IN PARTNERSHIP WITH:
Université des sciences et technologies de Lille (Lille 1)

Activity Report 2016

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

RESEARCH CENTER
Lille - Nord Europe

THEME
Distributed Systems and middleware

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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 work towards two directions: self-healing software systems with data mining solutions, and self-optimizing software systems with context monitoring. These two objectives are declined for two target environments: mobile computing and cloud computing.

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 [70], the NESSI Research Priorities for the next Framework Programme for Research and Technological Development FP8 [73], the Roadmap for Advanced Cloud Technologies under H2020 [71], and research roadmaps, such as [78], [69], [63].

3. Research Program

3.1. Introduction

Our research program on self-adaptive software targets two key properties that are detailed in the remainder of this section: *self-healing* and *self-optimization*.

3.2. Objective #1: Self-healing - Mining software artifacts to automatically evolve systems

Software systems are under the pressure of changes all along their lifecycle. Agile development blurs the frontier between design and execution and requires constant adaptation. The size of systems (millions of lines of code) multiplies the number of bugs by the same order of magnitude. More and more systems, such as sensor network devices, live in "surviving" mode, in the sense that they are neither rebootable nor upgradable.

Software bugs are hidden in source code and show up at development-time, testing-time or worse, once deployed in production. Except for very specific application domains where formal proofs are achievable, bugs can not be eradicated. As an order of magnitude, on 16 Dec 2011, the Eclipse bug repository contains 366,922 bug reports. Software engineers and developers work on bug fixing on a daily basis. Not all developers spend the same time on bug fixing. In large companies, this is sometimes a full-time role to manage bugs, often referred to as *Quality Assurance* (QA) software engineers. Also, not all bugs are equal, some bugs are analyzed and fixed within minutes, others may take months to be solved [75].

In terms of research, this means that: (i) one needs means to automatically adapt the design of the software system through automated refactoring and API extraction, (ii) one needs approaches to automate the process of adapting source code in order to fix certain bugs, (iii) one needs to revisit the notion of error-handling so that instead of crashing in presence of errors, software adapts itself to continue with its execution, *e.g.*, in degraded mode.

[1] http://cordis.europa.eu/fp7/ict/ssai

There is no one-size-fits-all solution for each of these points. However, we think that novel solutions can be found by using **data mining and machine learning techniques tailored for software engineering** [76]. This body of research consists of mining some knowledge about a software system by analyzing the source code, the version control systems, the execution traces, documentation and all kinds of software development and execution artifacts in general. This knowledge is then used within recommendation systems for software development, auditing tools, runtime monitors, frameworks for resilient computing, etc.

The novelty of our approach consists of using and tailoring data mining techniques for analyzing software artifacts (source code, execution traces) in order to achieve the **next level of automated adaptation** (*e.g.*, automated bug fixing). Technically, we plan to mix unsupervised statistical learning techniques (*e.g.* frequent item set mining) and supervised ones (*e.g.* training classifiers such as decision trees). This research is currently not being performed by data mining research teams since it requires a high level of domain expertise in software engineering, while software engineering researchers can use off-the-shelf data mining libraries, such as Weka [61].

We now detail the two directions that we propose to follow to achieve this objective.

3.2.1. Learning from software history how to design software and fix bugs

The first direction is about mining techniques in software repositories (*e.g.*, CVS, SVN, Git). Best practices can be extracted by data mining source code and the version control history of existing software systems. The design and code of expert developers significantly vary from the artifacts of novice developers. We will learn to differentiate those design characteristics by comparing different code bases, and by observing the semantic refactoring actions from version control history. Those design rules can then feed the test-develop-refactor constant adaptation cycle of agile development.

Fault localization of bugs reported in bug repositories. We will build a solid foundation on empirical knowledge about bugs reported in bug repository. We will perform an empirical study on a set of representative bug repositories to identify classes of bugs and patterns of bug data. For this, we will build a tool to browse and annotate bug reports. Browsing will be helped with two kinds of indexing: first, the tool will index all textual artifacts for each bug report; second it will index the semantic information that is not present by default in bug management software—*i.e.*, "contains a stacktrace"). Both indexes will be used to find particular subsets of bug reports, for instance "all bugs mentioning invariants and containing a stacktrace". Note that queries with this kind of complexity and higher are mostly not possible with the state-of-the-art of bug management software. Then, analysts will use annotation features to annotate bug reports. The main outcome of the empirical study will be the identification of classes of bugs that are appropriate for automated localization. Then, we will run machine learning algorithms to identify the latent links between the bug report content and source code features. Those algorithms would use as training data the existing traceability links between bug reports and source code modifications from version control systems. We will start by using decision trees since they produce a model that is explicit and understandable by expert developers. Depending on the results, other machine learning algorithms will be used. The resulting system will be able to locate elements in source code related to a certain bug report with a certain confidence.

Automated bug fix generation with search-based techniques. Once a location in code is identified as being the cause of the bug, we can try to automatically find a potential fix. We envision different techniques: (1) infer fixes from existing contracts and specifications that are violated; (2) infer fixes from the software behavior specified as a test suite; (3) try different fix types one-by-one from a list of identified bug fix patterns; (4) search fixes in a fix space that consists of combinations of atomic bug fixes. Techniques 1 and 2 are explored in [58] and [74]. We will focus on the latter techniques. To identify bug fix patterns and atomic bug fixes, we will perform a large-scale empirical study on software changes (also known as changesets when referring to changes across multiple files). We will develop tools to navigate, query and annotate changesets in a version control system. Then, a grounded theory will be built to master the nature of fixes. Eventually, we will decompose change sets in atomic actions using clustering on changeset actions. We will then use this body of empirical knowledge to feed search-based algorithms (*e.g.* genetic algorithms) that will look for meaningful fixes in a large fix space. To sum up, our research on automated bug fixing will try not only to point

to source code locations responsible of a bug, but to search for code patterns and snippets that may constitute the skeleton of a valid patch. Ultimately, a blend of expert heuristics and learned rules will be able to produce valid source code that can be validated by developers and committed to the code base.

3.2.2. Run-time self-healing

The second proposed research direction is about inventing a self-healing capability at run-time. This is complementary to the previous objective that mainly deals with development time issues. We will achieve this in two steps. First, we want to define frameworks for resilient software systems. Those frameworks will help to maintain the execution even in the presence of bugs—*i.e.* to let the system survive. As exposed below, this may mean for example to switch to some degraded modes. Next, we want to go a step further and to define solutions for automated runtime repair, that is, not simply compensating the erroneous behavior, but also determining the correct repair actions and applying them at run-time.

