INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team Adam

Adaptive Distributed Applications and Middleware

Lille - Nord Europe

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Activity Report

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ADAM is a joint project-team between INRIA, CNRS, and Université de Lille 1, via the Computer Science Laboratory of Lille : LIFL (UMR 8022).

1. Team

Research Scientist

Christophe Gransart [Research Associate (CR1), INRETS, external collaborator]
Philippe Merle [Research Associate (CR1), INRIA, vice-head of project-team]

Faculty Member

Xavier Blanc [Associate Professor, UPMC, secondment INRIA until September 30th 2009, HdR]
Laurence Duchien [Professor, Université de Lille 1, secondment INRIA until August 31th 2009, project-team leader, HdR]
Jean-Marc Geib [Professor, Université de Lille 1, external collaborator, HdR]
Anne-Françoise Le Meur [Associate Professor, Université de Lille 1, secondment INRIA since September 1st 2009]
Romain Rouvoy [Associate Professor, Université de Lille 1]
Lionel Seinturier [Professor, Université de Lille 1, HdR]

Technical Staff

Pierre Carton [Expert Engineer, INRIA, CAPPUCINO Project]
Yann Davin [Development Engineer, INRIA, INRIA ODL, until August 31th 2009]
Christophe Demarey [Research Engineer, INRIA, Galaxy ADT]
Nicolas Dolet [Expert Engineer, INRIA, ICT FP7, IP SOA4All Projects]
Estéban Duguepéroux [Recent Graduate Engineer, INRIA, CALICO ADT, since October 1st 2009]
Julien Ellart [Expert Engineer, INRIA, ICOM Project]
Damien Fournier [Expert Engineer, INRIA, Minalogic MIND Project]
Rémi Mélisson [Expert Engineer, INRIA, Minalogic MIND Project, since October 1st 2009]
Clément Quinton [Recent Graduate Engineer, INRIA, UbiNov ADT, since October 1st 2009]

PhD Student

Gabriel Hermosillo [INRIA CORDI-S grant]
Jonathan Labejof [CIFRE Thales, since October 1st 2009]
Guillaume Libersat [MERT grant]
Russel Nzekwa [INRIA CORDI-C grant, since October 1st 2009]
Carlos Andres Parra Acevedo [INRIA / Région Nord/Pas-de-Calais grant]
Aleš Plšek [INRIA CORDI-S grant, until September 15th 2009]
Daniel Romero [EIFFEL grant]
Alban Tiberghien [INRIA / Région Nord-Pas de Calais grant]
Guillaume Waignier [MERT grant]

Post-Doctoral Fellow

Frédéric Loiret [Expert Engineer, INRIA, ANR TLog Flex-eWare Minalogic MIND Project]
Nicolas Pessemier [Expert Engineer, INRIA, CAPPUCINO Project]
Anthony Cleve [ERCIM grant, since december 2009]

Administrative Assistant

Malika Debuysschere [INRIA]

Other

Russel Nzekwa [Master, February- September 2009]
Kevin Sénéchal [L3-M1, June - September 2009]
Patricia Jaimes [Master, January - June 2009]
Amirhosein Taherkordi [Internship INRIA, PhD student, March-June 2009]

2. Overall Objectives

2.1. Introduction

With the increasing need of self-managed systems and the emergence of multi-scale environments, software developers have to cope with variability. Software must be developed to be adapted and reconfigured automatically on heterogeneous platforms in accordance with the unavoidable evolution of information and communication technologies. Therefore, the adaptation is now considered as a first-class problem that must be taken into account throughout the entire software life-cycle.

An *adaptive system* is a software-intensive system that can adjust and respond to changes in its environment, evolving requirements, removal of obsolete technologies or introduction of new technologies, and new knowledge. The objective of the ADAM project-team is to provide a set of paradigms, approaches and frameworks based on advanced software engineering techniques, such as *Component-Based Software Engineering* (CBSE), *Aspect-Oriented Software Development* (AOSD), or *Context-Aware Computing* (CAC), to build distributed adaptive software systems evolving in multi-scale environments and to take into account the adaptation all along the software life-cycle. We propose to follow two research directions: the definition of adaptable component frameworks for middleware and the design of distributed applications for adaptive platforms.

2.2. Challenges

Software, whatever its objectives, has become a key element in all sectors of the economic activity. It must cope more and more with the variability of computing platforms and must be usable in various environments, in accordance with the unavoidable evolution of communication and information technologies. Software must now be developed to be adapted and reconfigured automatically on heterogeneous platforms that base themselves on different network and system paradigms, such as volatile or reliable connection, ambient or distributed reference, or energy-constrained or not. Depending on the application domains, software interacts with its execution context, *i.e.*, the end-users, their local environment, and the execution platform, which involve adaptation. Therefore, a system will not be built in only one step but has to be seen as a composition and evolution of existing systems or sub-systems. These systems are defined by software engineering paradigms, such as components, services or aspects. Moreover, these adaptations can be performed at design, compile or run time. Consequently, the entire life-cycle, from design to deployment and execution of software, has to be considered not only when the execution context changes, but also when functionalities are added or withdrawn in accordance with user needs. Thus, software life-cycle has to be defined to support the expression of adaptation at each of its levels. Consequently, there is a strong requirement to consider *adaptation* as a first-class problem in the development and execution of software.

As such, an *adaptive system* is a software-intensive system (see software-intensive systems report [101]) that can adjust and respond to changes in its environment, evolving requirements, removal of obsolete technologies or introduction of new technologies, and new knowledge [84]. It will have multiple applications considering technical changes, such as heterogeneous complex and large systems, embedded software systems for wireless networks, and in application domains, such as transport, home, communication, health, education, and service-oriented business applications based on Web Services.

Supporting the entire life-cycle of adaptive systems raises several challenges, from elaborating methods and tools for system design to the definition of middleware infrastructures to support the target system on heterogeneous and dynamic platforms. In current software engineering, paradigms, such as *Component-Based Software Engineering* (CBSE) and *Aspect-Oriented Software Development* (AOSD), allow the expression of software adaptation by composition or by weaving. Moreover, various abstractions for modeling structural and behavioral adaptation of applications in response to changes in the existing environment have been studied recently from resource-aware programming to adaptive software architecture. The ADAM challenges will be to study the entire life-cycle of adaptive multi-paradigm systems for multi-scale environments.

2.2.1. Life-cycle of Adaptive Systems

The first challenge will be to master the adaptation of distributed middleware and applications in accordance with the evolution of runtime constraints, while following this evolution from design to run time. Although occurring at different levels, adaptation must be managed consistently across the whole life-cycle of a system. In particular, in a Model-Driven Engineering (MDE) context, if a model at some level of the software life-cycle changes, then this change may have an impact on other models at the same level that are related to it, as well as on related models in earlier and later phases of the life-cycle. To reach this challenge, techniques and formalisms are needed to assess the impact of such changes, to synchronize models within and between different phases, to co-evolve models and implementations and to adapt the implementation at run time. Because of the mobility and the high dynamicity in adaptive systems, these tools and approaches should be more effective.

2.2.2. Multi-paradigm Applications

The second challenge will be to develop and process applications written with different software paradigms at the same time and to allow their co-existence. Developing adaptable applications requires the use of good practices on software engineering. However, in such context, applications are often composed of multiple sub-systems and services written in different languages and supported by systems using several paradigms. Implementation-level solutions, like AOP [77], patterns [74], generative programming [67], or reflective approaches [76], [98] are already employed and co-exist in nowadays software. However, in order to better support adaptation, application must be specified and developed with different paradigms, such as CBSE, AOSD, or services and be deployed on different runtime platforms, such as J2EE, JBI, FRACTAL, SCA or on new technological platforms, such as FAC [88] and AOKell [95]. For reaching this challenge, we will consider heterogeneity on paradigms, their unification on generic models that can be projected on specific platforms or their co-existence through interconnection of platforms.

2.2.3. On Supporting Multi-scale Environment

Finally, our research context considers multi-scale networks and runtime environment properties in the design and the execution of middleware and applications. We do not claim to propose advances in the fields of the ambient computing core or the grid core, but we take into account their definition and their properties as interesting adaptive systems on which we will test our multi-paradigm approaches and our life-cycle steps. They are for us experimentation fields. Environments, such as sensor networks, wireless networks for embedded systems, the Internet, or environments for grid computing do not have the same properties in terms of data and computation capacities. Considering data, sensor or mobile networks will manipulate small amounts of data, but with a large distribution and some inconsistencies. Internet networks and grid computing, on the other hand, will operate on large amount of data, which is mostly homogeneous, consistent, and centralized. Computation capacity must also be considered. PDAs, phones or sensors have small capacities in terms of battery, memory, or computation units, consequently the application and its run-time platform design will be designed and distributed according to these capacities.

2.3. Highlights of the year

- Following Naouel Moha's Ph.D. thesis [86], we have published this work in the journal of Formal Aspects of Computing Science (ranked A) and the journal of IEEE Transactions on Software Engineering (ranked A+). The first journal paper focuses on the automatic detection of code and design smells in software systems using a domain-specific language [14]. The second journal paper presents the DECOR method, which embodies and defines all the steps necessary for the specification and detection of code and design smells [13].
- The work on Soleil is the subject of Aleš Plšek's Ph.D. thesis [12] and is a component-based software framework to support development of Real-Time Java (RTJ) based applications in the Fractal component model. The goal of the framework is to automatically generate an execution infrastructure of a software system that will be executed under real-time conditions as it is described

in [90] and [91]. The Soleil framework is able to substantially alleviate the whole process of developing RTSJ-based applications. The key motivation for the project is both to shield developers from the complexities of RTSJ related code and to allow them to focus only on development of the application logic. The Soleil framework is divided into several parts. First, we introduce a component model which is specifically designed for RTSJ and allows designers to manipulate with RTSJ concerns at the architectural level. Second, Soleil proposes a methodology of designing architectures of real-time Java applications. Finally, when the application is designed, the Hulotte framework (see Section 5.6) is used to automatically generate an infrastructure that corresponds to this real-time architecture.

