is composed of a plurisciplinary group of researchers across France, Chile and Brazil to address the challenge of reducing the power consumption of artificial intelligence algorithms deployed in the context of high performance computing. By combining the unique scientifique expertise on this critical topic for the environment, we intend to leverage the existing hardware and software infrastructures to deliver new tools and recommendations for the scientific community on the appropriate design and deployment of sustainable AI algorithms.

10.1.2   Participation in other International Programs

Partnership for joint Curriculum Development and Research in Energy Informatics (PACE)

Participants:	Mohammed Chakib Belgaid, Guillaume Fieni, Clément Quinton, Romain Rouvoy *(contact person)*, Lionel Seinturier.

PACE is a 4-year (2019–22) project funded by the Research Council of Norway. The goal of the project is to establish a sustained education and research-oriented collaboration between four partner universities in energy informatics and green computing that will strengthen quality academic relations and mutually improve each other's quality of research and researcher training both at PhD and master level. Partner universities are: University of Oslo (Norway), University of Stavanger (Norway), TU Munich (Germany), Université de Lille.

10.1.3   Visits of international scientists

Amir Taherkordi associate professor at the University of Oslo visited the team for 3 weeks in July. He works with Romain Rouvoy and others in the team on green computing, especially in the context of the PACE partnership mentioned previously.

10.1.4   Visits to international teams

Maryam Rahmani spent 1 month in November at the University of Oslo in the context of the PACE partnership.

Jiali Xu spent 1 month in December at the University of Stavanger, Norway, in the context of the PACE partnership.

10.2   European initiatives

10.2.1   Other european programs/initiatives

DG ECHO AIDERS

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

AIDERS is an European project (2020–22) funded by the directorate general for European Civil Protection and Humanitarian Aid Operations of the EU. The partners are the University of Cyprus, the Cyprus Civil Defense, the Entente pour la Forêt Méditerranéenne french public organisation, the Corpo nazionale vigili del fuoco italian state organisation, the Center for Security Studies greek think thank, and the Spirals project-team. The AIDERS project aims at developing application-specific algorithms and novel mapping platform that will harness the large volume of data that first responders are now able to collect through heterogeneous sensors (including visual, thermal and multispectral cameras, LIDAR, CBRN sensors, etc.) on-board RPAS units, and converting that data into actionable decisions for improved emergency response.

DG ECHO ARTION

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

ARTION is a 18-month project (2021—22) that envisions to become a world-class network for knowledge sharing in the area of artificial intelligence for disaster management that will guide the development and use of AI tools by first responders across Europe. By achieving its strategic objectives ARTION aims to bridge the gap between AI scientists and disaster management experts, build capacity and competency of first responders in the use of AI technology, share knowledge and data, and stimulate further AI research towards application-specific challenges faced throughout the disaster management cycle.

FACADES

Participants:	Pierre Laperdrix *(contact person)*, Clémentine Maurice, Romain Rouvoy, Walter Rudametkin.

FACADES is a 42 month international project (2022–26) with CISPA and Saarland University funded in the context of the German-French ANR joint call. The projet 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.

10.3   National initiatives

10.3.1   ANR
ANR ARCHI-SEC

Participants:	Pierre Ayoub, Walid Ghandour, Clémentine Maurice *(contact person)*.

ANR ARCHI-SEC is a 42-month project (2019–23) funded by ANR. Attacks exploiting micro-architectural vulnerabilities, such as Meltdown, Spectre, Rowhammer,etc., are on the rise. Modern day SoCs "System-on a Chips" embed increasingly complex design features, such as branchprediction, Out-of-Order execution, cache coherency protocols, integrated GPUs/ FPGAs, new nonvolatile memories. The security aspect of these new architectures and technologies remains under-studied. The project aims at modeling the architectural problems with a virtual platform based on gem5. It will be used for penetration testing, evaluate the performance cost of countermeasures, anticipate new attacks and propose protections. These latter are validated on platforms based on ARM and RISC-V processors. The major impact of this project will be through the creation of a community around the virtual platform. Other partners include LTCI, LIRMM, LabHC, Secure-IC. The ongoing PhD thesis of Pierre Ayoub contributes to this project. Our first results in the context of this project have been published in [45].