Mining best effort values. A well-known principle of software engineering is the "fail-fast" principle. In a nutshell, it states that as soon as something goes wrong, software should stop the execution before entering incorrect states. This is fine when a human user is in the loop, capable of understanding the error or at least rebooting the system. However, the notion of "failure-oblivious computing" [68] shows that in certain domains, software should run in a resilient mode (*i.e.* capable of recovering from errors) and/or best-effort mode—*i.e.* a slightly imprecise computation is better than stopping. Hence, we plan to investigate data mining techniques in order to learn best-effort values from past executions (*i.e.* somehow learning what is a correct state, or the opposite what is not a completely incorrect state). This knowledge will then be used to adapt the software state and flow in order to mitigate the error consequences, the exact opposite of fail-fast for systems with long-running cycles.

Embedding search based algorithms at runtime. Harman recently described the field of search-based software engineering [62]. We think that certain search based approaches can be embedded at runtime with the goal of automatically finding solutions that avoid crashing. We will create software infrastructures that allow automatically detecting and repairing faults at run-time. The methodology for achieving this task is based on three points: (1) empirical study of runtime faults; (2) learning approaches to characterize runtime faults; (3) learning algorithms to produce valid changes to the software runtime state. An empirical study will be performed to analyze those bug reports that are associated with runtime information (*e.g.* core dumps or stacktraces). After this empirical study, we will create a system that learns on previous repairs how to produce small changes that solve standard runtime bugs (*e.g.* adding an array bound check to throw a handled domain exception rather than a spurious language exception). To achieve this task, component models will be used to (1) encapsulate the monitoring and reparation meta-programs in appropriate components and (2) support runtime code modification using scripting, reflective or bytecode generation techniques.

3.3. Objective #2: Self-optimization - Sharing runtime behaviors to continuously adapt software

Complex distributed systems have to seamlessly adapt to a wide variety of deployment targets. This is due to the fact that developers cannot anticipate all the runtime conditions under which these systems are immersed. A major challenge for these software systems is to develop their capability to continuously reason about themselves and to take appropriate decisions and actions on the optimizations they can apply to improve themselves. This challenge encompasses research contributions in different areas, from environmental monitoring to real-time symptoms diagnosis, to automated decision making. The variety of distributed systems, the number of optimization parameters, and the complexity of decisions often resign the practitioners to design monolithic and static middleware solutions. However, it is now globally acknowledged that the development of dedicated building blocks does not contribute to the adoption of sustainable solutions. This is confirmed by the scale of actual distributed systems, which can—for example—connect several thousands of devices to a set of services hosted in the Cloud. In such a context, the lack of support for smart behaviours at different levels of the systems can inevitably lead to its instability or its unavailability. In June 2012, an outage of Amazon's Elastic Compute Cloud in North Virginia has taken down Netflix, Pinterest, and

Instagram services. During hours, all these services failed to satisfy their millions of customers due to the lack of integration of a self-optimization mechanism going beyond the boundaries of Amazon.

The research contributions we envision within this area will therefore be organized as a reference model for engineering **self-optimized distributed systems** autonomously driven by *adaptive feedback control loops*, which will automatically enlarge their scope to cope with the complexity of the decisions to be taken. This solution introduces a multi-scale approach, which first privileges local and fast decisions to ensure the homeostasis [2] property of a single node, and then progressively propagates symptoms in the network in order to reason on a longer term and a larger number of nodes. Ultimately, domain experts and software developers can be automatically involved in the decision process if the system fails to find a satisfying solution. The research program for this objective will therefore focus on the study of mechanisms for **monitoring, taking decisions, and automatically reconfiguring software at runtime and at various scales**. As stated in the self-healing objective, we believe that there is no one-size-fits-all mechanism that can span all the scales of the system. We will therefore study and identify an optimal composition of various adaptation mechanisms in order to produce long-living software systems.

The novelty of this objective is to exploit the wisdom of crowds to define new middleware solutions that are able to continuously adapt software deployed in the wild. We intend to demonstrate the applicability of this approach to distributed systems that are deployed from mobile phones to cloud infrastructures. The key scientific challenges to address can be summarized as follows: *How does software behave once deployed in the wild? Is it possible to automatically infer the quality of experience, as it is perceived by users? Can the runtime optimizations be shared across a wide variety of software? How optimizations can be safely operated on large populations of software instances?*

The remainder of this section further elaborates on the opportunities that can be considered within the frame of this objective.

3.3.1. Monitoring software in the wild

Once deployed, developers are generally no longer aware of how their software behave. Even if they heavily use testbeds and benchmarks during the development phase, they mostly rely on the bugs explicitly reported by users to monitor the efficiency of their applications. However, it has been shown that contextual artifacts collected at runtime can help to understand performance leaks and optimize the resilience of software systems [77]. Monitoring and understanding the context of software at runtime therefore represent the first building block of this research challenge. Practically, we intend to investigate crowd-sensing approaches, to smartly collect and process runtime metrics (*e.g.*, request throughput, energy consumption, user context). Crowd-sensing can be seen as a specific kind of crowdsourcing activity, which refers to the capability of lifting a (large) diffuse group of participants to delegate the task of retrieving trustable data from the field. In particular, crowd-sensing covers not only *participatory sensing* to involve the user in the sensing task (*e.g.*, surveys), but also *opportunistic sensing* to exploit mobile sensors carried by the user (*e.g.*, smartphones).

While reported metrics generally enclose raw data, the monitoring layer intends to produce meaningful indicators like the *Quality of Experience* (QoE) perceived by users. This QoE reflects representative symptoms of software requiring to trigger appropriate decisions in order to improve its efficiency. To diagnose these symptoms, the system has to process a huge variety of data including runtime metrics, but also history of logs to explore the sources of the reported problems and identify opportunities for optimizations. The techniques we envision at this level encompass machine learning, principal component analysis, and fuzzy logic [67] to provide enriched information to the decision level.

3.3.2. Collaborative decision-making approaches

Beyond the symptoms analysis, decisions should be taken in order to improve the *Quality of Service* (QoS). In our opinion, collaborative approaches represent a promising solution to effectively converge towards the most appropriate optimization to apply for a given symptom. In particular, we believe that exploiting the wisdom

[2] Homeostasis is the property of a system that regulates its internal environment and tends to maintain a stable, relatively constant condition of properties [Wikipedia].

of the crowd can help the software to optimize itself by sharing its experience with other software instances exhibiting similar symptoms. The intuition here is that the body of knowledge that supports the optimization process cannot be specific to a single software instance as this would restrain the opportunities for improving the quality and the performance of applications. Rather, we think that any software instance can learn from the experience of others.

With regard to the state-of-the-art, we believe that a multi-levels decision infrastructure, inspired from distributed systems like Spotify [60], can be used to build a decentralized decision-making algorithm involving the surrounding peers before requesting a decision to be taken by more central control entity. In the context of collaborative decision-making, peer-based approaches therefore consist in quickly reaching a consensus on the decision to be adopted by a majority of software instances. Software instances can share their knowledge through a micro-economic model [56], that would weight the recommendations of experienced instances, assuming their age reflects an optimal configuration.

