



IN PARTNERSHIP WITH:  
**CNRS**

**Université Nice - Sophia  
Antipolis**

Activity Report 2013

## **Project-Team OASIS**

Active objects, semantics, Internet and  
security

IN COLLABORATION WITH: Laboratoire informatique, signaux systèmes de Sophia Antipolis (I3S)

RESEARCH CENTER  
**Sophia Antipolis - Méditerranée**

THEME  
**Distributed programming and Soft-  
ware engineering**



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# Project-Team OASIS

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## 2. Overall Objectives

### 2.1. Presentation

The team focuses its activities on distributed (Grid, Cloud, and more generally large-scale infrastructures) computing and more specifically on the development of secure and reliable systems using distributed asynchronous objects (active objects - OA of OASIS). From this central point of focus, other research fields are considered in the project:

- Semantics (first S of OASIS): formal specification of active objects with the definition of ASP (Asynchronous Sequential Processes) and the study of conditions under which this calculus becomes deterministic.
- Internet (I of OASIS): Large-scale, Internet-based computing with distributed and hierarchical components.
- Security (last S of OASIS): analysis and verification of programs written in such asynchronous models.

With these objectives, our approach is:

- theoretical: we study and define models and object-oriented languages (semantic definitions, equivalences, analysis);
- applicative: we start from concrete and current problems, for which we propose technical solutions;
- pragmatic: we validate the models and solutions with full-scale experiments.

Internet clearly changed the meaning of notions like locality, mobility and security. We believe that we have the skills to be significantly fruitful in this major application domain, i.e. Internet-based computing; more specifically, we aim at producing interesting results for Grid and more recently Cloud computing, peer-to-peer systems, service-based and collaborative applications.

### 2.2. Highlights of the Year

Oasis, together with the Coati team, have signed in Dec. 2013 an industrial grant with the Amadeus company, about distributed algorithms for searching paths in very large graphs.

Oasis started in Sep. 2013 the FP7 project DC4Cities. This will promote the data centres role as an "eco-friendly" through the usage of renewable energies. Accordingly, Oasis will propose innovative scheduling techniques to match such a powering method.

## 3. Research Program

### 3.1. Programming with distributed objects and components

The paradigm of object-oriented programming, although not very recent, is clearly still not properly defined and implemented; for example notions like inheritance, sub-typing or overloading have as many definitions as there are different object languages. The introduction of concurrency and distribution into objects also increases the complexity. It appeared that standard Java constituents such as RMI (Remote Method Invocation) do not help building, in a transparent way, sequential, multi-threaded, or distributed applications. Indeed allowing, as RMI does, the execution of the same application to proceed on a shared-memory multiprocessors architecture as well as on a network of computing units (intranet, Internet), or on any hierarchical combination of both, is not sufficient for providing a convenient and reliable programming environment.

The question is thus: how to ease the construction (i.e. programming), deployment and evolution of distributed applications?

One of the answers we suggest relies on the concept of active object, that acts as a single entity, abstraction of a thread, a set of objects and a location. Active objects communicate by asynchronous method calls thanks to the use of futures. ProActive is a Java library that implements this notion of active objects. ProActive can also be seen as a middleware supporting deployment, runtime support, and efficient communication for large scale distributed applications.

Another answer we provide relies on component-oriented programming. In particular, we have defined parallel and hierarchical distributed components starting from the Fractal component model developed by Inria and France-Telecom [41]. We have been involved in the design of the Grid Component Model (GCM) [4], which is one of the major results produced by the CoreGrid European Network of Excellence. The GCM has been standardized at ETSI ([45] for the last published standard), and most of our research on component models are related to it. On the practical side, ProActive/GCM is the implementation of the GCM above the ProActive programming library.

We have developed over time skills in both theoretical and applicative side fields, such as distribution, fault-tolerance, verification, etc., to provide a better programming and runtime environment for object oriented and component oriented applications.

### 3.2. Formal models for distributed objects

A few years ago, we designed the ASP calculus [6] for modelling distributed objects. It remains to this date one of our major scientific foundations. ASP is a calculus for distributed objects interacting using asynchronous method calls with generalized futures. Those futures naturally come with a transparent and automatic synchronisation called wait-by-necessity. In large-scale systems, our approach provides both a good structure and a strong decoupling between threads, and thus scalability. Our work on ASP provides very generic results on expressiveness and determinism, and the potential of this approach has been further demonstrated by its capacity to cope with advanced issues, such as mobility, group communications, and components [6].

ASP provides confluence and determinism properties for distributed objects. Such results should allow one to program parallel and distributed applications that behave in a deterministic manner, even if they are distributed over local or wide area networks.

The ASP calculus is a model for the ProActive library. An extension of ASP has been built to model distributed asynchronous components. A functional fragment of ASP has been modelled in the Isabelle theorem prover [8].