3. Scientific Foundations

3.1. Introduction

Mastering the complexity of the adaptation will be possible by self-adaptive knowledge systems that can obtain and adapt knowledge from different sources. In order to cope with this objective, we will consider software paradigms that will help us in our approach at the various levels of our life-cycle of adaptive systems, but also in the tools themselves for their composition. We will also study these paradigms in the middleware and application design in order to extend them and to have a better understanding. These extensions will be formalized as much as possible.

3.1.1. Aspect-Oriented Software Development (AOSD)

In modern software engineering, language constructs are classified according to how they recombine partial solutions for subproblems of a problem decomposition. Some constructs (*e.g.*, methods and classes) recombine partial solutions using classic hierarchical composition. Others recombine the partial solution using what is known as crosscutting (a.k.a. aspectual) composition. With crosscutting composition, two partial solutions (called aspects) are woven into each other in a way that is dictated by so-called pointcut languages. The necessity of crosscutting composition is the main motivation for the AOSD [58], [78] paradigm. The challenge will be first to study new expressive pointcut languages in order to have a better description of composition locations in adaptable software. The second objective will be to extend and to integrate new techniques of weaving at design time, but also at run time in order to compose software safely. The third objective will be to go beyond simple aspects as persistence and logging services. We plan to study complex aspects such as transactions or replication and to control their weaving in order to master the evolution of complex software.

3.1.2. Component-Based Software Engineering (CBSE)

In a post-object world [73], software components [83] are, with other artifacts such as aspects, one of the approaches that aims at overcoming the limitations of objects and providing more flexibility and dynamicity to complex applications. For that, software components present many interesting properties, such as modularity, encapsulation, and composability. Yet, many different component models and frameworks exist. A survey of the literature references more than 20 different models (including the most well-known, such as EJB [57] and CCM [56]), but the exact number is certainly closer to 30. Indeed, each new author proposes a model to address her/his own need related to a particular execution environment (from grid computing to embedded systems) or the technical services (from advanced transactions to real-time properties), which must be provided to the application components. These different component models seldom interoperate and their design and implementation are never founded on a common ground. The research challenge that we identify is to define and implement solutions for adaptive software components. These components will be adaptive in the sense that they will be able to accommodate execution environments of various granularities (from grid computing, to Internet-based applications, to mobile applications, to embedded systems) and incorporate on-demand different technical services. This challenge will be conducted by designing a micro-kernel for software components. This micro-kernel will contain a well-defined set of core concepts, which are at the root of all component models. Several concrete software component models will then be derived from this micro-kernel.

3.1.3. Context-Aware Computing (CAC)

In adaptive systems, the notion of "*context*" becomes increasingly important. For example, mobile devices sense the environment they are in and react accordingly. This is usually enabled by a set of rules that infer how to react given a certain situation. In the Ambient/Ubiquitous/Pervasive domain[1], CAC is commonly referred to as the new paradigm that employs this idea of context in order to enmesh computing in our daily lives [87]. Many efforts that exist today focus on human-computer interaction based on context. On the one hand, computational models, middleware, and programming languages are being developed to take the inherent characteristics of multi-scale environments into account, such as connection volatility, ambient resources, etc. An important challenge is to bridge the gap between the domain level and the computational level. The former is concerned with the expected behavior of the system from a user's viewpoint, such as how and when a system responds to changes in the context, when information can be made public, etc. On the other hand, the computational level deals with the inherent and very stringent hardware phenomena of multi-scale environments. Nevertheless, both levels have to coexist: the computational level needs to be steered by the concepts, behavior and rules which exist at the domain level, whereas the domain needs to adapt to the specificities of the ever changing environment that is monitored and managed by the computational level. In order to address this challenge, we first intend to investigate representations at the domain level of concepts such as user profile, local positioning information and execution context [97]. Furthermore, a mapping has to be devised between these concepts and generic concepts at the computational level, the latter being as independent as possible from concrete platforms or languages. This mapping has to be bidirectional: the computational level needs to be steered by the concepts, behavior and rules that exist at the domain level, whereas the domain needs to adapt to the particulars of the ever-changing environment that is monitored and managed at the computational level. Furthermore, the mapping has to be dynamic since the changes have to be propagated between the levels at run time. An explicit domain level is not only useful for bridging the aforementioned gap, but also for designing and developing open task-specific languages at the domain level, which allow users to dynamically adapt the behavior of the applications in multi-scale environments in well-defined ways.

We will base the design approach of the future implementation prototype on MDE. The goal of MDE [94] consists of developing, maintaining and evolving complex software systems by raising the level of abstraction from source code to models. The latter is in our case the domain level, which will be connected to the computational level by means of MDE techniques. One added benefit of MDE is that it provides means for managing model inconsistencies.

3.2. Two Research Directions

We propose to follow two research directions to foster software reuse and adaptation. The first direction, that could be coined as the spatial dimension of adaptation, will provide middleware platforms to let applications be adapted to changing execution contexts. The second direction, the so-called temporal dimension of adaptation, will provide concepts and artifacts to let designers specify evolvable applications.

3.2.1. Adaptable Component Frameworks for Middleware

As a cornerstone of next generation software, adaptation is a property which must be present throughout the entire life cycle, from design to execution. We develop then a vision where adaptation is not only a property that is desirable for end-user applications, but also for the middleware platform that executes these applications. Until now, middleware is a rather specialized activity where each new environment forces the development of a corresponding platform, which is specific to the given environment. This has led to a large number of platforms (from Web Services, to EJB, to CORBA, to ad hoc middleware for embedded systems). Although at a high level, solutions for communication interoperability often exist between these platforms, they stay loosely coupled and separated. Furthermore, the concepts which are at the core of these platforms and their architectures are too different to allow, for example, sharing technical services.

[1] These terms are more or less equivalent.

The research challenge that we propose here is to define and develop middleware and associated services which could be adapted to a broad range of environments from grid computing, to Internet-based applications, to local networks, to mobile applications on PDA's and smart phones, to embedded systems. The benefits of that are twofold. First, it enables the easier deployment of mobile applications in different environments by taking advantage of the common ground provided by adaptable middleware. Second, middleware is a rapidly changing domain where new technologies appear frequently. Yet, up to now, each new technological shift has imposed a complete re-development of the middleware. Having a common ground on which middleware is built would help in such transitions by fostering reuse. In terms of industrial output, the impact of these results will also be helpful for software editors and companies to adapt their products more rapidly to new and emerging middleware technologies.

This research challenge has close links with MDE and product line families. We believe that the added value of our proposal is to cover a more integrated solution: we are not only interested in middleware design with MDE technologies, but we also wish to integrate them with software component technologies and advanced programming techniques, such as AOP. We will then cover a broad spectrum of middleware construction, from design (MDE) to implementation (CBSE) to application development (AOP).

3.2.2. Distributed Application Design for Adaptive Platforms

Considering adaptation in the first design steps of an application allows for its preparation and follow-up during the entire life-cycle. As mentioned previously, some software paradigms help already in the design and the development of adaptable applications. AOSD proposes separation of concerns and weaving of models in order to increase the mastering and the evolution of software. MDE consists of evolving complex software systems by raising the level of abstraction from source code to models. Several programming approaches, such as AOP or reflective approaches, have gained in popularity to implement flexibility. Other approaches, such as CBSE, propose compositional way for reuse and compose sub-systems in the application building. Finally, context-aware programming for mobile environment proposes solutions in order to consider context evolution. Overall, the objective of these approaches is to assist the development of applications that are generic and that can be adapted with respect to the properties of the domain or the context.

The research challenge that we propose to address here is similar to static points of variation in product line families. We plan to study dynamic points of variation in order to take into account adaptation in the first design steps and to match this variation. The first research challenge is the introduction of elements in the modeling phase that allow the specification of evolution related properties. These properties must make it possible to build safe and dynamic software architectures. We wish to express and validate properties in the entire software life cycle. These properties are functional, non-functional, static, behavioral, or even qualitative properties. We also want to be able to check that all the properties are present, that the obtained behavior is the expected one, and that the quality of service is not degraded after the addition or the withdrawal of functionalities. We will base our approach on the definition of contracts expressed in various formalisms (*e.g.*, first order logic, temporal logic, state automata) and we will propose a composition of these contracts.

The second challenge will be to implement design processes that maintain coherence between the various stages of modeling in a MDE approach of the applications, as well as maintaining coherence between the phases of modeling and implementation. To do so, we will design and implement tools that will enable traceability and coherence checking between models, as well as between models and the application at execution time.

Finally, we will introduce context information in the development process. At the modeling level, we will represent concepts, behavior and rules of adaptive systems to express adaptation abstraction. These models will be dynamic and connected to implementation levels at the computational level and they will consider context knowledge. The goal is to bridge the gap between the computational level and the domain level in adaptive systems by synchronization of models and implementations, but also by representation of such common knowledge.

4. Application Domains

4.1. Application Domains

The ADAM project-team targets the software engineering of adaptive service-oriented applications and middleware. The application domain covered by ADAM is broad and spans from distribution applications to middleware. In all these cases, adaptability is the property which is sought: applications and middleware must be adaptable to new execution contexts, they must react to changes in the environment and they must be able to discover and integrate new services.