Beyond the peer level, the adoption of algorithms inspired from evolutionary computations, such as genetic programming, at an upper level of decision can offer an opportunity to test and compare several alternative decisions for a given symptom and to observe how does the crowd of applications evolves. By introducing some diversity within this population of applications, some instances will not only provide a satisfying QoS, but will also become naturally resilient to unforeseen situations.

3.3.3. Smart reconfigurations in the large

Any decision taken by the crowd requires to propagate back to and then operated by the software instances. While simplest decisions tend to impact software instances located on a single host (*e.g.*, laptop, smartphone), this process can also exhibit more complex reconfiguration scenarios that require the orchestration of various actions that have to be safely coordinated across a large number of hosts. While it is generally acknowledged that centralized approaches raise scalability issues, we think that self-optimization should investigate different reconfiguration strategies to propagate and apply the appropriate actions. The investigation of such strategies can be addressed in two steps: the consideration of *scalable data propagation protocols* and the identification of *smart reconfiguration mechanisms*.

With regard to the challenge of scalable data propagation protocols, we think that research opportunities encompass not only the exploitation of gossip-based protocols [59], but also the adoption of publish/subscribe abstractions [64] in order to decouple the decision process from the reconfiguration. The fundamental issue here is the definition of a communication substrate that can accommodate the propagation of decisions with relaxed properties, inspired by *Delay Tolerant Networks* (DTN), in order to reach weakly connected software instances. We believe that the adoption of asynchronous communication protocols can provide the sustainable foundations for addressing various execution environments including harsh environments, such as developing countries, which suffer from a partial connectivity to the network. Additionally, we are interested in developing the principle of *social networks of applications* in order to seamlessly group and organize software instances according to their similarities and acquaintances. The underlying idea is that grouping application instances can contribute to the identification of optimization profiles not only contributing to the monitoring layer, but also interested in similar reconfigurations. Social networks of applications can contribute to the anticipation of reconfigurations by exploiting the symptoms of similar applications to improve the performance of others before that problems actually happen.

With regard to the challenge of smart reconfiguration mechanisms, we are interested in building on our established experience of adaptive middleware [72] in order to investigate novel approaches to efficient application reconfigurations. In particular, we are interested in adopting seamless micro-updates and micro-reboot techniques to provide in-situ reconfiguration of pieces of software. Additionally, the provision of safe and secured reconfiguration mechanisms is clearly a key issue that requires to be carefully addressed in order to avoid malicious exploitation of dynamic reconfiguration mechanisms against the software itself. In this area, although some reconfiguration mechanisms integrate transaction models [65], most of them are restricted to local reconfigurations, without providing any support for executing distributed reconfiguration transactions.

Additionally, none of the approached published in the literature include security mechanisms to preserve from unauthorized or malicious reconfigurations.

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 build, 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 compétivité 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. Highlights of the Year

5.1. Highlights of the Year

Makitoo, the start-up company founded by Martin Monperrus and Nicolas Petitprez received the Bpifrance *Création d'entreprise innovante* award, which is a major award in France for startup companies, in the category *Création-développement*.

Makitoo won also a NETVA award from the French ministry of foreign affairs in order to develop its activities in the USA.

Romain Rouvoy has been awarded a Institut Universitaire de France (IUF) junior fellowship for 5 years (2016-21). IUF is an excellence award that is only granted to the top 2% of faculty members in French universities. The award recognizes the excellence of the research activities conducted by Romain Rouvoy.

Laurence Duchien has been elected for a 2-year term in the executive committee of the IEEE Technical Council on Software Engineering (TCSE). The IEEE TCSE helps advance software engineering research and practice. The executive committee determines TCSE policy and the nature of TCSE activities.

6. New Software and Platforms

6.1. APISENSE

KEYWORDS: Mobile sensing - Crowd-sensing - 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.

- Participants: Nicolas Haderer, Romain Rouvoy, Christophe Ribeiro, Julien Duribreux and Antoine Veuiller
- Partner: Université Lille 1
- Contact: Romain Rouvoy
- URL: http://www.apisense.io

6.2. Nopol

KEYWORD: Automatic software repair
FUNCTIONAL DESCRIPTION

Nopol is an automatic software repair tool for buggy conditional statements (i.e., if-then-else statements) in Java programs. Nopol takes a buggy program as well as a test suite as input and generates a patch with a conditional expression as output. The test suite is required to contain passing test cases to model the expected behavior of the program and at least one failing test case that reveals the bug to be repaired. The process of Nopol consists of three major phases. First, Nopol employs angelic fix localization to identify expected values of a condition during the test execution. Second, runtime trace collection is used to collect variables and their actual values, including primitive data types and objected-oriented features (e.g., nullness checks), to serve as building blocks for patch generation. Third, Nopol encodes these collected data into an instance of a Satisfiability Modulo Theory (SMT) problem, then a feasible solution to the SMT instance is translated back into a code patch.

- Contact: Martin Monperrus
- URL: https://github.com/SpoonLabs/nopol/

6.3. PowerAPI

KEYWORD: Energy management
FUNCTIONAL DESCRIPTION

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

PowerAPI differs from existing energy process-level monitoring tool in its software orientation, with a fully customizable and modular solution that let the user to 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.).

- Participants: Romain Rouvoy, Adel Noureddine, Loic Huertas and Maxime Colmant
- Contact: Romain Rouvoy
- URL: http://www.powerapi.org

6.4. SPOON

KEYWORDS: Java - Code analysis
FUNCTIONAL DESCRIPTION

Spoon is an open-source library that enables you to transform (see below) and analyze Java source code (see example) . Spoon provides a complete and fine-grained Java metamodel where any program element (classes, methods, fields, statements, expressions...) can be accessed both for reading and modification. Spoon takes as input source code and produces transformed source code ready to be compiled.

- Participants: Nicolas Petitprez, Martin Monperrus, Lionel Seinturier and Gérard Paligot
- Contact: Martin Monperrus
- URL: http://spoon.gforge.inria.fr

6.5. Saloon

KEYWORDS: Feature Model - Software Product Line - Cloud computing - Model-driven engineering - Ontologies
FUNCTIONAL DESCRIPTION

Saloon is a framework for the selection and configuration of Cloud providers according to application requirements. The framework enables the specification of such requirements by defining ontologies. Each ontology provides a unified vision of provider offers in terms of frameworks, databases, languages, application servers and computational resources (i.e., memory, storage and CPU frequency). Furthermore, each provider is related to a Feature Model (FM) with attributes and cardinalities, which captures its capabilities. By combining the ontology and FMs, the framework is able to match application requirements with provider capabilities and select a suitable one. Specific scripts to the selected provider are generated in order to enable its configuration.