### 3.3. Verification, static analysis, and model-checking

Even with the help of high-level libraries, distributed systems are more difficult to program than classical applications. The complexity of interactions and synchronisations between remote parts of a system increases the difficulty of analysing their behaviours. Consequently, safety, security, or liveness properties are particularly difficult to ensure for these applications. Formal verification of software systems has been active for a long time, but its impact on the development methodology and tools has been slower than in the domain of hardware and circuits. This is true both at a theoretical and at a practical level; our contributions include:

- the definition of adequate models representing programs,
- the mastering of state complexity through abstraction techniques, new algorithmic approaches, or research on advanced parallel or distributed verification methods,
- the design of software tools that hide to the final user the complexity of the underlying theory.

We concentrate on the area of distributed component systems, where we get better descriptions of the structure of the system, making the analysis more tractable, but we also find out new interesting problems. For instance, we contributed to a better analysis of the interplay between the functional definition of a component and its possible runtime transformations, expressed by the various management controllers of the component system.

Our approach is bi-directional: from models to program, or back. We use techniques of static analysis and abstract interpretation to extract models from the code of distributed applications, or from dedicated specification formalisms [3]. On the other hand, we generate “safe by construction” code skeletons, from high level specifications; this guarantees the behavioural properties of the components. We then use generic tools from the verification community to check properties of these models. We concentrate on behavioural properties, expressed in terms of temporal logics (safety, liveness), of adequacy of an implementation to its specification and of correct composition of software components.

## 4. Application Domains

### 4.1. Service Oriented Architectures (SOA)

Service Oriented Architectures aim at the integration of distributed services and more generally at the integration of distributed and heterogeneous data, at the level of the Enterprise or of the whole Internet (big data dimension).

The team seeks solutions to the problems encountered here, with the underlying motivation to demonstrate the usefulness of a large-scale distributed programming approach and runtime support as featured by ProActive and GCM:

- Interaction between services: the uniform usage of web services based *client-server* invocations, through the possible support of an Enterprise Service Bus, can provide a simple interoperability between them. For more loosely coupled interactions between services (e.g. compliant to the Web Services Notification standard), we pursue efforts to support *publish-subscribe* interaction models. Scalability in terms of number of notified events per time unit, and full interoperability through the use of semantic web notations applied to these events/data are some of the key challenges the community is addressing and we too. Events also correspond to data that may be worth to store, for future analytics, besides being propagated to interested parties (in the form of the event content). Our research can thus also contribute to the Big Data domain: we started to focus on how the use of flexible distributed and reconfigurable programming approaches through software components can allow us to devise powerful and flexible analytics on big data flows.
- Services compositions on a possibly large set of machines: if service compositions can even be turned as autonomic activities, these capabilities will really make SOA ready for the Open Internet scale (because at such a scale, a global management of all services is not possible). For service compositions represented as GCM-based component assemblies, we are indeed exploring the use



of control components put in the components membranes, acting as sensors or actuators, that can drive the self-deployment and self-management of composite services, according to negotiated Service Level Agreements. For service orchestrations usually expressed as BPEL like processes, and expressing the *composition in time* aspect of the composition of services, supports for deployment, management, and execution capable to support dynamic adaptations are also needed. Here again we believe a middleware based upon distributed and autonomous components as GCM is really helpful.

## 4.2. Simulation tools and methodology

Components are being used in simulation since many years. However, given its many application fields and its high computation needs, simulation is still a challenging application for component-based programming techniques and tools.

We have been exploring the application of Oasis programming methods to simulation problems in various areas of engineering problems, but also of financial applications.

More recently, with the arrival of O. Dalle in the team, and following a work previously started in the Mascotte project-team in 2006 [42], we are pursuing research on applying distributed component-based programming techniques to simulation.

With respect to the simulation methodology, we have also started to address some fundamental questions such as the time representation in discrete event simulation.

# 5. Software and Platforms

## 5.1. ProActive

**Participants:** Françoise Baude, Denis Caromel, Ludovic Henrio, Fabrice Huet [correspondant], Bastien Sauvan.

ProActive (**Proactive Parallel Suite**) is a Java library (Source code under AGPL license) for parallel, distributed, and concurrent computing, also featuring mobility and security in a uniform framework. With a reduced set of simple primitives, ProActive provides a comprehensive API to simplify the programming of applications that are distributed on a Local Area Network (LAN), on cluster of workstations, Clouds, or on Internet Grids.

The library is based on an Active Object pattern that is a uniform way to encapsulate:

- a remotely accessible object,
- a thread,
- an actor with its own script,
- a server of incoming requests,
- a mobile and potentially secure agent.

and has an architecture to inter-operate with (de facto) standards such as Web Service, HTTP transport, ssh, Globus, etc.