The ADAM project-team produces software and middleware building blocks. This explains why the application domain is broad, yet targeting applications where adaptability is the key requirement. This includes electronic commerce, embedded systems, health care information systems, and terrestrial transport information systems. These domains are in direct relation with our currently funded activities. They act as testbeds for the solutions that we propose in terms of middleware services, middleware platforms, runtime kernels, component libraries, languages design or domain modeling.

4.1.1. Electronic Commerce

Applications in the domain of electronic commerce are by essence distributed. They involve many different participants with heterogeneous information systems which cannot be changed. The challenge is then to provide an adaptation layer to be able to compose and let these systems interoperate. In the context of the ANR TLog SCOrWare, the ICT SOA4All and the CAPPUCINO projects (cf. sections 8.2 and 8.3), our activities in this domain will aim at supporting service-oriented architectures. We want to have adaptive architectures which can be composed and orchestrated seamlessly. In this domain, the business relationship with customers is vital and many different usage scenarios must be supported. Customers are roaming, and the services must be kept operational across different devices. This puts some constraints on the server tier where technical services must be adapted to manage, for instance, long lasting transactions. The application server infrastructure must then provide a support for adapting technical services.

4.1.2. Embedded Systems

Embedded systems is a domain where adaptation is a key requirement. The design and the implementation of modern embedded software uses advanced software engineering techniques such model-driven development or software component frameworks. In this domain, we are involved in several projects, such as the ANR TLog Flex-eWare, the ANR ARA REVE, and the trade cluster MIND (cf. section 8.2). Several challenges must be addressed here. For example, when a model-driven developed application is adapted, designers have to ensure that the models and the operational level are kept synchronized. The co-evolution of these two levels is one of the challenges that we are addressing. A second challenge is related to software components which need to be customized in order to fit the requirements imposed by constrained environments. It is, for example, a matter of providing component frameworks which can accomodate various granularities of services.

4.1.3. Health Care Information Systems

Health care information systems form a third application domain in which the ADAM project-team is involved, for instance through demonstrators which will be implemented in the context of the ANR TLog FAROS project (cf. section 8.2). The challenge here is to provide a distributed infrastructure where information will be available to medical staff wherever they are. This imposes to be able to provide this information on many different devices (from high resolution screens to embedded devices on the scene of an accident), while ensuring the privacy of the medical data of a patient (several level of data access must be granted depending on the categories of medical staff). Given the vital role of such an information system, we want to provide guarantees that the services will be highly available and trustworthy. We envision to provide a service-oriented architecture which will be extended to support software contracts and multi-scale environments.

4.1.4. Information Systems for Terrestrial Transport

Information systems for terrestrial transport are also a domain that we are relying on, to apply our research activities in accordance with the ANR ARA REVE project and the INRETS collaboration (cf. section 8.2). Applications are here characterized by frequent disconnections, poor quality network links, and high mobility. We want to provide an infrastructure where the technical services, and among others the communication services, can be adapted to support new requirements. One of the paths that we propose to investigate is to include such a scenario in the general context of the adaptiveness of component frameworks.

5. Software

5.1. Introduction

We intend to develop a number of software to evaluate and validate our solutions. We will complete our development by experimentation, benchmarks and deployment in multi-paradigm platforms. We list our actual software that we intend to continue and to extend in the ADAM project-team.

5.2. CALICO

Participants: Laurence Duchien, Estéban Duguepéroux, Anne-Françoise Le Meur, Guillaume Waignier [correspondant].

Following our previous work on component-based architecture design, we have extended CALICO [100], [99] to take into account the design of autonomic systems.

CALICO aims at supporting the design and validation of component-based assemblies. It enables software architects to specify their architectures as models, and to analyze them with respect to application and platform constraints. Analysis may be static or dynamic depending on whether runtime information are needed to check the compatibility of the specified constraints. From the architecture specifications, CALICO can automatically instantiate the running system, as well as the system code instrumentation that is required to perform constraint checking at execution time.

In order to describe autonomic systems, we have extended the previous version of CALICO to add an adaptation metamodel to enable architects to specify the adaptation rules that describe how the system must evolve accordingly to a change in the execution context. Moreover, we have added the support of QoS application properties required to execute autonomic systems. To achieve this goal, we have defined a QoS metamodel and a generic API so that existing QoS sensor frameworks can be integrated into CALICO. The current implementation reuses the WildCat sensor framework [68]. Furthermore, an adaptation engine, based on Event-Condition-Action paradigm, has been integrated in order to control the execution of adaptation rules.

CALICO has been developed in the context of Guillaume Waignier's PhD thesis. CALICO is an open source software available at http://calico.gforge.inria.fr.

5.3. Fractal Deployment Framework

Participants: Christophe Demarey, Nicolas Dolet, Damien Fournier, Philippe Merle [correspondant].

The work on FRACTAL Deployment Framework (FDF) is a part of the Jérémy Dubus's PhD thesis [70]. FDF is a component-based software framework to facilitate the deployment of distributed and heterogenous software systems. FDF supports any kind of deployment activities like uploading, installing, configuring, starting, stopping and uninstalling any kind of software stacks. For this purpose, FDF is composed of a high level deployment language, a library of deployment components, and a set of end-user tools.

The FDF language is a kind of high level scripting language allowing end-users to describe their deployments (*i.e.*, hosts of the target system and software to deploy on them). This language relies on a library of deployment components that wrap various file transfer protocols (*e.g.*, FTP, HTTP, SCP), remote access protocols (*e.g.*, TELNET, SSH), Unix and Windows shells, Internet-related notions (*e.g.*, hostname, port, host), and software (*e.g.*, middleware, services, daemons, application servers, application components). FDF also provides a graphical user interface allowing end-users to load their deployment descriptions, execute and manage them.

Currently, FDF supports the deployment of SOA-based systems (BPEL processes, ActiveBPEL and OW2 Orchestra BPEL engines, SCA and both FraSCAti and Apache Tuscany runtimes, JBI components and OW2 PEtALS distributed ESB), JEE-based systems (EAR, WAR, EJB and RAR, application servers, such as Apache Geronimo, JBoss, OW2 JOnAS or SUN GlassFish, OW2 JASMINe administration tool), Web-based systems (Apache Tomcat servlet container, HTTPd server), CORBA-based systems (CORBA middleware, OW2 OpenCCM, business components, and applications), OW2 FRACTAL-based systems (Julia, FRACTAL ADL, and RMI), Java-based systems (Apache Ant, SUN JRE, JamVM for Linux PDA), database systems (MySQL), network services (OpenLDAP server), and operating systems (QEMU).

In [72], we have shown how FDF can be self-deployed on Grid'5000, the french grid infrastructure dedicated to computer science research, in order to deploy large-scale distributed software systems.

FDF is designed with the OW2 FRACTAL component model, see section 5.4, and is implemented on top of its Java-based tools (Julia, Fraclet, FRACTAL ADL, RMI, and Explorer).

FDF is LGPL open source software hosted by the INRIA Forge at http://fdf.gforge.inria.fr, and is being developed since 2006. Known usages of FDF by external people include the deployment of the Jade autonomous platform (INRIA SARDES project), and the integration of FDF into the JOnAS JEE application server (http://jonas.ow2.org) and the JASMINe SOA platform management tool (http://jasmine.ow2.org) developed by Bull SA, and the PEtALS JBI implementation developed by EBM WebSourcing (http://petals.ow2.org). All these open source projects are hosted by the OW2 consortium. FDF is composed of around 25.000 lines of Java code and 21.000 lines of FRACTAL ADL descriptions.

5.4. Fractal

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

FRACTAL is a modular, extensible and programming language agnostic component model that can be used to design, implement, deploy and reconfigure systems and applications, from operating systems, middleware platforms to graphical user interfaces [61], [65], [85]. FRACTAL has been designed by both INRIA and France Telecom R&D. FRACTAL is also an open source software project hosted by the OW2 international consortium and is available at http://fractal.ow2.org [51].

Philippe Merle is the leader of the OW2 FRACTAL open source project. The ADAM project-team actively contributes to this project, and more specifically on the following modules:

- **AOKell** is an aspect-oriented implementation of the FRACTAL component model [95].
- **Fraclet** is an attribute-oriented programming model enabling the rapid development of FRACTAL components [15].
- **Fractal ADL** is the extensible architecture definition language for FRACTAL associated to an open FRACTAL component-based toolchain.
- **Fractal Distribution** is the module to produce packaged releases of the FRACTAL project.
- **Fractal Documentation** is the module to produce the whole documentation of the FRACTAL project.
- **Fractal Eclipse Plugin** is a plugin to create FRACTAL projects within the Eclipse IDE [49], [50]. This work was supported by an INRIA ODL and is contributed to the FUI MIND project.
- **Fractal Explorer** is a framework to build graphical consoles to introspect and manage FRACTAL components dynamically at runtime.

- **Fractal RMI** is a binding framework for distributed FRACTAL components.
- **Juliac** is an extensible framework for generating and compiling the code of FRACTAL component-based systems.
- **Koch** is an implementation of the FRACTAL component model where components have a component-based control membrane.

5.5. FraSCAti

Participants: Christophe Demarey, Nicolas Dolet, Damien Fournier, Philippe Merle [correspondant], Lionel Seinturier.