ANR CQFD

Participants:	Pierre Bourhis *(contact person)*.

CQFD is a 48-month project (2018–22) funded by ANR. The project focuses on the complex ontological queries over federated heterogeneous data. The project targets to set the foundations, to provide efficient algorithms, and to provide query rewriting oriented evaluation mechanisms, for ontology-mediated query answering over heterogeneous data models. This project is coordinated by Federico Ulliana from Inria Sophia Antipolis. Other partners include LaBRI, Inria Saclay, IRISA, LTCI, and LIG. Our first results in the context of this project have been published in [49, 51].

ANR Delta

Participants:	Pierre Bourhis *(contact person)*.

Delta is a 54-month project (2016–22) funded by ANR. The project focuses on the study of logic, transducers and automata. In particular, it aims at extending classical framework to handle input/output, quantities and data. This project is coordinated by M. Zeitoun from LaBRI. Other partners include LIF (Marseille), IRIF (Paris-Diderot), and D. Gallois from the Inria Lille Links team. Several results and publications have been obtained in the context of this project [47, 42, 43, 44].

ANR FP-Locker

> **Participants:**   Naif Mehanna, Vikas Mishra, Walter Rudametkin *(contact person)*.

FP-Locker is a 42-month project (2019–23) funded by ANR in the context of the JCJC program. This project proposes to investigate advanced browser fingerprinting as a configurable authentication mechanism. We argue that it has the potential to be the only authentication mechanism when used in very low-security, public websites; it can be used to block bots and other fraudulent users from otherwise open websites. It also has the potential to be used as a second factor authentication mechanism, or as an additional factor in Multi-Factor Authentication (MFA) schemes. Besides strengthening a session's initial authentication, it can also be used for continuous session authentication to protect against session hijacking. In many contexts, fingerprinting is fully transparent to users, meaning that contrary to authentication processes that rely on external verification cards, code generating keys, special apps, SMS verification codes, users do not have to do anything to improve their security. In more restricted contexts, administrators can enforce different policies, for example, enrolling fingerprints from devices that connect from trusted IP addresses (e.g., an internal network), and then verifying these fingerprints when the same users connect from untrusted IP addresses. Consequently, we plan to design an architecture and implement it to be able to plug the browser fingerprinting authentication process to an existing authentication system. Our first results in the context of this project have been published in [69, 83, 70].

ANR GreenAct

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

GreenAct is a 18-month project (2021–22) funded by ANR and Région Hauts-de-France in the context of the Résilience Hauts-de-France program. The project addresses the issues of the resilience of cloud infrastructures and of the the energy consumption generated by digital usages. The partner of the project is the OVHcloud cloud provider.

ANR Headwork

> **Participants:**   Pierre Bourhis *(contact person)*.

Headwork is a 62-month project (2016–22) funded by ANR. The main objective of Headwork is to develop data-centric workflows for programming crowd sourcing systems in a flexible declarative manner. The problem of crowd sourcing systems is to fill a database with knowledge gathered by thousands or more human participants. A particular focus is to be put on the aspects of data uncertainty and for the representation of user expertise. This project is coordinated by D. Gross-Amblard from the Druid Team (Rennes 1). Other partners include the Dahu team (Inria Saclay), Sumo (Inria Bretagne), and Links (Inria Lille) with J. Nierhen and M. Sakho. Our results from this project have been published in the following paper [41].

ANR Koala

> **Participants:**   Pierre Bourhis, Edouard Guegain, Clément Quinton *(contact person)*.

Koala is a 42-month project (2019–23) funded by ANR in the context of the JCJC program. The project aims to deliver a series of innovative tools, methods and software to deal with the complexity of fog computing environments configurations and adaptations. In particular, we take a step back on

the current limitations of existing approaches (e.g., lack of expressiveness and scalability) and address them placing knowledge as a first-class citizen. We plan to tackle configuration issues from a novel perspective in the field of variability management, using recent techniques from the area of knowledge compilation. Specifically, we will investigate the best-suited d-DNNF representation for each reasoning operation, and we plan to provide new variability modeling mechanisms (e.g., dimensions, priorities and scopes) required in a fog context. Regarding adaptation concerns, we want to leverage machine learning techniques to improve adaptation management and evolution under uncertainty, relying on a continuously enriched and reusable knowledge base. In particular, we plan to propose an approach for suggesting evolution scenarios in a predictive manner, relying on an evolution-aware knowledge base acquired at run-time through machine learning feedback. Our first results in the context of this project have been published in [59, 68].