ProActive is only made of standard Java classes, and requires **no changes to the Java Virtual Machine**, no preprocessing or compiler modification; programmers write standard Java code. Based on a simple Meta-Object Protocol, the library is itself extensible, making the system open for adaptations and optimisations. ProActive currently uses the RMI Java standard library as default portable transport layer, but others such as Ibis or HTTP can be used instead, in an adaptive way.

ProActive is particularly well-adapted for the development of applications distributed over the Internet, thanks to reuse of sequential code, through polymorphism, automatic future-based synchronisations, migration of activities from one virtual machine to another. The underlying programming model is thus innovative compared to, for instance, the well established MPI programming model.

In order to cope with the requirements of large-scale distributed and heterogeneous systems like the Grid, many features have been incorporated into ProActive, including support for many transport and job submission protocols, GCM component support, graphical visualization interface, object migration, distributed and non-functional exception handling, fault-tolerance and checkpointing mechanisms; file transfer capabilities, a job scheduler, a resource manager able to manage various hosting machines, support for JMX and OSGi capabilities, web service object exposition, an SCA personality, etc.

ProActive is a project of the former ObjectWeb, now OW2 Consortium. OW2 is an international consortium fostering the development of open-source middleware for cutting-edge applications: EAI, e-business, clustering, grid computing, managed services and more. For more information, refer to [39], [37] and to the web pages <http://www.objectweb.org> and <http://proactive.inria.fr/>.

ProActive management, distribution, support, and commercialisation is now ensured by the start-up company ActiveEon (<http://www.activeeon.com>), in the context of a collaboration with Inria and UNS.

This year, the OASIS team made the following extensions to the ProActive library:

- Implementations related to the multi-active object programming model: multi-active components, declarative request service priority.
- Extension of the support of non-functional aspects for component systems: scripting language for reconfiguration, interceptor components.

## 5.2. Vercors platform

**Participants:** Eric Madelaine, Ludovic Henrio, Bartłomiej Szejna, Alexandra Savu, Oleksandra Kulankhina, Dongqian Liu.

The Vercors tools (<http://www-sop.inria.fr/oasis/Vercors>) include front-ends for specifying the architecture and behaviour of components in the form of UML diagrams. We translate these high-level specifications, into behavioural models in various formats, and we also transform these models using abstractions. In a final step, abstract models are translated into the input format for various verification toolsets. Currently we mainly use the various analysis modules of the CADP toolset.

- We have finished conducting experiments within the Papyrus environment, aiming at the definition of a graphical specification environment combining some of the standard UML formalisms with a dedicated graphical formalism for the architecture of GCM components. We have concluded that Papyrus is not an appropriate environment for our purpose due to the fact that the software is very unstable and badly-documented.
- We have achieved this year a major port of the frontend of the Vercors, namely VCE, the Vercors Component Editor, that is now based on the Obeo Designer (Eclipse) platform (<http://www.obeodesigner.com>). The main motivation, and achievement of this port was to integrate editors for some existing UML formalisms (Class and State-machines) with our GCM architecture editor. The new version of Vercors Component Editor (VCE v.3) has an editor for the GCM Components diagrams integrated with the UML class and state-machines diagrams editors. It also includes a generator of the ADL v.2 specification of the GCM-based architecture and a diagrams validation module.

## 5.3. Open Simulation Architecture (OSA)

**Participant:** Olivier Dalle.

OSA stands for Open Simulation Architecture. OSA is primarily intended to be a federating platform for the simulation community: it is designed to favor the integration of new or existing contributions at every level of its architecture. The platform core supports discrete-event simulation engine(s) built on top of the ObjectWeb Consortium's Fractal component model. In OSA, the systems to be simulated are modeled and instrumented using Fractal components. In OSA, the event handling is mostly hidden in the controller part of the components, which alleviates noticeably the modeling process, but also eases the replacement of any part of the simulation engine. Apart the simulation engine, OSA aims at integrating useful tools for

modeling, developing, experimenting, and analysing simulations. OSA is also a platform for experimenting new techniques and approaches in simulation, such as aspect oriented programming, separation of concerns, innovative component architectures, and so on.

## 5.4. BtrPlace

**Participants:** Fabien Hermenier, Vincent Kherbache, Huynh Tu Dang.

Btrplace (<http://btrp.inria.fr>) is an open source virtual machine (VM) placement algorithm for datacenters. BtrPlace has been designed to be extensible. It can be customized by plugins from third party developers to address new SLAs or optimization constraints. Its extensibility is possible thanks to a composable core reconfiguration algorithm implemented using Constraint Programming. BtrPlace is currently bundled with a catalog of more than 20 constraints to address performance, fault tolerance, isolation, infrastructure management or energy efficiency concerns. It is currently used inside the FSN project OpenCloudWare (<http://opencloudware.org/>) and the European project DC4Cities (<http://dc4cities.eu/>).