FraSCAti is a runtime platform for the *Service Component Architecture* (SCA) component framework. SCA is an initiative for unifying *Service Oriented Architectures* (SOA) and *Component-Based Software Engineering* (CBSE). SCA is supported by the Open SOA consortium, which includes partners, such as IBM, Oracle, Sun and Iona, and will become a set of standardized OASIS's specifications. FraSCAti includes Tinfi, which provides a SCA personality for the FRACTAL component model. Thanks to the openness of this latter model, the necessary code elements (so called *controllers* and *membranes*) have been designed and developed to customize FRACTAL and to end up with components owning both a FRACTAL personality and a SCA personality. As far as we know, this result is original and is the first one to concretely demonstrates that FRACTAL is open and flexible enough to implement different component personalities. Moreover, Tinfi reuses the aspect-oriented concepts defined in FAC [89] for component-based programming and allows integrating smoothly non functional concerns (so called intents and policy sets in SCA terms). FraSCAti and Tinfi have been implemented by reusing modules developed in the context of the FRACTAL project, and among others, the Juliac FRACTAL compiler. The development of the FraSCAti platform is conducted in the context on some current and past funded project (ICT FP7 SOA4All Integrated Project, ANR TLog SCOrWare project).

FraSCAti is LGPL open source software, hosted by the OW2 consortium since November 2008 at http://frascati.ow2.org.

5.6. Hulotte

Participants: Frédéric Loiret [correspondant], Aleš Plšek, Lionel Seinturier.

Component-based technologies are widely used in various application domains (from grid computing to embedded systems) for which the functional needs are heterogeneous. To cope with such an heterogeneity, the execution infrastructures that provide the basic services required by the applications should be adapted to these targeted domains. Within ADAM, various works have been conducted to carry out this adaptation needed at infrastructure level, in particular :

- by using generative approaches allowing the generation of the sub-set of the infrastructure dedicated to the targeted domain,
- by exploiting the component paradigm not only at applicative level but also at infrastructure level. This allows us to capture the invariants of the infrastructure that could be reused independently of the targeted domain.

Hulotte is a generic framework focused on these two aspects. The originality of Hulotte is to be based on a flattened and unified representation of the whole system—*i.e.*, it allows reasoning on the applicative level as well as the infrastructure level. It is a mandatory requirement in order to ease the generation of domain-dependent components based on global properties of the system. The experiment described in [82] has been conducted using Hulotte. Hulotte is also based on several software developed within the ADAM team: Juliac, Koch, Spoon.

5.7. SPACES

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

SPACES is a context mediation middleware that follows the *REpresentational State Transfer* (REST) principles [71]. The current implementation of SPACES is based on COSMOS context framework [64], [93] and the COMANCHE web server [61]. Both, COSMOS and COMANCHE are based on the FRACTAL component model and use the JULIA implementation of the FRACTAL runtime environment [61].

The main features of the current SPACES implementation are presented below:

1. *Ubiquitous connectors*: SPACES define connectors that encapsulate the distribution concern. These connectors expose the COSMOS context nodes as REST resources with logical URLs associated, and enable interactions between consumers and producers via different communication protocols and the discovery of the available context sources. The current SPACES implementation supports interaction using the HTTP and twitter [81] protocols. For the discovery, the implementation uses the Service Location Protocol (SLP) [75].
2. *Context Representation*: Following the REST principles, SPACES support multiple representations of the context information: JSON [66], XML and Java serialization.
3. *Quality of context (QoC) information*: The QoC properties are incorporated as service attributes in the SLP advertisements of the context information.
4. *Context selection*: The restrictions in terms of QoC of the required context information are expressed as LDAP filters [96]. SPACES benefits from the LDAP based queries of SLP to select the context providers.

We use the XStream 1.3.13 [60] and JSON-lib 2.2.34 [59] to serialize context information as XML and JSON documents. For SLP and twitter we employ jSLP 1.0.0 [92] and twitter-4j 2.0.6 [102].

5.8. M2C

Participants: Pierre Carton, Laurence Duchien, Carlos Andres Parra Acevedo, Nicolas Pessemier [correspondant], Clément Quinton.

Model2Code (M2C) is directly connected to the work of Carlos Parra's PhD which covers the definition and implementation of a Context-Aware Dynamic Software Product Line (DSPL) named CAPucine. It provides a set of tools for metamodel transformation and code generation. The current implementation of M2C addresses transformation from CAPucine metamodel towards OSOA SCA metamodel, and Spoon EMF metamodel. The transformations were formerly written in pure Java, and are now in QVT language, which is a dedicated language for transformation, enhancing the readability. M2C meta models are based on the Eclipse Modeling Framework. Code generators are all written in Java. The M2C project will be soon published as a LGPL project in the INRIA Gforge repository.

5.9. TRASER

Participants: Laurence Duchien, Julien Ellart [correspondant], Gabriel Hermosillo, Lionel Seinturier.

Today's companies are suffering changes in the way they deal with their inventories and the management of their whole supply chain. New technologies are emerging to help them adapt to these changes and keep a competitive status, but the adoption of such technologies is not always easy. Even though a lot of research has been done for RFID, there are still some areas that are being left aside, like the traceability aspect, which is one of the most important in the retail supply chain. We propose a service named TRASER (TRAceability SErvice for the Retail supply chain) that will help companies to adopt new technologies into their existing environments, dealing with persistence and traceability, and allowing users to manage their operation according to their business rules, workflows and historical data [18]. This service is part of the whole platform ICOM, which goal is the creation of a shared technical infrastructure which is generic, parametrized and capable of managing the communication of heterogeneous systems (RFID, bar codes, NFC, etc.), within them and with existing IT services, and so to help companies to exploit and benefit from the current technologies. TRASER uses OW2 Nova Bonita as a workflow engine. TRASER has been developped in the context of the ICOM project, funded by «Pôle de compétitivité» PICOM and the Région Nord-Pas-de-Calais and is published as a LGPL project in the INRIA Gforge repository.

6. New Results

6.1. Adaptive Middleware for SOA

Participants: Nicolas Dolet, Damien Fournier, Philippe Merle, Lionel Seinturier.

The Service Component Architecture (SCA) is a technology agnostic standard for developing and deploying distributed service-oriented applications. However, SCA does not define standard means for runtime manageability (including introspection and reconfiguration) of SOA applications and of their supporting environment. [27] presents the FraSCAti platform, which brings runtime management features to SCA, and discusses key principles in its design: the adoption of an extended SCA component model for the implementation of SOA applications and of the FraSCAti platform itself; the use of component-based interception techniques for dynamically weaving non-functional services such as transaction management with components. [27] presents micro-benchmarks that show that runtime manageability in the FraSCAti platform is achieved without hindering its performance relative to the de facto reference SCA implementation, Apache's Tuscany.

A poster on FraSCAti [52] was also presented at the GDR GPL national days.

For more details on FraSCAti, see section 5.5.

6.2. Software Components for Embedded Systems

6.2.1. Components-Based Software Engineering for Embedded Systems

Participants: Frédéric Loiret, Guillaume Libersat, Philippe Merle, Lionel Seinturier.

As embedded systems must constantly integrate new functionalities, their development cycles must be based on high-level abstractions, making the software design more flexible. Component-Based Software Engineering (CBSE) provides an approach to these new requirements. However, low-level services provided by operating systems are an integral part of embedded applications, furthermore deployed on resource-limited devices. Therefore, the expected benefits of CBSE must not impact on the constraints imposed by the targeted domain, such as memory footprint, energy consumption, and execution time. According to these considerations, two new results can be put forward:

- we have "componentized" a legacy industry-established Real-Time Operating System (microC/OS-II) and provided a design space for component-based applications built on top for it [22]. We used the Think framework that allows the creation of flexible systems while paying for flexibility only where desired. We have performed experimentations showing that the induced overhead by the component-based design is negligible.
- we have proposed a tool-assisted methodology based on the notions of multi-view specification and model refinement that aims at providing a way for the operating system developers to use these technologies while still being able to stick to the strict requirements of operating systems.

6.2.2. Constructing Domain-Specific Component Frameworks

Participants: Frédéric Loiret, Guillaume Libersat, Philippe Merle, Aleš Plšek, Lionel Seinturier.

The success of Component-Based Software Engineering has been proved by the variety of its applications, from the general component frameworks, such as Fractal, to domain specific component frameworks (DSCF) addressing a wide scale of challenges such as embedded or real-time constraints, dynamic adaptability, distribution support. DSCF offers a domain-specific component model and a tool-support that allow developers to address domain-specific challenges by using appropriate abstractions available at the component-model level. Although, the ad-hoc nature of these frameworks hamper the reuse of features across different domains. According to our experience in this field, we believe that DSCFs actually share many architectural concepts, design patterns, and principles that are applied when designing and implementing the domain-specific parts of these frameworks. From this observation, we proposed Hulotte [21] for the specification and implementation of arbitrary domain-specific concerns in a unified way, which is easily extensible towards different application domains. Hulotte relies on a generic component model for which the architectural artifacts are annotated by domain-specific annotations. The latter are then implemented by dedicated runtime infrastructures within extensible component containers. Moreover, Hulotte allows the definition and checking of domain-specific constraints from components' architecture to their implementations [25]. Hulotte has been experimented for RTSJ-based systems (Real-Time Specification for Java), distributed and reconfigurable component-based systems.

6.3. Middleware for Context-awareness and Ambient Intelligence

6.3.1. Integrating Context Information as RESTful services

Participants: Russel Nzekwa, Daniel Romero, Romain Rouvoy, Lionel Seinturier.

In pervasive environments, the context information is used by applications in order to adapt their behavior to the current user needs. To access this context information, it must be advertised, discovered, and selected according to its properties. All of these operations must be performed with respect of the heterogeneity in terms of providers and consumers, as well as the mobility typical to pervasive environments. Unfortunately, although context dissemination [63] is a keystone in pervasive environments, existing approaches fail to do so in a flexible way. To tackle this problem, we have proposed SPACES [37], a simple but efficient middleware solution for flexible context distribution in pervasive environments. SPACES defines ubiquitous software connectors following the *REpresentational State Transfer* (REST) principles [71].