ANR MIAOUS

> **Participants:**   Thomas Rokicki, Clémentine Maurice *(contact person)*.

ANR MIAOUS is a 42-month project (2019–23) funded by ANR in the context of the JCJC program. The project aims to propose a generic framework to provide a better understanding of the attack surface for microarchitectural attacks, both on the hardware and on the software side, and the tools to close the attack surface. Hardware is often considered as an abstract layer that behaves correctly, executing instructions and giving an output. However, side effects due to software implementation and its execution on actual hardware can cause information leakage from side channels, resulting in critical vulnerabilities impacting both the security and privacy of these systems. The project targets in particular information leakage that does not require any physical proximity to devices and that is due to processor microarchitecture, as well as the constructions of novel countermeasures. The ongoing PhD thesis of Guillaume Didier and the defended PhD thesis of Thomas Rokicki contribute to this project. Several results and publications have been obtained in the context of this project [26, 27, 75, 31, 53, 48, 64, 24, 65].

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 ongoing PhD thesis of Hugo Monfleur contributes to this project.

PEPR Cybersecurity IPoP

> **Participants:**   Pierre Bourhis, Imane Fouad, Clémentine Maurice, Pierre Laper-
> drix *(contact person)*, Romain Rouvoy, Walter Rudametkin.

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.

10.4 Regional initiatives

ASCOT

Participants: Imane Fouad, Pierre Laperdrix *(contact person)*.

ASCOT is a 36-month (2020–23) project funded in the context of the STaRS program of Hauts-de-France region. The goal of the project is to improve web security and privacy and put back control into users hands by blocking unwanted trackers. The project will combine information flow analysis, machine learning and deobfuscation to detect a wide range of trackers. The project will also identify page breakage when blocking online trackers. All in all, this project aims to advance the actual techniques that protect users online while maintaining a high level of usability that is key to offer a comfortable browsing experience. First results have been published in [75].

BRiCoS

Participants: Simon Bliudze *(contact person)*, Larisa Safina.

BRiCoS is 24-month (2021–22) project funded by the I-Site ULNE Foundation in the framework of its "Support for young researchers 2020" programme. The project addresses two fundamental challenges for the implementation of the Rigorous System Design approach to general-purpose software: 1) obtaining behavioural models of the coordinated software entities and 2) detecting the deviations between these models and the corresponding executable code in the face of software evolution.

10.5 Inria initiatives

Inria Défi Federated Machine Learning over the Internet

Participants: Adrien Luxey, 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.

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 participe to this Défi along with the OVHcloud company.

Inria Défi Pushing carbon-neutral services towards the edge

Participants: Sophie Cerf, 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 participe to this Défi along with the Qarnot Computing company. This Défi is led by Romain Rouvoy for Inria and Rémi Bouzel for Qarnot Computing.

11   Dissemination

11.1   Promoting scientific activities

11.1.1   Scientific events: organisation

Laurence Duchien: co-organiser of the "Journées Sciences du Logiciel : de l'idée au binaire", CNRS INS2I, 19-20 September.

General chair, scientific chair
Sophie Cerf: Chair of the Control for Computing invited session at the 2022 IEEE Conference on Control Technology and Applications (CCTA).
Clément Quinton: Workshop co-chair of the 26th ACM International Systems and Software Product Line Conference (SPLC).
Pierre Laperdrix: Vice-president of the CNIL-Inria Privacy Award 2022.

Member of the organizing committees
Romain Rouvoy: 6ème école d'hiver du GDR RSD & de l'ASF (chapitre français de l'ACM SIGOPS) sur les systèmes distribués et les réseaux.

11.1.2   Scientific events: selection

Chair of conference program committees
Clémentine Maurice: USENIX Security Symposium Artifact Evaluation co-chair.