This year, the catalog of constraints has been augmented according to the needs expressed inside OpenCloudWare. It has also been upgraded to support for *continuous constraints* [11], a safer restriction mode to ensure the constraints can be satisfied at any moment, even during a reconfiguration process. A significant effort has also been made to make BtrPlace more usable and visible thanks to frequent releases, software documentation, tutorials, and live demo.

## 5.5. EventCloud

**Participants:** Françoise Baude, Fabrice Huet, Laurent Pellegrino, Bastien Sauvan, Iyad Alshabani, Maeva Antoine, Amjad Alshabani, Justine Rochas, Michel Jackson de Souza.

EventCloud (<http://eventcloud.inria.fr>) is an open source middleware that aims to act as a distributed datastore for data fulfilling the W3C RDF specification ([www.w3.org/RDF/](http://www.w3.org/RDF/)). It allows storing and retrieving quadruples (RDF triples with context) through SPARQL but also managing events represented as quadruples. The EventCloud architecture is based on a structured P2P overlay network targeting high-performance elastic data processing. Consequently it aims to be deployed on infrastructures like grids, clouds, i.e. whose nodes acquisition and relinquishment can be dynamic and subject to a pay-per-use mode. Each node participating in the overlay networks constituting EventCloud instances is responsible for managing the storage of subsets of the events, and helps in matching potential looked up events and disseminating them in a collaborative manner. As such, each node is also potentially an event broker responsible for managing subscriptions and routing notifications.

The EventCloud middleware has been developed using the GCM/ProActive library embedding the most recent advances from the Multi-active Object model (see Section 6.1.1) and its implementation. Interactions from end user applications with an EventCloud instance can happen directly using Java APIs along the GCM/ProActive model, or they can be achieved through GCM interfaces exposed following the Web Services Notification specification. Web Services Notification (WSN) is a set of specifications from the OASIS consortium ([www.oasis-open.org](http://www.oasis-open.org)) that standardises the way Web Services interact using "Notifications" or "Events". They form the foundation for Event Driven Architectures built using Web Services.

The EventCloud middleware is currently used as a component within the platforms developed within ANR SocEDA (Section 7.1.1) and FP7 PLAY (Section 7.2.1.1) projects. A significant effort has also started to apply it in application domains from the BigData area, as in Intelligent Transportation Systems 7.2.2.

# 6. New Results

## 6.1. Programming and Composition Models for Large-Scale Distributed Computing

### 6.1.1. Multi-active Objects

**Participants:** Ludovic Henrio, Fabrice Huet, Justine Rochas.

The active object programming model is particularly adapted to easily program distributed objects: it separates objects into several *activities*, each manipulated by a single thread, preventing data races. However, this programming model has its limitations in terms of expressiveness – risk of deadlocks – and of efficiency on multicore machines. We proposed to extend active objects with *local multi-threading*. We rely on declarative *annotations* for expressing potential concurrency between requests, allowing easy and high-level expression of concurrency. This year we realized the following:

- publication of the multiactive object programming model in COORDINATION 2013 [19]
- extension of the annotations to support the specification of:
  - thread management. This aims at specifying (i) thread reservation and (ii) thread limitation in order to control more finely the allocation of threads in a multiactive object.
  - priority of requests. The programmer can now specify a priority graph to have an influence on the order of execution of requests in a multiactive object

This extension was initially explored in a master thesis [34] and led to a publication in SAC 2014 [21].

- extensive use of multiactive objects in our CAN P2P network and implementation of usecases.

We plan to continue to improve the model, especially about compile-time checking of annotations and about fault tolerance of multiactive objects.

### 6.1.2. Algorithmic skeletons

**Participant:** Ludovic Henrio.

In the context of the SCADA associated team, we worked on the algorithmic skeleton programming model. The structured parallelism approach (skeletons) takes advantage of common patterns used in parallel and distributed applications. The skeleton paradigm separates concerns: the distribution aspect can be considered separately from the functional aspect of an application. In the previous year we designed the possibility for a skeleton to output events, which increases the control and monitoring capabilities. This year we achieved the following objectives:

- Encapsulation of the skandium skeleton runtime in a component in order to allow distributed execution of skeletons: local parallelism is handled by skandium while distributed execution is handled by the GCM component library.
- We applied the event framework for skeletons to design a framework allowing the skeleton execution to adapt autonomically in order to achieve a required quality of service. We have first promising results on this aspect and a publication has just been accepted to PMAM 2014.