These ubiquitous connectors not only expose the context as REST resources that are accessible via different interaction protocols, but also enable spontaneous interoperability [79], [103] between clients and providers.

Our middleware solution benefits from the extensibility of the discovery protocols to augment the context advertisement with *Quality of Context* (QoC) properties [69], [62].

SPACES also applies LDAP filters [96] to select the context providers based on this QoC information.

In this way, our approach fosters the notion of context as RESTful services that can be accessed by heterogeneous entities. SPACES has been applied on the legacy COSMOS framework [64], [93] to allow the definition of distributed context policies, and validated with a smart home scenario.

6.3.2. Middleware Support for Stable Self-Adaptation in Ubiquitous Environments

Participants: Russel Nzekwa, Romain Rouvoy, Lionel Seinturier.

The correct behavior of pervasive applications requires continuous system adaptation, according to the changes observed in the application environment. Adaptation is a costly process for the system, therefore it should happen only when significant variations occur. Several pervasive applications use various stabilization techniques to reduce the overhead introduced by the system reconfiguration. But usually, the implementation of stabilization techniques is done in an ad-hoc, non-reusable, non-flexible way. The key motivation of our work, is to provide a flexible and generic approach to handle the stabilization of pervasive applications. In our approach [53], [34], we first propose our vision of the stabilization of context-aware applications, where the stabilization mechanisms are located before and after the decision making block. Then, we present a flexible methodology to stabilize pervasive systems, by composing stabilization mechanisms. These stabilization mechanisms have been applied on the legacy COSMOS framework [64], [93] to improve the quality of context inference.

6.3.3. Context-Aware Modelling and Dynamic Adaptation

Participants: Xavier Blanc, Pierre Carton, Laurence Duchien, Carlos Andres Parra Acevedo, Nicolas Pessemier.

Context-aware applications are applications that can react to changes on their environment. To achieve such reacting behavior, several challenges have to be faced in terms of: context management, support for dynamic reconfiguration, automation of development, and a consistent development process. One possible way to face those challenges is to use the principles of Software Product Line (SPL) and specifically dynamic SPL (DSPL). DSPLs focus on variability management and aim at deriving different products from a same product family. Additionally, DSPLs allow for products to be derived both at design and at runtime. This enables applications to be adapted during execution and dynamically fit new requirements or resource changes. In [26] we have presented a Dynamic Software Product Line to build context-aware systems based on SOA services named CAPucine (Context-Aware Software Product Line). Such DSPL enables a complete service development from requirements to implementation, and a management of context throughout the software life-cycle. We have defined at the same time a service-oriented and context-aware derivation process that monitors the context information in order to dynamically integrate the appropriate assets in a running system. Our target applications follow the service-oriented approach. We used FraSCAti, an SCA platform with dynamic properties, and sensed information from the environment, to dynamically realize the product derivation. Additionally in [36] we have also identified new ways of apply such approach of DSPL, in the domain of Web Services. To enhance the DSPL, we have started to study a high level representation of variability that can be easily transformed and used at design time as well as at runtime. A possible workaround to such problematic refers to Aspect Oriented Modeling. Using aspect models to express variability allows developers to define separated concerns. Afterwards, each model representing a different concern can be woven statically or dynamically depending on the particular needs for the product being designed or adapted. This work corresponds to Carlos Parra's PhD thesis and is partially funded by the CAPPUCINO project.

6.3.4. Adaptation Models for Complex Event Processing

Participants: Laurence Duchien, Julien Ellart, Gabriel Hermosillo, Lionel Seinturier.

Context information could be read from sensors, but also from RFID, NFC, bar code readers. We need to process these events for an integration into software systems. CEVICHE is a framework that intends to facilitate the integration of Complex Event Processing into existing business processes and to allow these processes to be adapted to different circumstances [33]. As part of this framework, there exists a Standard Business Process Language (SBPL) which is used to gather all the information about the processes, contextual environment, business rules and adaptation conditions in a simple XML file. The goal of CEVICHE is to be able to work with any CEP engine available, using the same SBPL file to configure the business processes and rules. To achieve this, the SBPL file is sent to a translation framework which will use a specialized translation plug-in to adapt the information in the file to specific CEP engine's format. This way, if we want to use another CEP engine, all we have to do is change the plug-in, without rewriting all the specifications of the business processes. CEVICHE relies on different technologies to achieve the process adaptation. It needs a CEP engine that will manage the business rules, it uses COSMOS to deal with context-awareness feeding all the context changes to the CEP engine and finally it uses AO4BPEL to adapt the existing processes in runtime without the need to redeploy the processes, avoiding to lose all the current transactions by doing so. CEVICHE is the subject of Gabriel Hermosillo's PhD. thesis and is still in development. It will include a user interface to generate the SBPL file, a translation framework to deploy the business rules in different CEP engines and an aspect manager to handle the changes in the business processes.

This work is partially funded by the ICOM project.

6.4. Software Evolution

6.4.1. Static and Dynamic Checking of Component Interactions

Participants: Laurence Duchien, Anne-Françoise Le Meur, Guillaume Waignier.

Building autonomic applications, *i.e.,* systems that must adapt to their execution context, requires architects to calibrate and validate the adaptation rules by executing their applications in a realistic execution context. Unfortunately, existing works do not allow architects to monitor and visualize the impact of their rules, nor that they let them adjust these rules easily.

In the context of Guillaume Waignier's PhD thesis, we are working on a model-based framework that enables architects to design and debug autonomic systems in an iterative and uniformed process [30], [55], [35]. This work has led to the extension of our previous work, called CALICO, a Component AssembLy Interaction Control FramewOrk (cf. sections 5.2). At design-time, architects can specify, using models, the application's structure and properties, as well as the desired adaptation rules. At debugging-time, the running application and the models coexist such that the models control the application dynamic adaptation, thanks to a control loop that reified runtime events. Each triggered adaptation is first tested at the model level to check that no application property is broken. Furthermore, architects can modify the models at any time in order to adjust the adaptation rules or even parts of the application. All changes at the model level, if checked correct, are directly propagated to the running application.

Furthermore, our solution is generic regarding the underlying platforms. The current version of CALICO handles three component-based platforms. Moreover, the benchmarks of our implementation show that CALICO is usable to design reliable large systems up-to 10000 components, which is the maximum load of most runtime platforms.

CALICO is available on http://calico.gforge.inria.fr.

6.4.2. Detection of Design Defects

Participants: Laurence Duchien, Anne-Françoise Le Meur.

Following Naouel Moha's Ph.D. thesis [86], two journal papers have been submitted and accepted.

One paper focuses on the detection of code and design smells in software systems. More precisely, it presents an approach to automate the generation of algorithms from specifications written using a domain-specific language [14].

The other paper presents the DECOR method, which embodies and defines all the steps necessary for the specification and detection of code and design smells. The paper presents also a concrete implementation and an empirical validation of the method [13]. This paper represents the core of Naouel Moha's Ph.D. thesis [86].

7. Contracts and Grants with Industry

7.1. Thales

Participants: Jonathan Labejof, Philippe Merle, Lionel Seinturier.

This contract is associated to the CIFRE Ph.D thesis of Jonathan Labejof between ADAM and the Thales company. The goal of the project is to study the evolution of heterogeneous service-oriented architectures. We address two problems. First, we study some various forms of support for heterogeneity in service architectures in terms of communication protocols and software component personalities. Second, we propose solutions for systems which are agile and respond smoothly to changes in their execution contexts. Overall, the goal of this project is to propose to design a model for adaptability, a runtime infrastructure and to provide some means by which these two levels can be causally connected and kept consistent.

8. Other Grants and Activities

8.1. Local Initiatives

8.1.1. INRIA ADT CALICO

Participants: Laurence Duchien, Estéban Duguepéroux, Anne-Françoise Le Meur, Guillaume Waignier.

The CALICO ADT (Action de Développement Technologique) is an ADT local to the INRIA Lille Nord Europe Center that aims to maintain and develop the CALICO framework (cf. sections 5.2). The architecture of CALICO is based on a co-evolution approach where the model level enables software architects to describe and reason on application properties, and the runtime level holds the running application executing on a given platform. CALICO is generic and extensible in terms of target platforms, analyses at the model level, etc. This particularity makes CALICO a framework that could federate several of the ADAM research works and integrate external contributions. Estéban Duguepéroux (newly graduated engineer) has been recruited in the context of this INRIA ADT.

8.2. National Initiatives

8.2.1. ANR ARA REVE

Participants: Laurence Duchien, Christophe Gransart, Anne-Françoise Le Meur, Frédéric Loiret, Aleš Plšek, Lionel Seinturier.

REVE (*safe Reuse of Embedded components in heterogeneous enVironmEnts*) is a 3-years project funded by the ANR ARA SI (Sécurité, Systèmes embarqués et Intelligence Ambiante) program of the ANR. Five partners are involved: CEA, CNAM, INRETS, INRIA, and INSA. The objective of the project is to define a component model, a type system, and an execution platform for context-aware embedded applications [80]. Lionel Seinturier is the scientific leader of this project. The project has started in January 2006 and is scheduled for a 42-months period. Further information is available on the website of the project: http://www.ara-reve.org.

8.2.2. ANR ARPEGE SALTY

Participants: Laurence Duchien, Philippe Merle, Russel Nzekwa, Romain Rouvoy, Lionel Seinturier.