Member of the conference program committees
Simon Bliudze: 24th International Conference on Coordination Models and Languages (COORDI-NATION; PC and Steering Committee), 27th International Conference on Formal Methods for Industrial Critical Systems (FMICS), International Conference on Formal Methods in Software Engineering (FormaliSE; PC and Steering Committee), 9th International Conference on Algebraic Informatics (CAI), 10th International Conference on Fundamentals of Software Engineering (FSEN).
Pierre Bourhis: 19th International Conference on Knowledge Representation and Reasoning (KR).
Sophie Cerf: 30th Mediterranean Conference on Control & Automation (MED).
Laurence Duchien: 26th ACM International Systems and Software Product Line Conference (SPLC) Journal first track, 9th IEEE International Conference on Software Architecture (ICSA) New and emerging ideas track & Poster & Technical tracks, 20th International Conference on Software and Systems Reus (ICSR), 16th International Working Conference on Variability Modelling of Software-Intensive Systems (VaMoS), Steering Committee of the European Conference on Software Architecture (ECSA), Steering Committee of the ACM International Systems and Software Product Line Conference (SPLC).
Pierre Laperdrix: Workshop on Measurements, Attacks, and Defenses for the Web (MADWeb'22), 29th ACM Conference on Computer and Communications Security (CCS'22) "Web Security" track, 15th European Workshop on Systems Security (EuroSec'22), SecWeb Workshop (SecWeb'22), 19th Conference on Detection of Intrusions and Malware & Vulnerability Assessment (DIMVA'22), 32nd USENIX Security Symposium (USENIX Security'23), 2023 ACM Web Conference (WWW'23) "Security, Privacy, and Trust" track.
Clémentine Maurice: 29th ACM Conference on Computer and Communications Security (CCS'22), 43rd IEEE Symposium on Security and Privacy (S&P 2022), Symposium sur la sécurité des technologies de l'information et des communications (SSTIC 2022). Steering committee of IEEE Workshop on Offensive

Technologies (WOOT, co-located with S&P), and Conference on Detection of Intrusions and Malware & Vulnerability Assessment (DIMVA).

Philippe Merle: 14th International Conference on Adaptive and Self-Adaptive Systems and Applications (ADAPTIVE), 13th International Conference on Cloud Computing, GRIDs, and Virtualization (CLOUD COMPUTING), 28th International Conference on Cooperative Information Systems (CoopIS), 14th International Conference on Evolving Internet (INTERNET), 14th International Conference on Advanced Service Computing (SERVICE COMPUTATION), 16th International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies (UBICOMM).

Clément Quinton: 26th ACM International Systems and Software Product Line Conference (SPLC), ACM Symposium on Applied Technology (SAC) SA-TTA track, 16th International Working Conference on Variability Modelling of Software-Intensive Systems (VaMoS).

Lionel Seinturier: European Conference on Software Architecture (ECSA), ACM Symposium on Applied Technology (SAC) SA-TTA & OS tracks, International Conference on Service Computing (ICSOC), ACM International Conference on Management of Emergent Digital Ecosystems (MEDES).

11.1.3 Journal

Member of the editorial boards
    Laurence Duchien: Special Issue co-editor for Journal of System and Software (JSS).
    Philippe Merle: Member of the editorial board of MDPI IoT.

Reviewer - reviewing activities
    Simon Bliudze: Science of Computer Programming, International Journal of Foundations of Computer Science.
    Pierre Bourhis: IEEE Transaction of Parallel and Distributed Systems.
    Clémentine Maurice: IEEE Transactions on Information Forensics & Security.
    Philippe Merle: Elsevier Future Generation of Computer Systems (FGCS).
    Clément Quinton: Journal of Systems and Software.
    Lionel Seinturier: Springer Computing Journal.

11.1.4 Invited talks

Clémentine Maurice: Invited keynote at EuroSec 2022 "Reproductible Research: from Paper to Artifact Evaluation", Invited keynote at the 25th International Symposium on Research in Attacks, Intrusions and Defenses (RAID 2022) "Micro-architectural attacks: from CPU to browser", Invited lecture at the Cyber in Nancy Summer School, Invited lecture at the Summer School on real-world crypto and privacy, Šibenik, Croatia.