- Participants: Clement Quinton, Daniel Romero Acero, Laurence Duchien, Lionel Seinturier and Romain Rouvoy
- Partner: Université Lille 1
- Contact: Lionel Seinturier
- URL: https://gitlab.irisa.fr/drome00A/saloon

7. New Results

7.1. Change Impact Analysis

In [21], we have proposed a novel evaluation technique for change impact analysis (CIA). CIA is a prediction problem that, given a source code element in a program, determines the other source code elements impacted if one changes this original source code element. Given the large size of the element space in complex programs, this prediction requires a trade-off between different dimensions: precision, completeness, time. The novelty of the result lies in the use of mutation analysis to study simultaneously these three dimensions. This result is backed by an empirical evaluation performed on 10 open-source Java programs and 5 mutation operators, which enabled to generate 17,000 mutants and study how the error they introduce propagates. This result has been achieved in the context of the PhD thesis, defended in November 2016, of Vicenzo Musco [15].

7.2. Learning Power Models for Distributed and Virtualized Environments

Energy efficiency is a major concern for modern ICT infrastructures. The a priori estimation of the level of energy consumed by a given service is a difficult problem given the intricate nature of hardware and software that are involved. Consequently, even before considering saving, measuring the exact amount of energy consumed by a given software service or process is required. Over the last few years, a dozen of ad hoc power models have been proposed in the literature. Nevertheless they cannot cope with the constant evolution of software and hardware architecture. We have therefore defined and implemented a toolkit that automatically learns the power models of a given architecture, independently of the features and the complexity it exhibits. This toolkit considers traditional distributed environment as well as virtualized, cloud-based ones. This result has been achieved in the context of the PhD thesis, defended in November 2016, of Maxime Colmant [11].

7.3. Crowdmining to Increase the Quality of Software Systems

Modern software systems, especially in the open source world, are more and more part of ecosystems where large quantities of data about these systems are available. These data may come for example from application stores (e.g. Google Play Store or Apple Store for mobile applications), forges (e.g. GitHub), or from the usage conditions experienced by users of these software systems. This large amount of data enables to unlock some specific challenges where knowledge about the software systems can be automatically mined and learnt. In this domain, we obtained new results on the mining of mobile software antipatterns on a crowd of mobile applications and their versions to study their impact on resource consumption [32]. This result has been achieved in the context of the PhD thesis, defended in November 2016, of Geoffrey Hecht [13]. We also consider the crowd of mobile devices and users to detect and reproduce application crashes in the wild. By leveraging our results in the domain of in-breath monitoring, we use the APISENSE® platform (see Section 6.1) to collect extended crash reports that can be aggregated to infer the minimal execution path that lead to a crash [28]. This result has been achieved in the context of the PhD thesis, defended in December 2016, of María Gomez Lacruz [12]. These results are also in relation with our activities in the context of the SOMCA associated team (see Section 9.4).

7.4. Self-Optimization of Virtualized Environments

Elasticity is a major property of virtualized computing environments. In this domain, we especially work at the infrastructure and platform levels of a cloud computing system where we obtained two results that enable to better self-optimize the consumed resources. At the infrastructure level, we proposed CloudGC, a new middleware service for suspending, resuming, and recycling idle virtual machines. The algorithm has been implemented on top of the OpenStack cloud operating system. At the platform level, we proposed a new self-balancing approach to dynamically optimize the performance of the Hadoop framework for the distributed storage and processing of large data sets. These results have been achieved in the context of the PhD thesis, defended in December 2016, of Bo Zhang [16].

8. Bilateral Contracts and Grants with Industry

8.1. ip-label

Participant: Romain Rouvoy [correspondant].

A software exploitation license 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.

8.2. Orange Labs

Participants: Laurence Duchien [correspondant], Amal Tahri.

This collaboration aims at bridging the gap between home networks and cloud environments for the design, the provisioning and the administration of distributed services. The purpose is to define solutions, essentially software design tools and runtime infrastructures, for the seamless migration of distributed applications and services between home networks and cloud environments. The envisioned approach is based on the research activities that we are conducting in the domain of software product lines.

This collaboration is conducted in the context of the ongoing PhD thesis of Amal Tahri.

8.3. Scalair

Participants: Yahya Al-Dhuraibi, Philippe Merle [correspondant].

This collaboration aims at proposing a framework to deal with elasticity in cloud computing environments. This framework must cover all kind of resources, IaaS, PaaS, SaaS, must provide a solution for interoperability between different clouds and virtualization technologies, and must enable the specification and composition of reactive and predictive strategies.

This collaboration is conducted in the context of the ongoing PhD thesis of Yahya Al-Dhuraibi.

8.4. OpenIO

Participants: Philippe Merle, Romain Rouvoy [correspondant], Lionel Seinturier.

This collaboration aims at producing a scientific and technical state-of-the-art analysis of solutions for the large scale storage of object data in the cloud. This study aims at identifying the main properties of the existing solutions, and their differentiating factors. The solution provided by the OpenIO company will be positioned with respect to the other solutions existing on the market and in the international scientific community. Starting from this state-of-the-art, several perspectives will be identified and a research roadmap will be defined.

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Région Nord-Pas De Calais

9.1.1.1. Citizen Awareness and Contribution to Air Quality Monitoring

Participants: Daniel Romero Acero, Romain Rouvoy [correspondant], Lionel Seinturier.

This is a 3-year project in the context of the so-called "Chercheur citoyen" program that started in 2015. The partners are LISIC/Université Côte d'Opale (leader), ATMO Nord-Pas De Calais, Association Bâtisseurs d'Economie Solidaire. This project targets the distributed monitoring of air quality with crowd-sensing solutions obtained via sensors connected to smart devices. We aim at inciting citizens to perform their own measures, and to obtain thanks to GPS geo-localisation a large-scale database and a dynamic fine-grained cartography of air quality. This project takes advantage of the APISENSE® crowdsensing platform (see Section 6.1).

9.1.2. Inria Lille - Nord Europe

9.1.2.1. ADT Spoon3R

Participants: Gérard Paligot, Martin Monperrus [correspondant].

ADT Spoon3R (2014–16) is a technology development initiative supported by the Inria Lille - Nord Europe Center that aims at supporting the development of the SPOON software library. (see Section 6.4) Spoon3R aims at extending SPOON with the features defined in the context of our research activities on automated software repair.

9.1.2.2. ADT LibRepair

Participants: Benjamin Danglot, Martin Monperrus [correspondant], Simon Urli.

ADT LibRepair (2016–18) is a technology development initiative supported by the Inria Lille - Nord Europe Center that aims at supporting the development of an integrated library of automated software repair algorithms and techniques. This ADT builds on our results about with the Astor, Nopol and NpeFix that have been obtained in the context of the defended PhD theses of Matias Martinez [66] and Benoit Cornu [57].

9.1.2.3. North European Lab LLEX

Participants: Martin Monperrus [correspondant], Lionel Seinturier.