SALTY is a 3-year ANR ARPEGE project started in November 2009 and involving University of Nice, Deveryware, EBM WebSourcing, INRIA ADAM, MAAT-G France, Thales, University Paris 8 and University Paris 6.

The main objective of the SALTY project is an autonomic computing framework for large-scale service-oriented architectures and infrastructures. The SALTY project will result in a coherent integration of models, tools and runtime systems to provide a first end-to-end support to the development of autonomic applications in the context of large-scale SOA in a model-driven way, including never-covered aspects such as the monitoring requirements, the analyse (or decisionmaking) model, and an adaptation model tackling large-scale underlying managed components. The project will be validated by two large use-cases: a neurodegenerative disease study for exploring the capacity of grid infrastructures and a path tracking application for exploiting the different positioning methods and appliances on a fleet of trucks.

Further information is available on the website of the project: http://salty.unice.fr.

8.2.3. ANR ARPEGE ITEmIS

Participants: Jonathan Labejof, Philippe Merle, Lionel Seinturier.

ITEmIS is a 30-months ANR ARPEGE project started in March 2009 and involving Thales, EBM WebSourcing, INRIA ADAM and ARLES, LAAS,ScalAgent, IRIT.

The ITEmIS project aims at easing the evolution from today's world ofseparate lightweight embedded applications and IT services to the futureworld of seamlessly integrated services, thus qualifying and defining anew generation SOA enabling IT and Embedded Integrated Systems (ITEmISsystems). This endeavour is undertaken along three main lines: (1) Atbusiness level, where IT/embedded services are integrated into advancedworkflows supporting the multi-faceted interoperability and scalabilityrequired for ITEmIS systems; (2) At service infrastructure level, byintroducing a specialized ESB-based and component-based solutionaddressing the requirements of the embedded world including deployment;and (3) Transversally for both above levels addressing end-to-endassurance of Quality of Service (QoS) and correctness verification ofdeployments and workflows at the level of their execution models. ThePhD thesis of Jonathan Labejof is conducted in the context of this project.

8.2.4. ANR TLog FAROS

Participants: Laurence Duchien, Damien Fournier, Anne-Françoise Le Meur, Lionel Seinturier, Guillaume Waignier.

FAROS (composition de contrats pour la Fiabilité d'ARchitectures Orientées Services) is an ANR TLog project involving EDF R&D, France Telecom, Alicante, IRISA, I3S and LIFL. This project addresses issues related to the safe integration of services in service-oriented architectures. The overall goal of this project is to provide a methodology to guide and automate the different tasks involved in the integration process, thus enabling the integration process to become reproducible. Our approach will be based on the definition of contracts, which will allow static and dynamic verifications to be performed. The feasibility of our approach will be demonstrated through the development of three dynamic and constrained applications (Health, Education, Electricity).

The project has started in January 2006 and is scheduled for a 36-months period. Several deliverables have been produced this year [48], [46] and the final review was at the end of September 2009. Further information is available on the website of the project: http://www.lifl.fr/faros.

8.2.5. ANR TLog Flex-eWare

Participants: Frédéric Loiret, Philippe Merle, Aleš Plšek, Lionel Seinturier.

Flex-eWare is a 3-years ANR TLog project (of type "*plate-forme exploratoire*"), which has started on January 1st 2007. The project aims at defining an open and adaptable middleware platform for component-based applications in the domain of embedded systems. This project addresses issues that are related to components, software architectures, and adaptable middleware. One of the research challenges of this project is to be able to define software components, which are context-aware and can take into account the specificities in terms of resource management of the targeted embedded systems. Besides, Flex-eWare aims at federating and unifying the component approaches (Lw-CCM and FRACTAL) of the industrial and academic partners of the project, consolidating these technologies for the domain of embedded systems, and opening and fostering the use of these technologies by contributing some reference open source implementation. The partners of this project are: Thales (leader), France Telecom, Schneider, STMicroelectronics, Teamlog, Trialog, CEA, ENST, INRIA, Univ. Paris 6. Further information is available on the website of the project: http://www.flex-eware.org.

8.2.6. ANR TLog SCOrWare

Participants: Nicolas Dolet, Damien Fournier, Philippe Merle, Lionel Seinturier.

SCOrWare is a 24-months ANR TLog project started in January 2007, closed in March 2009, and involving Artenum, EBM WebSourcing, Edifixio, INRIA (ADAM, OW, and Sardes project-teams), INT, IRIT, Obeo, Open Wide, and Thales Communications. Philippe Merle is the scientific leader of the project.

The SCOrWare project has tree main goals: 1) Studying links between *Service-Oriented Architectures* (SOA) and architectural component-based approaches, and especially similarities/differences between *Service Component Architecture* (SCA), *Java Business Integration* (JBI), and FRACTAL component models, 2) developing a component-based implementation of the SCA specification, and 3) developing high-level MDE tools that will help end-users to adopt this new technology. For more details, see at http://www.scorware.org.

The main ADAM's contributions are: FraSCAti (see section 5.5) to support at runtime the SCA component model, and FDF (see section 5.3) to deploy distributed SCOrWare infrastructures and applications.

Deliverables involving ADAM are [40], [43].

8.2.7. INRIA ADT Galaxy

Participants: Christophe Demarey, Philippe Merle, Lionel Seinturier.

The galaxy ADT (*Technology Development Action*) contributes to make INRIA a value-added player in the SOA arena, by designing and developing an Open Framework for Agile and Dynamic Software Architecture. This ADT will work for INRIA and INRIA's research project-teams direct benefit, and aims at pre-assembling technological bricks from various teams, projects and preparing them to be transferred through the open source software channel.

The goal of the galaxy ADT is to provide an IT agile platform, built on dynamic software architecture principles, and fitting for flexibility, dynamical reconfiguration, adaptability, continuity and autonomic computing. FRACTAL, SCA-FraSCAti and GCM-ProActive are the major technologies which will be the technological drivers of this ADT. The different usage scenarios as well as the different tools which will be developed at infrastructure, application and business levels will demonstrate that this platform is able to support the design, modelling, deployment and execution of business processes. At the same time, the ADT will target the definition of a new common language to manipulate dynamically adaptive distributed SOA-based systems, encompassing application and middleware layers. This common language will take different forms, inherited from works done by several project-teams with their distinct skills, and illustrates a new kind of collaboration between teams, coupling research and development works.

A demonstration of the agile galaxy platform was presented at Java One - San Francisco - 1st to 5th june 2009 (http://www.inria.fr/actualites/2009/javaone.en.html).Especially, Christophe Demarey showed reconfiguration of SOA applications with our OW2 FraSCAti open source platform.

Contributors to this ADT are mainly research project-teams, including ADAM, ECOO, OASIS, OBASCO, SARDES and TRISKELL, and the galaxy ADT is led and managed by the TUVALU team. For more details, see at http://galaxy.gforge.inria.fr.

8.2.8. INRIA ADT Ubinov

Participants: Laurence Duchien, Nicolas Dolet, Nicolas Pessemier, Clément Quinton.

The UbiNov ADT (Action de Développement Technologique) aims at building a Software Product Line (SPL) for mobile applications. This SPL allows developers to build context-aware and dynamic reconfigurable applications for mobile devices in ubiquitous environments, reusing the technologies developed in the ADAM project-team. Clément Quiton (INRIA ADAM New Graduate Engineer) has been recruited to achieve this task. The produced SPL will be transfered to a spin-off led by Nicolas Dolet and Nicolas Pessemier (INRIA ADAM Engineers).

8.2.9. INRIA ARC BROCCOLI

Participants: Philippe Merle, Romain Rouvoy, Lionel Seinturier, Alban Tiberghien.

The goal of the BROCCOLI ARC project is to design a platform for describing, deploying, executing, observing, administrating, and reconfiguring large-scale component-based software architectures, in particular for building discrete event simulation applications. Both the platform and the applications considered are based on software components and architecture description languages, and in particular on the FRACTAL component model. Therefore, the main issue addressed in this project is the scalability of such component-based architectures based on FRACTAL. Indeed, by allowing FRACTAL to scale-up to millions of components running on thousand of nodes, our aim is to establish the foundations of a massively distributed component-based simulator based on FRACTAL. However, the Broccoli road is paved of ambushes: existing ADLs are insufficient to describe very large architectures, the numerous data-flows and statistics generated by observations need smart context management policies, and distributed simulation is a long studied but still challenging problem, especially when combined with AOP techniques and FRACTAL special features such as shared components.

This project establishes a collaboration between the INRIA MASCOTTE and ADAM project-teams, and Télécom SudParis ACMES team. For more details, see at http://golgoth.inria.fr/oldwiki/Contrats/Broccoli.

8.2.10. Trade cluster CAPPUCINO

Participants: Pierre Carton, Laurence Duchien, Carlos Andres Parra Acevedo, Nicolas Pessemier, Daniel Romero, Romain Rouvoy, Lionel Seinturier.

CAPPUCINO (Construction et Adaptation d'aPPlications Ubiquitaires et de Composants d'INtergiciels en environnement Ouvert pour l'industrie du commerce) is a 36-months project of the competitiveness cluster of trade industry of Nord/Pas-de-Calais PICOM (Pôle des Industries du COMmerce – http://www.picom.fr), which has started in September 2007. The Project CAPPUCINO aims to propose reliable solutions with the design, the deployment and execution problems of applications for ambient environments in the trade industry. This project addresses issues which are related to modeling context-aware information for ambient environments and take into account this information into runtime platforms. We propose to study the adaptation of the components - application components and execution platform supports - and their context evolution throughout the complete lifecycle of the application. The first ADAM's results are described in the section 6.3.