### 6.1.3. Behavioural models for Distributed Components

**Participants:** Eric Madelaine, Nuno Gaspar, Oleksandra Kulankhina, Ludovic Henrio.

In the past [3], we defined the behavioural semantics of active objects and components. This year we extended this work to address group communications. On the practical side, this work contributes to the Vercors platform; the overall picture being to provide tools to the programmer for defining his application, including its behavioural specification. Then some generic properties like absence of deadlocks, but also application specific properties, can be validated on the composed model using an existing model-checker. We mainly use the CADP model-checker, that also supports distributed generation of state-space. This year our main achievements are the following:

- We improved the specification of the behavioural model generation for component systems that we specified last year [36]. A journal version is under submission.
- We extended the formal model of the GCM architecture and included the specification of the non-functional aspects.

- We worked on the design of a bisimulation equivalence relation adapted to pNets; such an equivalence relation would justify some of the verifications and simplifications we do in our verification platform. Bisimulation theory gives tools to prove the equivalent behaviour of two processes, but adapting it to the structural nature and to the parameterized definitions of pNets is a challenging task. We have obtained promising preliminary results on this aspect: we have a good library of examples illustrating the expressiveness of pNets and use it to study bisimulation techniques.
- We additionally have put considerable efforts on the improvement of the Vercors platform (see Section 5.2). We have totally updated the Vercors Components Editor. We have integrated the UML state machines editor from Obeo UML Designer (<http://marketplace.obeonetwork.com/module/uml>) into Vercors platform. The integrated editor provides the tools for the specification of the components behavior.
- We have started implementing the behavioural semantics of [36] in the Vercors platform. This task consists in generating the behavior of GCM components in the form of pNets from the GCM architecture defined using VCE. This is an important task, involving intricate engineering issues, but also interesting research on methods for reducing the size of the generated models.

This work was done in collaboration with Rabéa Ameur-Boulifa from Télécom-Paristech and Min Zhang from ECNU Shanghai.

In parallel with core developments of the behavioural specification environment, we further collaborated with our industrial partners and enhanced our work around the use of proof assistants for our specification and verification purposes. In particular, this year:

- We made significant improvements on Mefresa, our Mechanized Framework for the Reasoning on Software Architectures. These were published in [17]. Moreover, we obtained preliminary results regarding its integration with GCM/ProActive, our java middleware for parallel and distributed programming.
- We specified, verified and implemented the HyperManager, a GCM distributed application for the management and monitoring of E-Connectware — a solution for the management of distributed RFID infrastructures. This work was published as an industrial case study in [18].

#### **6.1.4. Autonomic Monitoring and Management of Components**

**Participants:** Françoise Baude, Bastien Sauvan.

We have completed the design of a framework for autonomic monitoring and management of component-based applications. We have provided an implementation using GCM/ProActive taking advantage of the possibility of adding components in the membrane. The framework for autonomic computing allows the designer to describe in a separate way each phase of the MAPE autonomic control loop (Monitoring, Analysis, Planning, and Execution), and to plug them or unplug them dynamically.

- This year, we worked on a journal paper presenting our implementation of GCM component model using active objects, and its use to provide autonomic components. The paper is under revision for SPE journal.

#### **6.1.5. Optimization of data transfer in SOA and EDA models**

**Participants:** Amjad Alshabani, Iyad Alshabani, Françoise Baude, Laurent Pellegrino, Bastien Sauvan, Quirino Zagareze.

Traditional client-server interactions rely upon method invocations with copy of the parameters. This can be useless in particular if the receiver does not effectively uses them. On the contrary, copying and transferring parameters lazily, and allowing the receiver to proceed without only some of them is a meaningful idea that we proved to be effective for active objects in the past [38]. This idea wasn't so far realized in the context of the web services technology, the most popular one used today for client-server SOAP-based interactions.

- We contributed to the offloading of objects representing parameters of the web service Java Apache CXF API [46]. It is innovative notably in the way the offloading of parameters for on-demand access can be delegated from services to services, which resembles the concept of first-class futures from ASP.
- Relying upon such an effective approach, we have applied a similar idea of “lazy copying and transfer” to the data parts of events in the context of event-driven architecture applications [26]. The middleware dynamically off-loads data (generally of huge size) attached to an event, according to some user-level policy expressed as annotation in the Java code at the subscriber side. The event itself, without its attachments, gets forwarded into the publish/subscribe brokering system (in our case, the EventCloud middleware, see Section 5.5) and its attachments are transferred to the subscriber on-demand. Compared to some existing propositions geared towards a data centric publish-subscribe pattern (e.g. the DDS OMG standard), ours is more user-friendly as it does not require the user code to explicitly program when to get the data attached to notified events. Also it features very low performance overhead, as additional experiments conducted show it: they are reported in an extended version of the SAC 2013 paper that is under minor revision for a special issue of the Science of Computer Programming journal.