North European Lab LLEX (2015–17) is an international initiative supported by the Inria Lille - Nord Europe Center that takes place in the context of a collaboration between Inria and University College London. LLEX deals with research on automatic diagnosis and repair of software bugs. Automatic software repair is the process of fixing software bugs automatically An automatic software repair system fixes software bugs with no human intervention. The goal of automatic software repair is to save maintenance costs and to enable systems to be more resilient to bugs and unexpected situations. This research may dramatically improve the quality of software systems. The objective of the partnership is to work on the automated diagnosis of exceptions with a focus on null pointer exceptions.

9.1.2.4. LEDA

Participant: Philippe Merle [correspondant].

LEDA (2013–16) Laboratoire d'Expérimentation et de Démonstrations Ambiantes is a demonstration space allocated by the Inria Lille - Nord Europe Center whose goal is to show the scientific results of the Spirals team in the domains of distributed systems, adaptable middleware, software product lines, green computing, and ambiant computing. These results are illustrated around the scenario of a mock digital home.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR BottleNet

Participants: Romain Rouvoy [correspondant], Walter Rudametkin Ivey, Lionel Seinturier.

BottleNet is a 48-month project funded by ANR that started on October 2015. The objective of BottleNet is to deliver methods, algorithms, and software systems to measure Internet Quality of Experience (QoE) and diagnose the root cause of poor Internet QoE. Our goal calls for tools that run directly at users' devices. We plan to collect network and application performance metrics directly at users' devices and correlate it with user perception to model Internet QoE, and to correlate measurements across users and devices to diagnose poor Internet QoE. This data-driven approach is essential to address the challenging problem of modeling user perception and of diagnosing sources of bottlenecks in complex Internet services. BottleNet will lead to new solutions to assist users, network and service operators as well as regulators in understanding Internet QoE and the sources of performance bottleneck.

9.2.1.2. ANR SATAS

Participants: Philippe Merle [correspondant], Romain Rouvoy, Lionel Seinturier.

SATAS is a 48-month project funded by ANR that started on October 2015. SATAS aims to advance the state of the art in massively parallel SAT solving with a particular eye to the applications driving progress in the field. The final goal of the project is to be able to provide a "pay as you go" interface to SAT solving services, with a particular focus on its power consumption. This project will extend the reach of SAT solving technologies, daily used in many critical and industrial applications, to new application areas, which were previously considered too hard, and lower the cost of deploying massively parallel SAT solvers on the cloud.

9.2.2. Competitivity Clusters

9.2.2.1. FUI StoreConnect

Participants: Julien Duribreux, Romain Rouvoy, Lionel Seinturier [correspondant], Antoine Veuiller.

StoreConnect is a 24-month project funded by FUI and labelized by the PICOM (Pôle des Industries du COMmerce) competitivity cluster which has started in September 2016. The partners are Neosensys (leader), Tevolys, Ubudu, Smile, STIME, Leroy Merlin, Insiteo, Inria Spirals, Inria Fun, Inria Stars. The goal of the project is to define a modular multi-sensors middleware platform for indoor geolocation.

9.2.3. Programme Investissement d'Avenir (PIA)

9.2.3.1. PIA Datalyse

Participants: Romain Rouvoy, Lionel Seinturier [correspondant], Bo Zhang.

Datalyse is a 42-month project of the Programme Investissement d'Avenir Cloud Computing 3rd call for projects. The project started in May 2013. The partners are Eolas (leader), Business & Decision, Groupement des Mousquetaires, Université Grenoble 1, Université Lille 1, Inria, Université Montpellier 2. The project aims at defining an elastic cloud computing infrastructure for processing big volumes of data. The originality of the project is to consider jointly data generated by users and by the infrastructure, and to correlate data at these two levels.

9.2.3.2. PIA OCCIware

Participants: Romain Rouvoy, Philippe Merle [correspondant], Lionel Seinturier.

OCCIware is a 36-month project of the Programme Investissement d'Avenir Cloud Computing and Big Data 4th call for projects. The project started in December 2014. The partners are Open Wide (leader), ActiveEon SA, CSRT, Institut Mines-Télécom/Télécom SudParis, Inria, Linagora GSO, Obeo, OW2 Consortium, Pôle Numérique, and Université Joseph Fourier - Grenoble. The project aims at defining a formal framework for managing every digital resources in the clouds, based on *Open Cloud Computing Interface* (OCCI) recommendations from *Open Grid Forum* (OGF).

9.2.4. Inria National Initiatives

9.2.4.1. Inria ADT Focus CrowdLab

Participants: Julien Duribreux, María Gómez Lacruz, Romain Rouvoy [correspondant], Antoine Veuiller.

The purpose of the ADT Focus CrowdLab (2014–2016) is to strengthen the technological part of the Metroscope consortium and to promote the APISENSE® crowd-sensing platform (see Section 6.1) as a reference platform fo gathering mobile data within the scientific community. The CrowdLab project focuses on three stringent goals: (1) consolidating the current technological solutions, (2) technical and logistical support of the research activities initiated in different scientific domains, and (3) the improvement of security and anonymity of collected data. In addition to the Metroscope consortium, the Inria research teams participating of the ADT Focus CrowdLab project are: Spirals (coordinator), Madynes, Diana, Muse.

9.2.4.2. Inria IPL BetterNet

Participants: Lakhdar Meftah, Romain Rouvoy [correspondant].

BetterNet (2016–19) aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Our observatory can be defined as a vantage point, where: (1) tools, models and algorithms/heuristics will be provided to collect data, (2) acquired data will be analyzed, and shared appropriately with scientists, stakeholders and civil society, (3) and new value-added services will be proposed to end-users. IPL BetterNet is lead by Isabelle Chrisment (Inria Madynes), with the participation of the Diana, Dionysos, Inria Chile, Muse, and Spirals Inria project-teams.

9.2.5. Others

9.2.5.1. CNRS INS2I JCJC FPDefendor

Participant: Walter Rudametkin Ivey [correspondant].

FPDefendor is a 12-month project funded by the CNRS INS2I institute. The JCJC program targets young researchers. Walter Rudametkin is the recipient of such a grant. The project aims at better understanding browser fingerprinting, its risks to privacy, and to provide measures to detect it and effective countermeasures to mitigate it. The proposal brings together software engineering, security and privacy, and formal verification to propose a platform that uses dynamic reconfiguration as a means to evade fingerprint tracking.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: FP7 ICT.

Project acronym: PaaSage.

Project title: Model Based Cloud Platform Upperware.

Duration: October 2012–September 2016.

Coordinator: ERCIM.

Other partners: ERCIM (Fr), SINTEF (No), STFC (UK), U. of Stuttgart (De), Inria (Fr), CETIC (Be), FORTH (El), Be.Wan (Be), EVRY Solutions (No), SysFera (Fr), Flexiant (UK), Lufthansa Systems AG (De), Gesellschaft fur wissenschaftliche Datenverarbeitung mbh Gottingen (De), Automotive Simulation Center Stuttgart (De).