Several deliverables have been produced this year [41], [47], [39], [38].

The PRES - University Lille - Nord de France has awarded the research prize "Collaborative project" 2009 of the competitiveness cluster of trade industry (PICOM) to the CAPPUCINO Project.

The partners of this project are NorSys (leader) which is a SME service company, TELCOM SUD Paris (School of Telecom industry), INRIA, AUCHAN and SI3SI (2 trade companies).

8.2.11. Trade cluster ICOM

Participants: Laurence Duchien, Julien Ellart, Gabriel Hermosillo, Lionel Seinturier.

This project is realized in the context of the competitiveness cluster of trade industry of Nord-Pas de Calais PICOM (Pôle des Industries du COMmerce – http://www.picom.fr) and it has started in March 2008 and is a 24-months project. Trade industry is being in constant evolution. The massive presence of the Internet, the increasing exigence of quality of service, the ubiquitous and pervasive informatics shatter the traditional trade practices, their economical and organizational models.

ICOM (Infrastructure pour le COMmerce du futur) aims at helping enterprises to enable a fast and easy deployment of new applications using new technologies and infrastructures from ubiquitous informatics. It will provide a smart infrastructure that will hide the heterogeneity of identifiers (RFID, NFC, bar code) and manage data storage and request routing to provide scalability.

A deliverable has been produced this year [42].

The partners of this project are Atos Origin, Auchan, Décathlon, La Poste, La Redoute, INRIA-ASAP, INRIA-ADAM, INRIA-POPS, GS1, ORANGE France.

8.2.12. Trade cluster MIND

Participants: Yann Davin, Damien Fournier, Frédéric Loiret, Rémi Mélisson, Philippe Merle, Lionel Seinturier.

MIND is a 2-years project funded by the Minalogic cluster on micro- and nano-technologies. The project started in 2008. It aims at consolidating the component-based technologies and the tools, which exist around the FRACTAL component model for building middleware and systems. The goal is to transfer these results into an industrial strength software tool suite in order to foster the adoption of the component-based technologies for designing and developing embedded applications and systems. The partners of this project include: STMicroelectronics (Leader), CEA, France Telecom R&D, Grenoble 1, INERIS, INRIA, ICT, ISTIA, Itris Automation Square, LOGICA, Schneider Electric, Sogeti High Tech, VERIMAG.

8.3. European Initiatives

8.3.1. EGIDE PHC Aurora: University of Oslo

Participants: Gabriel Hermosillo, Daniel Romero, Romain Rouvoy, Russel Nzekwa, Lionel Seinturier, Alban Tiberghien.

For the last years, Internet has been catalyzing the development of large scale distributed systems. These distributed systems provide users with advanced interaction artifacts developed to achieve a common objective. These systems, while still being investigated predominantly in the defense sector, is also seeing application in such fields as national air and auto transportation, space exploration, and health care, to name a few. These systems, also known as *Systems-of-Systems* (SoS) are made of heterogeneous pieces of software, which need to be combined in order to build a coherent platform. Keating, et al. define SoS as meta-systems that *"are themselves comprised of multiple autonomous embedded complex systems that can be diverse in technology, context, operation, geography and conceptual frame"*. A remaining challenge of SoS is the dependability and adaptation dimensions. From a scientific perspective the objective of this collaboration is to jointly research and develop common research projects with the goal of providing innovative approaches for the dependability and the adaptation of Systems of Systems. In particular we aim at developing a common framework that will include a comprehensive support for the following aspects:

- **Hierarchical SoS adaptation** is concerned with the layered adaptation of SoS. This activity consists in developing adaptation mechanisms that support the consistent adaptation of of the different layers of a SoS, from the high level application down to the low level hardware resources;
- **Decentralized SoS adaptation** is concerned with the large scale adaptation of SoS. This activity consists in developing adaptation mechanisms that are able to perform adaptations independently based on information communicated by other adaptation mechanisms deployed in the system;
- **Dependable SoS adaptation** is concerned with the development of advanced adaptation mechanisms that are capable to cope with failure of non-dependable components. Our second objective is to make the adaptation planning mechanism itself fault-tolerant;
- **Adaptive SoS dependability** is concerned with providing multiple levels of guarantees, by deploying a variety of mechanisms that achieve adaptation planning in a coordinated fashion. The mechanisms belong to two categories: i) consistent replication techniques based on reliable group communication, and ii) strong agreement protocols.

8.3.2. ERCIM Working Group Software Evolution

Participant: Laurence Duchien.

The Working Group (WG) on Software Evolution is one of the many working groups supported by ERCIM. The main goal of the WG is to identify a set of formally-founded techniques and associated tools to support software developers with the common problems they encounter when evolving large and complex software systems. With this initiative, the WG plans to become a Virtual European Research and Training Centre on Software Evolution. Read more at http://www.planet-evolution.org.

8.3.3. IAP MoVES

Participants: Laurence Duchien, Carlos Andres Parra Acevedo, Aleš Plšek, Daniel Romero, Guillaume Waignier.

The Belgium IAP (Interuniversity Attraction Poles) MoVES (Fundamental Issues in Software Engineering: Modeling, Verification and Evolution of Software) is a project whose partners are the Belgium universities (VUB, KUL, UA, UCB, ULB, FUNDP, ULg, UMH) and three European institutes (INRIA, IC and TUD) respectively from France, Great Britain and Netherlands. This consortium combines the leading Belgian research teams and their neighbors in software engineering, with recognized scientific excellence in MDE, software evolution, formal modeling and verification, and AOSD. The long term objective of our network is to strengthen existing collaborations and forge new links between those teams, and to leverage and disseminate our research expertise in this domain at an European level. The project focusses on the development, integration and extension of state-of-the-art languages, formalisms and techniques for modeling and verifying dependable software systems and supporting the evolution of Software-intensive systems. The project has started in January 2007 and is scheduled for a 60-months period. Read more at http://moves.vub.ac.be

8.3.4. ICT FP7 SOA4All Integrated Project

Participants: Nicolas Dolet, Philippe Merle, Alban Tiberghien.

Service-Oriented Architectures for All (SOA4All) is a large-scale Integrating Project funded by the European Seventh Framework Programme, under the Service and Software Architectures, Infrastructures and Engineering research area. This is a 36-months project started in March 2008. Partners are: Atos Origin (Spain), British Telecommunications (UK), CEFRIEL (Italy), EBM WebSourcing (France), Hanival Internet Services GmbH (Austria), INRIA (France), Intelligent Software Components (Spain), Ontotext Lab (Bulgaria), Open University (UK), SAP AG (Germany), Seekda OG (Austria), TIE (Nederlands), The University of Manchester (UK), TXT e-Solutions Spa (Italy), Universitaet Karlsruhe (Germany), University Innsbruck (Austria).

SOA4All will help to realize a world where billions of parties are exposing and consuming services via advanced Web technology: the main objective of the project is to provide a comprehensive framework and infrastructure that integrates complementary and evolutionary technical advances—*i.e.*, SOA, context management, Web principles, Web 2.0 and Semantic Web—into a coherent and domain-independent service delivery platform. For more details, see at http://www.soa4all.eu.

Deliverables involving ADAM are [44], [45].

8.4. International Initiatives

8.4.1. OW2

Participants: Yann Davin, Nicolas Dolet, Damien Fournier, Philippe Merle, Romain Rouvoy, Lionel Seinturier.

OW2, previously ObjectWeb, is an international consortium to promote high quality open source middleware (see at http://www.ow2.org). The vision of OW2 is that of a set of components which can be assembled to offer high-quality middleware.

We are members of this consortium since a long time ago. Philippe Merle is the leader of both FRACTAL and FraSCAti projects, which are hosted by this consortium. Philipe Merle and Lionel Seinturier are members of the Technology Council of OW2.

8.5. Other Activities

8.5.1. Collaboration INRIA - Université Pierre et Marie Curie, Paris 6

Participant: Xavier Blanc.

This collaboration was mainly about the Praxis approach and related to the detection of inconsistencies within models. In [24], we propose an approach to automatically generate huge models. Our approach is uniform, which means that all models of a same size have the same probability to be generated. In [16], we propose an approach to instantaneously detect inconsistencies within models. This approach has the key advantage to need only a small fixed amount of memory to run. In [23], we propose to make Praxis distributed. In particular, we propose to deploy the Praxis detection engine on top of a peer-to-peer platform that support collaborative edition of models.

An HDR has been defended in november the 18th [11].

8.5.2. Collaboration INRIA - INRETS-LEOST

Participant: Christophe Gransart.

Since several years, we collaborate with the *Laboratoire Electronique, Ondes et Signaux pour les Transports* (LEOST laboratory) of the french *Institut National de REcherche sur les Transports et leur Sécurité* (INRETS institute), and especially with Christophe Gransart. In the PlaiiMOB CISIT project, he is working on the definition and the adaptation of the context dedicated to transport applications[32].

Christophe Gransart has made a course during the summer school about Ambiant Computing at Lille during the summer 2009 [31].

Following the InteGRail FP6 project, a research activity is currently done with Alstom to design a software architecture to host applications in the field of intelligent mobility [17].

9. Dissemination

9.1. Visiting Researchers

- P. Jaimes, ITSEM, Mexico January – June 2009,
- A. Taherkordi, Univ. Oslo, Norway, March–May 2009.