Overall, this work opens the way towards a strong convergence between service oriented and event-driven technologies.

### 6.1.6. Multi-layer component architectures

**Participant:** Olivier Dalle.

Since a few years, we have been investigating the decomposition of a simulation application into multiple layers corresponding to the various concerns commonly found in a simulation: in addition to the various modeling domains that may be found in a single simulation application (e.g. telecommunications networks, road-networks, power-grids, and so on), a typical simulation includes various orthogonal concerns such as system modelling, simulation scenario, instrumentation and observation, distribution, and so on. This large number of concerns has put in light some limits of the traditional hierarchical component-based architectures and their associated ADL, as found in the FCM and GCM. In order to cope with these limitations, we started a new component architecture model called Binding Layers centered on the binding rather than the component, with no hierarchy but advanced layering capabilities, and offering advanced support for dynamic structures. This project is composed of four levels of specification: the two first levels are ready for public release, but some work is still needed for the development of the validation prototypes.

## 6.2. Middleware for Grid and Cloud computing

### 6.2.1. Distributed algorithms for CAN-like P2P networks

**Participants:** Ludovic Henrio, Fabrice Huet, Justine Rochas.

The nature of some large-scale applications, such as content delivery systems or publish/subscribe systems, built on top of Structured Overlay Networks (SONs), demands application-level dissemination primitives which do not overwhelm the overlay, i.e. which are efficient, and which are also reliable. Building such communication primitives in a reliable manner would increase the confidence regarding their behavior prior to deploying them in real settings. In order to come up with real efficient primitives, we take advantage of the underlying geometric topology of the overlay network and we also model the way peers communicate with each other. Our objective is to design and prove an efficient (in terms of messages and execution time) and reliable broadcast algorithm for CAN-like P2P networks. To this aim, this year, we realized the following:

- publication in FASE 2013 of a formalisation, in Isabelle/HOL, of CAN-like P2P networks [15]. Thank to this work, we proved that there exist a broadcast algorithm that does not produce any duplicated message in those networks. A first naive algorithm was exhibited to prove it.
- design and publication of an optimal broadcast algorithm for CAN-like P2P networks in OPODIS 2013 [20]. The solution we have proposed is proven to be correct, optimal in terms of number of messages, and also efficient, as it provides a good parallelization during the dissemination.

We are also investigating new algorithms to efficiently build a SON when the peer involved already have data. Most of the work on SONs assume that new peers joining the network will arrive without data and thus get assigned a random position. However, if they already have data, they will have to send them to other peers, depending on the key space they are responsible of. In 2013, we continued on the tracks investigated in 2012:

- We proposed a first version of new join algorithms which try to allocate key sub-spaces to peers so that the amount of data that needs to be moved is minimal. An expected benefit of this work is that it should allow for fast and efficient reconstruction of a SON in case of a crash, without having to use distributed snapshots.
- We have conducted preliminary experiments which shows a reduction of data transfer between 20% and 90%.

### 6.2.2. *Open Virtual Machines Placement Algorithms*

**Participants:** Fabien Hermenier, Vincent Kherbache, Huynh Tu Dang.

Clients of IaaS providers are looking for dependable infrastructures that can cope with their SLA requirements. To stay attractive, a cloud must then rely on a Virtual Machine (VM) placement algorithm with features matching wrt the SLAs expectations. These constraints are however very specific to each of the tenants but also the infrastructure. They also cover a large range of concerns (reliability, performance, security, energy-efficiency, ...) that are continuously evolving according to new trends and new technologies. To address these issue, we advocate for a flexible VM placement algorithm that can be specialized through plugins to address new concerns.

This year, we first validate our approach with BtrPlace, a composable VM placement algorithm built over Constraint Programming [9]. The usage of Constraint Programming makes placement constraints independent of each other. New constraints can be added without changing the existing implementation. The expressivity of BtrPlace has been verified by implementing more than 20 placement constraints that reproduce, extend but also bring new meaningful restrictions on the VM placement with regards to constraints available in commercial placement algorithm. Each constraint was implemented by an average of 30 lines of Java code. An experienced developer implemented some of the them in half a day, while external developers, without any background in CP, have implemented constraints related to power efficiency [43].

Secondly, we exhibited a lack of reliability in the common approach to address placement constraints in some algorithms. Usually, a constraint controls the VM placement only at the end of the reconfiguration process and ignores the datacenter intermediary states between the beginning and the end of the reconfiguration process. In [11], we advocated that this discrete approach is not sufficient to satisfy the SLAs continuously as an uncontrolled actions schedule may indeed lead to temporary violations. We relied on the flexibility provided by BtrPlace to exhibit these violations and to propose *continuous constraints* to control the quality of service at any moment. We implemented preliminary version of continuous constraints and confirmed they improve the datacenter reliability by removing any temporary violations.