Abstract: Cloud computing is a popular and over-hyped concept in ICT. The concept of infinitely scalable elastic resources changing without complex systems administration and paying only for resources used is attractive. These benefits are not immediately realizable. Within organisation benefits are realizable at considerable cost. IaaS (*Infrastructure-as-a-Service*) public Clouds have different interfaces and conditions of use thus for an organisation to "scale out" requires considerable investment using skilled technical staff. The business need is to allow organisations to "scale out" from their private Cloud to public Clouds without a technical chasm between. This cannot easily be achieved. Aligned with the EU strategic direction of an open market for services, SOA (*Service-Oriented architecture*) offers a way to virtualize across heterogeneous public Clouds and organizational private Clouds. It opens a market for European SMEs to provide services to be utilized (and paid for) by business applications and for all organisations to benefit from a catalogue of services that can be used across the environment. PaaSage will deliver an open and integrated platform, to support both deployment and design of Cloud applications, together with an accompanying methodology that allows model-based development, configuration, optimisation, and deployment of existing and new applications independently of the existing underlying Cloud infrastructures. Specifically it will deliver an IDE (*Integrated Development Environment*) incorporating modules for design time and execution time optimisation of applications specified in the Cloud Modeling Language (Cloud ML), execution-level mappers and interfaces and a metadata database.

Participants: Laurence Duchien, Daniel Romero Acero, Romain Rouvoy, Lionel Seinturier [correspondant].

Program: FP7 FET.

Project acronym: DIVERSIFY.

Project title: More software diversity. More adaptivity in CAS.

Duration: 36 months (2013–16).

Coordinator: Inria.

Other partners: SINTEF (Norway), Trinity College Dublin (Ireland), University of Rennes 1 (France).

Abstract: DIVERSIFY explores diversity as the foundation for a novel software design principle and increased adaptive capacities in CASs (*Collective Adaptive Systems*). Higher levels of diversity in the system provide a pool of software solutions that can eventually be used to adapt to unforeseen situations at design time. The scientific development of DIVERSIFY is based on a strong analogy with ecological systems, biodiversity, and evolutionary ecology. DIVERSIFY brings together researchers from the domains of software-intensive distributed systems and ecology in order to translate ecological concepts and processes into software design principles.

Participants: Martin Monperrus [correspondant].

Program: H2020 ICT-10-2016.

Project acronym: STAMP.

Project title: Software Testing Amplification.

Duration: 36 months (2016–19).

Coordinator: Inria.

Other partners: ActiveEon (France), Atos (Spain), Engineering (Italy), OW2 (France), SINTEF (Norway), TellU (Norway), TU Delft (The Netherlands), XWiki (France).

Abstract: By leveraging advanced research in automatic test generation, STAMP aims at pushing automation in DevOps one step further through innovative methods of test amplification. It will reuse existing assets (test cases, API descriptions, dependency models), in order to generate more test cases and test configurations each time the application is updated. Acting at all steps of development cycle, STAMP techniques aim at reducing the number and cost of regression bugs at unit level, configuration level and production stage.

Participants: Benjamin Danglot, Martin Monperrus [correspondant].

Program: H2020 JU Shift2Rail.

Project acronym: X2Rail-1.

Project title: Start-up activities for Advanced Signalling and Automation System.

Duration: 36 months (2016–19).

Coordinator: Siemens.

Other partners: 19 partners, among others Bombardier, Siemens, Thales, IRT Railenium.

Abstract: Our contribution to the project is focused on adaptive communication middleware for cyber-physical railway systems.

Participants: Lionel Seinturier [correspondant].

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: EUREKA Celtic-Plus.

Project acronym: SENDATE.

Project title: SEcure Networking for a DATa Center Cloud in Europe.

Duration: 36 months (2016–19).

Coordinator: Nokia.

Other partners: 50+ partners in Finland, France, Germany, Norway, and Sweden. Selected partners involved: Nokia, Orange.

Abstract: The project addresses the convergence of telecommunication networks and IT in the context of distributed data centers. We are involved in the TANDEM subproject that targets the infrastructure of such a distributed system. More specifically, we are studying new approaches in terms of software engineering and component-based solutions for enabling this convergence of network and IT.

Participants: Lionel Seinturier [correspondant].

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. SOMCA

Title: Self-Optimization of Service Oriented Architectures for Mobile and Cloud Applications

International Partner (Institution - Laboratory - Researcher):

Université du Québec À Montréal (Canada) - LATECE - Naouel MOHA

Start year: 2014

See also: http://sofa.uqam.ca/somca.php

The long-term goal of this research program is to propose a novel and innovative methodology embodied in an software platform, to support the runtime detection and correction of anti-patterns in large-scale service-oriented distributed systems in order to continuously optimize their quality of service. One originality of this program lies in the dynamic nature of the service-oriented environments and the application on emerging frameworks for embedded and distributed systems (e.g., Android/iOS for mobile devices, PaaS/SaaS for Cloud environments), and in particular mobile systems interacting with remote services hosted on the Cloud.

9.4.2. Participation in Other International Programs

9.4.2.1. STIC AmSud - Project MineAPI

Participants: María Gómez Lacruz, Martin Monperrus [correspondant], Vincenzo Musco, Gérard Paligot, Romain Rouvoy.

MineAPI is a STIC AmSud project (2015–16) between with University Diego Portales, Santiago, Chile, and Federal University of Uberlândia, Brazil. The coordinator on the French side is Damien Cassou from Inria Rmod. The project aims at facilitating the usage of frameworks and application programming interfaces (APIs) by mining software repositories. Our intuition is that mining reveals how existing projects instantiate these frameworks. By locating concrete framework instantiations in existing projects, we can recommend to developers the concrete procedures for how to use a particular framework for a particular task in a new system. Our project also tackles the challenge of adapting existing systems to new versions of a framework or API by seeking repositories for how other systems adapted to such changes.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Prof. Marcelo Maia, from the Federal University of Uberlândia, Brazil, visited us for 1 week in November 2016 in the context of the MineAPI project.

Fernanda Madeiral Delfim, PhD Student from the Federal University of Uberlândia, Brazil, started a 6-month visit in December 2016 in the context of the MineAPI project.

Mohamed Berkane, associate professor at the University Constantine 2, Algeria, visited us for 1 month in October 2016.

9.5.1.1. Research Stays Abroad

María Gómez spent 4 months from January to April 2016 at Universität Hamburg in the research group of Prof. Walid Maalej.

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events Organisation

10.1.1.1. General Chair, Scientific Chair

Laurence Duchien has been General Chair of (EJCP'2016), that is an international summer school in the domain of software engineering. The summer school was held in Lille from 27 June to 1 July 2016.