9.2. Scientific Community Animation

9.2.1. Examination Committees

- **Laurence Duchien** was in the examination committee of the following HDR thesis:
  - Mireille Blay, April 2009, University of Nice (referee),
  - Noël de Palma, June 2009, University of Grenoble (referee),
  - Xavier Blanc, November 2009, University of Paris 6 (chair),
  - Fabienne Boyer, December 2009, University of Grenoble (referee).
- **Laurence Duchien** was in the examination committee of the following Ph.D. thesis:
  - Thomas Pareaud, January 2009, University of Toulouse (referee),
  - Sylvain Sicard, March 2009, University of Grenoble (chair),
  - Riadh Ben Halima, June 2009, University of Toulouse (referee),
  - Hugo Arboleda, October 2009, University Los Andes, Colombia,(referee),
  - Hani Abdeen, November 2009, University of Lille (chair),
  - Xavier Renault, December 2009, University of Paris 6 (referee),
  - Romain Delamarre, December 2009, University of Rennes (referee).
- **Philippe Merle** was in the examination committee of the following Ph.D. thesis:
  - Aleš Plšek, September 2009, University of Lille 1 (co-advisor),
  - Boris Daix, December 2009, University of Rennes (referee).
- **Lionel Seinturier** was in the examination committee of the following Ph.D. thesis:
  - David Benavides, January 2009, Ecole des Mines de Nantes (referee),
  - Daniel Cheung-Foo-Wo, February 2009, University of Nice (referee),
  - Firas Alhalabi, May 2009, INSA Lyon (referee),
  - Romain Pellerin, September 2009, CNAM Paris (referee),
  - Aleš Plšek, September 2009, University of Lille 1 (co-advisor),
  - Ahmid Mukhtar, November 2009, Telecom SudParis (referee),
  - Etienne Borde, November 2009, Telecom ParisTech (referee),
  - Djamel Benmerzoug, December 2009, University Paris 6 & University of Constantine, Algeria (referee).

9.2.2. Journals, Conferences, Workshop

- **Xavier Blanc** has been member of the following committees:
  - Progam committee of 5th European Conference on Model-Driven Architecture Foundations and Applications (ECMDA 2009) http://www.utwente.nl/projecten/ecmda2009/.
- **Laurence Duchien** has been
  - member of the following committees:
    - Program committee NOTERE 2009, http://www.notere2009.uqam.ca/,
    - Program committee AFADL 2009, http://www.irit.fr/afadl09/,
    - Program committee WICSA/ECSA 2009, http://www.wicsa.net/,
    - Program committee MCPC 2009, http://siwn.org.uk/2009leipzig/MCPC09.htm,
    - Program committee ASEA 2009, http://www.sersc.org/ASEA2009/,
    - Program committee SHWS 2009, http://www.servicescongress.org/2009/1/shws-2009.html.
  - reviewer for the following journals:
    - Editorial board of special issue Services Web Sémantiques, Revue ISI, Hermès, 2009.
    - Editorial board of special issue Special Issue Software Components, Architectures and Reuse of the Journal of Universal Computer Science (J.UCS), 2009.
- **Anne-Françoise Le Meur** has been member of the following committees:
  - Organizing committee and program committee of the 4th AOSD Workshop on Domain Specific Aspect Languages (DSAL'09),
  - Program committee of the 4th International MCETECH Conference on eTechnologies, http://www.mcetech.org/.
- **Philippe Merle** has been member of the following committees:
  - Editorial board of the RSTI-L'Objet journal, Hermès,
  - Program committee of the 8th Middleware Workshop on Adaptive and Reflective Middleware (ARM'09), http://www.comp.lancs.ac.uk/ gracep/ARM2009,
  - Organization committee of the Workshop on Semantic Extensions to Middleware: Enabling Large Scale Knowledge Applications (OTM SEMELS 2009), http://www.onthemove-conferences.org/index.php/semels09.
- **Lionel Seinturier** has been a member of the following committees:
  - Editorial board of the TSI (Hermes) journal,
  - Program committee of the 14th International Conference on Reliable Software Technologies (Ada-Europe'09) http://conferences.telecom-bretagne.eu/rst2009/,
  - Program committee of the 2nd Workshop on Context-aware Adaptation Mechanisms for Pervasive and Ubiquitous Services (CAMPUS'09) http://campus09.ifi.uio.no/,
  - Program committee of the Conference on Software Engineering and Advanced Applications (SEAA) Service and Component-Based Software Engineering Track http://seaa2009.vtt.fi/,
  - Program committee of the 3rd French Conference on Architectures Logicielles (CAL'09) http://cal-idm-lmo-2009.loria.fr,

  - Program committee of the 5th Journées sur l'Ingénierie Dirigée par les Modèles (IDM'09) http://cal-idm-lmo-2009.loria.fr,
  - Program committee of the 15th Conférence Francophone sur les Langages et Modèles à Objets (LMO'09) http://cal-idm-lmo-2009.loria.fr.
- **Romain Rouvoy** has been a member of the following committees:
  - Organizing committee and Program chair of the 2nd International DisCoTec Workshop on Context-aware Adaptation Mechanisms for Pervasive and Ubiquitous Services (CAMPUS'09), http://campus09.ifi.uio.no,
  - Program committee of the International Workshop on Adaptive and Reflective Middleware (ARM'09),http://www.comp.lancs.ac.uk/ gracep/ARM2009,
  - Program committee of the International Workshop on Middleware for Pervasive Mobile and Embedded Computing (M-MPAC'09),http://www.smartlab.cis.strath.ac.uk/M-MPAC/,
  - Program committee of the French Conference on Operating Systems (CFSE 09), http://www.irit.fr/Toulouse2009/.

9.3. Scientific and Administrative Responsibilities

Team members have several scientific and administrative responsibilities in the university, the INRIA institute and at the national level:

- **Xavier Blanc** is member of the CDS that is in charge of the recruitment of associate professors at the University Pierre et Marie Curie;
- **Laurence Duchien** is in the steering committee of the ERCIM Software Evolution Group since 2006. She is also Co-chair (with Jean-Louis Giavitto) of the Languages and Verification group of the GDR CNRS GPL (Génie de la Programmation et du Logiciel – http://gdr-gpl.imag.fr) since 2008. In 2009 she has served as member of the Postdoc and PhD CORDI-S Committee for the CR INRIA-Lille-Nord Europe. She has served as chair of the AERES evaluation committee for the Computer Science Laboratory LIUPPA, Université de Pau et de l'Adour. She has also been member of the scientific committee in the ANR ARPEGE Program. She has served as member of the recruitment committee for the junior scientists at INRIA Lille-Nord Europe. She is also the local contact for the Intenational Relations Department at INRIA.
- **Anne-Françoise Le Meur** was in the Comité de sélection for recruiting associate professors at the IEEA faculty of the University of Lille 1. She is elected member of the board of the LIFL laboratory;
- **Philippe Merle** is vice-president of *Technological Development Council* (CDT) of the INRIA Lille Nord Europe research center, and member of the *Incitative Action Working Group* (GTAI) of the *Scientific and Technological Orientation Council* (COST) of INRIA; He is member of the steering committee of the "Grilles, Système et Parallélisme" (GSP) working group of the CNRS ARS GdR.
- **Lionel Seinturier** is elected member of the Comité de Centre INRIA Lille Nord Europe and member of Comité Hygiène et Sécurité INRIA Lille Nord Europe. He is a member of vivier 27nd section of University of Lille 1. In the LIFL laboratory, he is member of the council and member of the executive committee in charge of financial activities. Lionel Seinturier was in the Comité de sélection for recruiting associate professors and professors at the IEEA faculty of the University of Lille 1, and in the Comité de sélection for recruiting professors at CNAM Paris. Lionel Seinturier is member of the board of the IEEA faculty (UFR) at the University of Lille 1. He has served as chair of the AERES evaluation committee for the Laboratoire de Génie Informatique et d'Ingénierie de Production (LGI2P) of the Ecole des Mines d'Ales (December 2009).

9.4. Teaching

Permanent members teach the following courses:

- **Xavier Blanc** teaches a course on Software Engineering in the Master of Computer Science at the université de Pierre et Marie Curie;
- **Laurence Duchien** teaches a course on Architecture Description Languages in Master Research Sciences et Technologies Mention Informatique and a course on software project management in Master MIAGE at the Université de Lille 1, UFR IEEA; she has also given a seminar on Adaptation Paradigms in Master of Computer Science at ENS Cachan;
- **Anne-Françoise Le Meur** teaches distributed application design (Master 1), databases and the Internet (Master 2 pro), systems programming (Licence 3) and a course on Domain-Specific Languages (DSL) and on “Being a researcher” in Master 2 Research at the Université de Lille 1, UFR IEEA;
- **Philippe Merle** teaches a course on Middleware and Design Patterns in Master Research Sciences et Technologies Mention Informatique at the Université de Lille 1, UFR IEEA;
- **Lionel Seinturier** Lionel Seinturier heads the E-Service specialty of the Master of Computer Science at the University of Lille 1. He teaches several courses on middleware, component-based software engineering, aspect-oriented programming, and object-oriented design in Master of Computer Science at the University of Lille 1;
- **Romain Rouvoy** teaches several courses on advanced dabatabases (Licence 3/Master 1), advanced object-oriented design (Master 1), service-oriented design (Master 2), distributed application design (Master 2), and dependable & adaptive middleware (Master 2 Research) at the University of Lille 1, UFR IEEA.

9.5. Miscellaneous

- The team has organized its internal seminar, Mont-Cassel, France, August 31th, September 1st and 2nd, 2009.
- The team has organized the 1st Aurora Workshop, INRIA, Lille, May 5th, 2009.
- The team has organized an AOM workshop, at the GDR GPL days, Toulouse, January 26th, 2009.
- The team has participated to INRIA/Entreprise Day, Lille, June 2009 (CAPPUCINO demonstration).

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