### 6.2.3. *GPU-based High Performance Cloud Computing*

**Participants:** Michael Benguigui, Françoise Baude, Fabrice Huet.

To address HPC, GPU devices are now considered as unavoidable cheap, energy efficient, and very efficient alternative computing units. The barrier to handle such devices is the programming model: it is both very fine grained and synchronous. Our long term goal is to devise some generic solutions in order to incorporate GPU-specific code whenever relevant into a parallel and distributed computation. The first step towards this objective was to gain some insight on how to efficiently program a non trivial but well known algorithm. Our previous work [40] highlights the necessity to target a GPU rather than distributed CPUs to provide the same performance level. By this way we price complex American basket options through the Picazo pricing algorithm, in the same order of time than a CPU cluster implementation on a 64-core cluster. This year, we achieved the following tasks

- We proposed a multi GPU based implementation of this method, allowing pricing time to fall below 1 hour on 18 GPUs, for a 40-assets American option [14].

- We are currently designing a task dispatching model to load balance tasks in a CPU-GPU cluster. This will allow us to drastically lower the overall computation time of a portfolio estimation, and moreover, the computation time of the Monte Carlo value at risk of a portfolio of complex assets.

#### 6.2.4. *MapReduce Based Frameworks for Big Data*

**Participants:** Fabrice Huet, Ge Song.

MapReduce is a programming model which allows the processing of vast amounts of data in parallel, on a large number of machines. It is particularly well suited to static or slow changing set of data since the execution time of a job is usually high. However, in practice data-centers collect data at fast rates which makes it very difficult to maintain up-to-date results. To address this challenge, we propose in [25] a generic mechanism for dealing with dynamic data in MapReduce frameworks. Long-standing MapReduce jobs, called *continuous Jobs*, are *automatically* re-executed to process new incoming data at a minimum cost. We present a simple and clean API which integrates nicely with the standard MapReduce model. Furthermore, we describe cHadoop, an implementation of our approach based on Hadoop which does not require modifications to the source code of the original framework. Thus, cHadoop can quickly be ported to any new version of Hadoop. We evaluate our proposal with two standard MapReduce applications (WordCount and WordCount-N-Count), and one real world application (RDF Query) on real datasets. Our evaluations on clusters ranging from 5 to 40 nodes demonstrate the benefit of our approach in terms of execution time and ease of use.

Another important point is the difficulty to predict the performance of a MapReduce job. This is particularly important when using pay-as-you-go resources such a Cloud. We have proposed a simple framework to predict the performance of Hadoop jobs. It is composed of a dynamic light-weight Hadoop job analyzer, and a prediction module using locally weighted regression methods. Our framework makes some theoretical cost models more practical, and also fits well with jobs and clusters diversity. It can also help those users who want to predict the cost when applying for an on- demand cloud service.

### 6.3. Application Domains

#### 6.3.1. *Publish-Subscribe in Distributed Environments*

**Participants:** Françoise Baude, Fabrice Huet, Laurent Pellegrino, Bastien Sauvan, Iyad Alshabani, Maeva Antoine, Amjad Alshabani.

In the context of the FP7 STREP PLAY and French SocEDA ANR research projects we have developed a middleware dubbed EventCloud (Section 5.5). This last aims to store and retrieve Resource Description Framework (RDF) data but also to relay them to interested parties through a publish/subscribe layer that allows the formulation of content-based subscriptions. Content-based subscriptions are automatically deduced from more complex rules deployed onto a Complex Event Processing engine, the aim of these CEP rules being to trigger new (complex) events after detecting interesting situations [24]. The EventCloud architecture relies on a CAN structured P2P overlay network we initially designed and implemented for the former SOA4ALL FP7-IP project [44].

This year we continued to improve the performances of the EventCloud middleware and its usability as a standalone component but also as a component integrated within the previous projects' platform. Concretely, we proposed a new publish/subscribe matching algorithm for RDF events made of several related RDF triples, that was thoroughly presented in [31] and [22]. To further improve performance, we pursue some efforts to finalize the usage of the newest multi-active object library (cf. Section 6.1.1). Also, to handle more efficiently multicast messaging, we replaced our initial and naive solution with the optimal one presented in Section 6.2.1. Finally, we proposed a solution for managing multiple EventCloud instances on various cloud platforms, especially for the integration of our middleware in the PLAY and SocEDA platforms (whose latest assessment can be found in [32]). Details about EventCloud management are provided in [29].

Since RDF resources have the property to be poorly balanced, we are also investigating new algorithms that decrease load imbalance for events and data.