10.1.2. Scientific Events Selection

10.1.2.1. Member of the Conference Program Committees

Laurence Duchien

International Systems and Software Product Line Conference, Vision Track (SPLC)

IEEE Conference on Software Engineering Education & Training (CSEE&T)

International Workshop on Software Engineering for Systems-of-Systems (SESoS)

European Conference on Software Architecture (ECSA)

Philippe Merle

International Symposium on Security in Computing and Communications (SSCC)

International Workshop on Adaptive and Reflective Middleware (ARM)

Informatique des Organisation et Systèmes d'Information et de Décision (INFORSID)

Workshop on CrossCloud Infrastructures & Platforms (CrossCloud)

International Conference on Cloud Computing and Services Science (CLOSER), Special Session on Experiences with OCCI

Martin Monperrus

International Symposium on Software Testing and Analysis (ISSTA)

International Conference on Software Maintenance and Evolution (ICSME)

Romain Rouvoy

ACM/IFIP/USENIX Middleware conference (Middleware)

ACM Symposium on Applied Computing (SAC), track on Dependable, Adaptive, and Trustworthy Distributed Systems (DADS)

International Symposium on Symbolic and Numeric Algorithms for Scientific Computing (SYNASC)

International Conference on Ambient Systems, Networks and Technologies (ANT)

International Conference on Formal Aspects of Component Software (FACS)

IEEE International Workshop on Big Data Management for the Internet of Things (BIOT)

International Workshop on Meta-Programming Techniques and Reflection (Meta)

Lionel Seinturier

International Conference on Service Oriented Computing (ICSOC)

ACM/IEEE Joint Conference WICSA and CompArch (ICSA)

ACM Symposium on Applied Computing (SAC), tracks Software Architecture Theory Technology and Applications (SA-TTA), Operating Systems (OS)

IEEE International Symposium on Software Crowdsourcing (ISSC)

Euromicro Conference on Software Engineering and Advanced Applications (SEAA), track Model-based development Components and Services (MOCS)

International Conference on Software Paradigm Trends (ICSOFT-PT)

International Cloud Forward Conference (CF)

International Workshop on Interplay of Security, Safety and System/Software Architecture (ISSA)

International Workshop on Models@run.time @ MODELS

International Workshop on Models@run.time @ ICAC

Workshop on Software Engineering for Sustainable Systems (SE4SuSy)

International Workshop on Advanced Information Systems for Enterprises (IWAISE)

Workshop on Model-driven Engineering for Component-based Software Systems (ModComp)

10.1.3. Journal

10.1.3.1. Member of the Editorial Boards

Martin Monperrus is member of the editorial board of the international journal Springer Empirical Software Engineering (IF-2015: 1.933).

Romain Rouvoy is member of the editorial board of the journal Lavoisier Technique et Science Informatiques (TSI).

Lionel Seinturier is editor for software engineering of the ISTE-Wiley Computer Science and Information Technology book collection.

10.1.3.2. Reviewer - Reviewing Activities

Laurence Duchien: Lavoisier Technique et Science Informatiques (TSI), Wiley Software Practice and Experience (SPE), Elsevier Journal of Software and Systems (JSS).

Martin Monperrus: Springer Empirical Software Engineering (EMSE), Elsevier Information and Software Technology (IST), IEEE Transactions on Software Engineering (TSE).

Romain Rouvoy: Wiley Journal of Software: Evolution and Process (JSME), Elsevier Journal of Pervasive and Mobile Computing (PMC), Elsevier Journal of Computer Networks (COMNET), Elsevier Journal of Computer Communications (COMCOM), Elsevier Journal of Network and Computer Applications (JNCA), Elsevier Journal on Science of Computer Programming (SCICO).

Lionel Seinturier: ACM Computing Surveys, Elsevier Information and Software Technology (IST), Wiley Software Practice and Experience (SPE), Elsevier Science of Computer Programming (SCP), Springer International Journal on Software and Systems Modeling (SoSyM), Springer Knowledge and Information Systems (KAIS), Elsevier Computers & Electrical Engineering (CAEE), Oxford The Computer Journal, Revue Africaine de la Recherche en Informatique et Mathématiques Appliquées (ARIMA), Inderscience International Journal of Computer Applications in Technology (IJCAT).

10.1.4. Invited Talks

Romain Rouvoy gave on keynote at ECAAS 2016 in the 1st workshop on Engineering Context-Aware Applications and Services, on mobile crowdsensing.

Walter Rudametkin gave an invited talk on browser fingerprinting at CiComp 2016, the 8th International Congress on Computational Sciences.

Lionel Seinturier gave an webinar at the West University of Timisoara, Romania, on High-level Language Support for Reconfiguration Control in Component-Based Architectures.

10.1.5. Leadership within the Scientific Community

Martin Monperrus is the co-head of the "Groupe de Travail Génie Logiciel Empirique" of the GDR GPL.

Romain Rouvoy is the co-head of the "Groupe de Travail Génie Logiciel pour les Systèmes Cyber-physiques" of the GDR GPL.

10.1.6. Scientific Expertise

Laurence Duchien was member of the recruitment committee for Chaire Inria at Ecole des Mines de Nantes, and deputy head of the recruitment committee for Chargés de Recherche at Inria Lille - Nord Europe. She did some scientific expertises for Direction des Relations Internationales of the French Ministry of Research.

Martin Monperrus has evaluated grants for the Natural Sciences and Engineering Research Council of Canada (NSERC).

Romain Rouvoy has evaluated Discovery Grants for the Natural Sciences and Engineering Research Council of Canada (NSERC) and research proposals for the STIC-AmSud Program.

Lionel Seinturier was member of the recruitment committees for professors in computer science at the University of Bordeaux, and the University of Grenoble. He was scientific expert for ANRT and University Paris 6. He was member of the Agence Nationale de la Recherche (ANR) Scientific Evaluation Committee for Software and Network (CES25).

10.1.7. Research Administration

Laurence Duchien is member of the Scientific Advisory Board for the Certus Center of the Simula Lab Norway (2014-2016). She is member of the CNRS CoCNRS section 6 committee, and of the "bureau" of this committee.

Philippe Merle is member of the scientific board of Inria. He is in charge of creating the Lille's instance of the Irill research and innovation institute on free software. He is president of the CUMI (Comité des Utilisateurs des Moyens Informatiques), alternate member of the Comité de centre, member of the CLHSCT (Comité Local d'Hygiène, de Sécurité et de Conditions de Travail).

Romain Rouvoy is member of the CLDD (Commission Locale de Développement Durable), member of the CUB (Commission des Utilisateurs du Bâtiment), member of the CER (Commission Emplois Recherche), and member of the Horizon Startup committee for the Inria Lille - Nord Europe research center.

Lionel Seinturier is president of the CDT (Commission Développement Technologique), member of the BCP (Bureau du Comité des Projets), and scientific correspondant for DPEI (Direction Partenariat Europe et International), for the Inria Lille - Nord Europe research center. He heads the committee (so-called "vivier 27 rang A") that selects members of recruitment committees in Computer Science at the University of Lille.

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

Laurence Duchien teaches at the University of Lille 1, IEEA faculty. She heads the Carrières et Emplois service and is referent for the professional insertion in the PhD program in Computer Science at ComUE University Lille Nord de France. She is Director of Doctoral Studies for Computer Science in the Doctoral School Engineering Science (SPI) - ComUE Lille Nord de France.