Pierre Laperdrix: Invited talk at FIC 2022 "Traçage par empreintes de navigateur : passé, présent et évolutions", Invited talk at Journées nationales du GDR Sécurité Informatique 2022 "Browser fingerprinting: current research and the years ahead".

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)

Laurence Duchien

- President of the scientific council of IRT SystemX

- Scientific advisor at INS2I (until June)

Romain Rouvoy

- Elected member of CoNRS section 6 (since September)

- Elected member of the "bureau" 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 "Génie Logiciel pour les Systèmes Cyberphysiques" working group of the GDR GPL

11.1.6 Scientific expertise

Laurence Duchien

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

- Member of the scientific advisory board of IMT Atlantique

- Member of the recruitment committee for a professor position, INP Bordeaux

- Member of the recruitment committee for a "Chargé de recherche" position, Inria Lyon

- Member of the recruitment committee for a "Chargé de recherche (concours Handicap)" position, Inria

Pierre Laperdrix

- Member of the recruitment committee for a "Maître de conférences" position, Université de Rennes

Clémentine Maurice

- Member of the recruitment committee for a "Maître de conférences" position, Université de Rennes

- Reviewer of a research proposal for the Israel Science Foundation (ISF)

Philippe Merle

- Member of the recruitment committee for two "Maître de conférences" positions, Université de Rennes I

Lionel Seinturier

- Member of the jury for senior chairs at Institut Universitaire de France (IUF)

- President of the recruitment committee for a professor position, Université de Grenoble-Alpes

- President of the recruitment committee for two R&D engineer positions at Inria Lille

11.1.7 Research administration

Simon Bliudze

- Elected member of the Centre Committee of the Inria Lille – Nord Europe research center

- Member of the Gender Parity committee of the CRIStAL laboratory

Laurence Duchien

- In charge of the Career development & Intersectoral secondments in the PEARL Project ("Programme for EArly-stage Researchers in Lille") at I-SIte Université Lille Nord Europe

- Elected member of the council of the Faculty of science and technology of the University of Lille (until June)

- Dean of the Faculty of science and technology at the University of Lille (since July)

Antonin Durey

- Elected member of the CRIStAL laboratory council

Clémentine Maurice

- Member of the Gender Parity committee of the CRIStAL laboratory

Philippe Merle

- Elected member of the Inria scientific board (CS)

- Elected member of the Inria technical committee (CTI)

- Deputy secretary of the Inria national committee on "hygiène, de sécurité et des conditions de travail" (CNHSCT)

- Permanent secretary of the "Comité Local d'Hygiène, de Sécurité et de Conditions de Travail" (CLHSCT)

- Elected member of the centre committee for the Inria Center of University of Lille

Lionel Seinturier

- President of section 27 (Informatique) of Conseil national des universités (CNU)

- Member of the scientific council of University of Lille

Walter Rudametkin

- Member of the CDT (Comité de Développement Technologique) of the Inria Lille - Nord Europe research center

- Elected member of the CRIStAL laboratory council

11.2   Teaching - Supervision - Juries

11.2.1   Teaching

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

- CSE 202: Design and Analysis of Algorithms, 28h, 2nd year of the Bachelor cycle

Pierre Bourhis is, in addition to his tenure Junior Researcher position at CNRS, part-time Associate Professor of Data Science at École Polytechnique, Palaiseau, France, in the Department of Computer Sciences (DIX).

- Info553: Bases de données, 18h, Cycle Polytechnique

- Modal Graphe Géant, 36h

- INF517: Projet de Recherche Data Science, 20h

- INF583: System for Big Data, 20h

Sophie Cerf teaches at Centrale Lille Institute.

- Système de Transport Autonome, 12h, 2nd year of the Engineering cycle, École Centrale Lille

- Commande des Systèmes, 24h, Level L2, ITEEM

- Projet d'intégration en Robotique, 10h, Level M1, ITEEM

Laurence Duchien teaches at the Université de Lille in the FST faculty. She is project leader for doctoral studies at Université de Lille.

- Software engineering project, 60h, Level M2, Master MIAGE FI

- Software engineering project, 50h, Level M2, Master MIAGE FC/FA

- Research initiation, 20h, Level M2, Master of Computer Science

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

- Informatics, 36h, Level L3, Licence of Computer Science

- Computer networks, 20h, Level L3, Licence of Computer Science

- Software Engineering, 18h, Level L3, Licence of Computer Science

- Distributed systems, 48h, 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

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, 36h, Level L2, Licence of Computer Science

- Javascript, 18h, Level L2, Licence of Computer Science

- Object-oriented design, 31h, 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

Walter Rudametkin teaches at the Polytech Lille engineering school.

- GIS4 Programmation par Objets, 32h

- GIS4 Architectures Logicielles, 26h

- GIS2A3 (apprentissage) Projet programmation par Objet, 24h

- IMA2A4 (apprentissage) Conception Modélisation Objet, 24h

- IMA3 Programmation Avancée, 62h

- GBIAAL4 Bases de données, 22h

- GIS5 Suivi de projets, 42h

- GIS2A (apprentissage) Suivi d'apprentis, 28h

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, 52h, Level M2, Master of Computer Science

11.2.2   Supervision

- PhD defended: Antonin Durey, Leveraging Browser Fingerprinting to Strengthen Web Authentication, defended on 14 January 2022, supervised by Romain Rouvoy & Walter Rudametkin, [35].

- PhD defended: Thomas Rokicki, Detection and exploitation of side-channel vulnerabilities, defended on 29 November 2022, supervised by Clémentine Maurice.

- PhD defended: Sacha Brisset, Towards Understanding Web Applications: Automated Abstraction Inference and its Applications, defended on 5 December 2022, supervised by Lionel Seinturier & Romain Rouvoy & Renaud Pawlak, [34].

- PhD defended : Mohammed Chakib Belgaid, Green Coding: an Empirical Approach to Harness the Energy Consumption of Software Services, defended on 14 December 2022, supervised by Romain Rouvoy & Lionel Seinturier, [33].

- PhD defended: Guillaume Fieni, Towards Modeling the Power Usage Efficiency of Software-Defined Computing Infrastructures, defended on 15 December 2022, supervised by Romain Rouvoy & Lionel Seinturier, [36].

- PhD in progress: Pierre Ayoub, IoT devices security inside 5G networks through side-channel analysis, since October 2020, supervised by Clémentine Maurice.

- PhD in progress: Alexandre Bonvoisin, Reducing the Energy Consumption of Software Stacks, since October 2022, supervised by Romain Rouvoy & Clément Quinton.

- PhD in progress: Guillaume Didier, Studying hardware prefetchers using cache side channels, since October 2019, supervised by Clémentine Maurice.

- PhD in progress: Tristan Coignion, Environmental Impact of Development Assistants, since October 2022, supervised by Romain Rouvoy & Clément Quinton.

- PhD in progress: Salman Farhat, Safe Dynamic Reconfiguration of Cloud Applications, since October 2020, supervised by Laurence Duchien & Simon Bliudze.

- PhD in progress: Romain Fouquet, Improving Online Privacy through Content Blocking and Information Restriction, since October 2020, supervised by Romain Rouvoy & Pierre Laperdrix.

- PhD in progress: Omid Gheibi, Dependable Adaptive Software Systems for the Digital World, since October 2020, supervised by Laurence Duchien & Clément Quinton, co-supervision with Danny Weyns (KU Leuven).

- PhD in progress: Antoine Geimer, Détection et correction automatique de vulnérabilités par canaux auxiliaires dans les librairies cryptographiques, since October 2022, supervised by Sandrine Blazy & Clémentine Maurice.

- PhD in progress: Edouard Guegain, Configuration of Large Scale Fog Environments, since October 2020, supervised by Clément Quinton.

- PhD in progress: Jean Luc Intumwayase, Improving Online Privacy through Content Blocking and Information Restriction, since November 2020, supervised by Romain Rouvoy & Pierre Laperdrix.

- PhD in progress: Pierre Jacquet, Fostering the frugal design of cloud services, since October 2021, supervised by Romain Rouvoy in collaboration with Thomas Ledoux (Inria Stack).