Software Project Management, 50h, Level M2, Master MIAGE

Design of distributed applications, 42h, Level M1, Master of Computer Science

Software Product Lines, 8h, Level M2, Master of Computer Science

Research and Innovation Initiation, 22h, Level M2 IAGL, Master of Computer Science

Tutoring Internship, 16h, Level M2, Master of Computer Science

Martin Monperrus teaches at the University of Lille 1, IEEA faculty. He heads the IAGL specialty of the Master of Computer Science at the University of Lille 1.

Introduction to programming, 48h, Level L1, Licence of Computer Science

Object-oriented design, 39h, Level L3, Licence of Computer Science

Automated software engineering, 40h, Level M2 IAGL, Master of Computer Science

Romain Rouvoy teaches at the University of Lille 1, IEEA faculty. He heads the Master of Computer Science program at the University of Lille 1. He supervises the Agil-IT Junior Enterprise.

Infrastructures et Frameworks Internet, 32h, Level M2 IAGL, Master of Computer Science

Innovation & Initiation à la Recherche, 14h, Level M2 IAGL, Master of Computer Science speciality

Outils pour la Programmation des Logiciels, 12h, Level M2 IAGL, Master of Computer Science

Suivi de projets, 20h, Level M2, Master of Computer Science

Suivi d'alternants, 20h, Level M2, Master of Computer Science

Walter Rudametkin Ivey teaches at the University of Lille 1, Polytech engineering school.

GIS4 Programmation par Objets

GIS4 Architectures Logicielles

GIS2A3 (apprentissage) Projet programmation par Objet

IMA2A4 (apprentissage) Conception Modélisation Objet

GBIAAL4 Bases de données

Lionel Seinturier teaches at the University of Lille 1, IEEA faculty.

Conception d'Applications Réparties, 50h, Level M1, Master MIAGE

Conception d'Applications Réparties, 36h, Level M1, Master of Computer Science

Infrastructures et Frameworks Internet, 52h, Level M2 E-Services IAGL and TIIR, Master of Computer Science

10.2.2. Supervision

Defended HdR: Martin Monperrus, On Oracles for Automated Diagnosis and Repair of Software Bugs, 3 May 2016.

Defended PhD: Vincenzo Musco, Usages of Graphs and Synthetic Data for Software Propagation Analysis, 3 November 2016, Philippe Preux (Inria SequeL) & Martin Monperrus.

Defended PhD: Maxime Colmant, Multi-Dimensional Analysis of Software Power Consumptions in Multi-Core Architectures, 24 November 2016, Lionel Seinturier & Romain Rouvoy.

Defended PhD: Geoffrey Hecht, Détection et analyse de l'impact des défauts de code dans les applications mobiles, 30 November 2016, Romain Rouvoy.

Defended PhD: María Gómez Lacruz, Towards Improving the Quality of Mobile Apps by Leveraging Crowdsourced Feedback, 2 December 2016, Lionel Seinturier & Romain Rouvoy.

Defended PhD: Bo Zhang, Self-optimization of Infrastructure and Platform Resources in Cloud Computing, 12 December 2016, Lionel Seinturier & Romain Rouvoy.

In progress PhD: Benjamin Danglot, December 2016, Martin Monperrus.

In progress PhD: Lakhdar Meftah, November 2016, Romain Rouvoy & Isabelle Chrisment (Inria Madynes).

In progress PhD: Miguel Gonzalez, October 2016, Martin Monperrus & Romain Rouvoy & Walter Rudametkin.

In progress PhD: Sarra Habchi, Une supervision de contexte sensible à la confidentialité pour les développements logiciels en crowdsource, October 2016, Romain Rouvoy.

In progress PhD: Antoine Vastel, Cartographie de la qualité d'expérience pour l'accès à l'internet mobile, October 2016, Romain Rouvoy & Walter Rudametkin.

In progress PhD: Yahya Al Dhuraibi, Un cadre flexible pour l'élasticité dans les nuages, October 2015, Philippe Merle.

In progress PhD: Stéphanie Challita, Un cadre formel et outillé pour la gestion de toute ressource en nuage, October 2015, Philippe Merle.

In progress PhD: Thomas Durieux, Search-based Monitoring and Root Cause Diagnosis in Production, September 2015, Lionel Seinturier & Martin Monperrus.

In progress PhD: Gustavo Sousa, Towards dynamic software product lines to optimize management and reconfiguration of cloud applications, October 2012, Laurence Duchien & Walter Rudametkin Ivey.

In progress PhD: Amal Tahri, Evolution logicielle multi-vues, des réseaux domestiques au Cloud, March 2013, Laurence Duchien.

10.2.3. Juries

Laurence Duchien

HDR Tewfik Ziadi (University Paris 6), reviewer

HDR Christelle Urtado (University of Montpellier), reviewer

HDR Anne Etien (University of Lille 1), chair

HDR Martin Monperrus (University of Lille 1), garant

HDR Fabien Dagnat (University Rennes 1), reviewer

Bui Thi Mai Anh (University Paris 6), examiner

Alix Gogey (University of Lille 1), chair

Guillaume Bécan (University Rennes 1), reviewer

Martin Monperrus

Alan Charpentier (University of Bordeaux), examiner

Vincenzo Musco (University of Lille 1), co-supervisor

Romain Rouvoy

Assaad Moawad (University of Luxembourg), reviewer

Simon Dupont (École des Mines de Nantes), reviewer

Lucas Perronne (University of Grenoble), reviewer

Alexandre Caron (University of Lille 1), chair

Maxime Colmant (University of Lille 1), co-supervisor

Geoffrey Hecht (University of Lille 1 & UQAM), co-supervisor

María Gómez Lacruz (University of Lille 1), co-supervisor

Bo Zhang (University of Lille 1), co-supervisor

Lionel Seinturier

HDR Brahim Hamid (University of Toulouse), reviewer

Sebastian Martinez (University Bretagne Occidentale), reviewer

Julie Rochas (University of Nice), reviewer

Hamza Chehili (University Constantine 2, Algérie), reviewer

Naweulo Zhou (University of Grenoble), reviewer

Anca Iordache (University Rennes 1), examiner

Maxime Colmant (University of Lille 1), co-supervisor

María Gómez Lacruz (University of Lille 1), co-supervisor

Bo Zhang (University of Lille 1), co-supervisor

10.3. Popularization

Romain Rouvoy is in charge of a demonstrator of APISENSE® as part of the Xperium initiative of the LILLIAD Learning center Innovation at the University of Lille 1.

Lionel Seinturier has participated in October to the event Chercheur itinérant organized by the Inria Lille Nord Europe research center in the context of La Fête de la science. Two classrooms (3ème) have been visited. The theme of the visit was crowd-sensing and data gathering from mobile devices.

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