- PhD in progress: Trình Lê Khánh, Design of Correct-by-Construction Self-Adaptive Cloud Applications using Formal Methods, since October 2019, supervised by Philippe Merle & Simon Bliudze.

- PhD in progress: Maxime Huyghe, Automated Software Testing to Improve the Privacy of Browsers, since October 2022, supervised by Lionel Seinturier & Clément Quinton & Walter Rudametkin.

- PhD in progress: Naif Mehanna, Hardening Web Authentication with Browser Fingerprinting, since October 2020, supervised by Walter Rudametkin.

- PhD in progress: Maryam Rahmani, Multi-scale processing of spatio-temporal data applied to air quality in urban areas, since October 2021, supervised by Romain Rouvoy

- PhD in progress: Thibault Simon, Sustainable software engineering, since November 2021, supervised by Romain Rouvoy

- PhD in progress: Yifan Wang, Autonomous Management of Database Systems, since October 2022, supervised by Romain Rouvoy & Pierre Bourhis.

11.2.3 Juries

Laurence Duchien

- HDR Arnaud Liefooghe (U Lille), president

- Pierrick Pochelu (U Lille), president

- Luisa Rincon (U. Paris 1), president

Clémentine Maurice

- Cesar Pereida García (Tampere University, Finland), dissertation pre-examiner

- Ben Gras (VU Amsterdam, The Netherlands), reviewer

- Hadrien Barral (ENS Paris), examiner

- Amine Jaamoum (Université Grenoble Alpes), examiner

Lionel Seinturier

- Yuwei Wang (Telecom SudParis), reviewer

11.3 Popularization

Daniel Romero, Romain Rouvoy and Lionel Seinturier participated to Fête de la science by giving talks and demonstrations on the topic of energy management for software system and on the PowerAPI demonstrator that is installed in the Interface showroom of Inria Lille. Talks and demonstrations given on 7 October. Similar talks and demonstrations were done on 13 October during the 'Option Innovation' day.

Pierre Laperdrix gave a talk on the topic of privacy and private data "Données (pas très) personnes sur les routes des Hauts-de-France" to high school pupils on 8 November.

Lionel Seinturier participated to the Chiche program by giving talks to high school pupils in the context of the SNT Sciences numériques et technologie courses. Talks given at Lycée Albert Châtelet, Douai, 29 November.

Rémy Raes gave a talk on his position as research engineer to high school pupils on 6 December.

12 Scientific production

12.1 Major publications

[1] M. Benedikt, P. Bourhis, L. Jachiet and E. Tsamoura. 'Balancing expressiveness and inexpressiveness in view design'. In: *KR 2020 - 17th International Conference on Principles of Knowledge Representation and Reasoning*. Ed. by D. Calvanese, E. Erdem and M. Thielscher. Proceedings of the 17th International Conference on Principles of Knowledge Representation and Reasoning. Rhodes, Greece: IJCAI Organization, Sept. 2020, pp. 109–118. DOI: 10.24963/kr.2020/12. URL: https://hal.telecom-paris.fr/hal-02964692.

[2] 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. URL: https://hal.inria.fr/hal-01529654.

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12.2 Publications of the year

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[14]   G. Dandachi, S. Cerf, Y. Hadjadj-Aoul, A. Outtagarts and E. Rutten. 'A robust control-theory-based exploration strategy in deep reinforcement learning for virtual network embedding'. In: *Computer Networks* 218 (17th Sept. 2022), pp. 1–27. DOI: 10.1016/j.comnet.2022.109366. URL: https://hal.inria.fr/hal-03792078.

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International peer-reviewed conferences

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Scientific books

[32]   S. Bliudze and L. Bocchi. *Selected Papers of the 22nd International Conference on Coordination Models and Languages (COORDINATION 2020)*. June 2022. URL: https://hal.inria.fr/hal-03720404.

Doctoral dissertations and habilitation theses

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Reports & preprints

[37]   E. Guégain and C. Quinton. *The ICO Tool Suite: Optimizing Highly Configurable Systems*. 27th Nov. 2022. URL: https://hal.science/hal-03874051.

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Other scientific publications

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12.3   Cited publications

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