### 6.3.2. Large-scale Simulation Platform: Techniques and methodologies

**Participants:** Olivier Dalle, E. Mancini, Damian Vicino.

In the domain of simulation techniques and methodologies, this year, we conducted research in the two following areas:

**Distributed Network Simulation** NetStep[16], is a prototype we developed for the distributed simulation of very large scale network simulations, such as the simulation of peer-to-peer applications. We use simulation micro-steps as a means for optimizing the overlap of communications and computations, without changing the original event-driven model. As a consequence, NetStep allows for the reuse of unmodified existing sequential simulators for building large-scale distributed simulations: the overall simulation is divided both in time and space, into a large number of simulation micro-steps, each of which being executed by a legacy sequential simulator. By choosing the time-step smaller than the minimal look-ahead due to communications, we avoid the need for synchronization between logical processes (LPs) during the simulation. Instead, the simulated communications become inputs and outputs of the simulation micro-steps, and are routed in parallel between LPs by a NetStep dedicated entity. Our prototype is based on the SimGrid sequential simulator.

**Discrete Time Representation** The representation of time in simulations is a long standing issue, for which many solutions and formalisms have been proposed. However, once the formalism is chosen, the implementation of the time representation is still a non trivial problem: Integer values have a limited range and require the selection of a minimal fixed step that does not support well the multi-scale models; Floating Points numbers have numerous limitations and hidden effects such as rounding due to quantization; those issues result in inaccuracies or even timing errors. In collaboration with our partner in the DISSIMINET Associated Team, we have started a new research on this topic. This research will be released in the form of a new Discrete Event Simulation engine library for the DEVS formalism, designed to fully exploit the 2011 C++ standard; it is candidate for inclusion in the BoostC++ Libraries.

## 7. Partnerships and Cooperations

### 7.1. National Initiatives

#### 7.1.1. ANR SocEDA

Title: SOCIAL Event Driven Architecture

Program: Platform

Duration: July 2009 - October 2013

Coordinator: Linagora (ex EBM Web Sourcing)

Others partners: SMEs: ActiveEon, industry: Thales, OrangeLabs, academics: Inria, CNRS IMAG, LIRIS, ARMINES

See also: <http://www.soceda.org/display/soceda/>

Abstract: SocEDA is an ANR project of type Platform, also labelled by two competitiveness clusters, PEGASE and SCS. The aim is to provide a "Cloud based platform for large scale social aware Event-Driven Architecture (EDA)". OASIS is in charge of managing the storage and publication/subscription of events on the cloud.

#### 7.1.2. ANR Songs

Title: Simulation of Next Generation Systems

Program: Infra 13

Duration: January 2012 - December 2015

Coordinator: Inria (Nancy, Grenoble, Bordeaux)

Others partners: IN2P3 Villeurbanne, LSIIT Strasbourg, I3S Sophia-Antipolis, LINA Nantes

See also: <http://infra-songs.gforge.inria.fr/>

Abstract: SONGS (2012-2015) is the continuity of SIMGRID project (2009-2012), in the ANR INFRA program. The aim of SONGS is to continue the development of the SimGrid simulation platform for the study of large distributed architectures, including data grids, cloud computing facilities, peer-to-peer applications and HPC/exascale architectures.

### 7.1.3. FUI CloudForce (now OpenCloudWare)

Program: FSN, labelled by Minalogic, Systematic and SCS.

Duration: January 2012 - December 2014

Coordinator: France-Telecom Research

Others partners: ActiveEon, Armines, Bull, eNovance, eXo Platform, France Telecom (coordinator), Inria, IRIT – INP Toulouse, Linagora, OW2, Peergreen, Télécom Paris Tech, Télécom Saint Etienne, Thales Communications, Thales Services, Université Joseph Fourier, Université de Savoie – LISTIC, UShareSoft

See also: <http://www.opencloudware.org/>

Abstract: The OpenCloudware project aims at building an open software engineering platform for the collaborative development of distributed applications to be deployed on multiple Cloud infrastructures.

The results of OpenCloudware will contain a set of software components to manage the lifecycle of such applications, from modelling (Think), developing and building images (Build), to a multi-IaaS compliant PaaS platform (Run) for their deployment, orchestration, performance testing, self-management (elasticity, green IT optimisation), and provisioning. Applications will be deployed potentially on multi IaaS (supporting either one IaaS at a time, or hybrid scenarios). The results of the project will be made available as open source components through the OW2 Open Source Cloudware initiative.

### 7.1.4. Oseo-Isis Spinnaker

Duration: June 2011 - May 2015

Coordinator: Tagsys-RFID

Others partners: SMEs: Inside-Secure, STIC, Legrand; Academic: IPG, ENS des Mines de St Etienne, Un. du Maine, Un. F. Rabelais Tours, AETS ESEO Angers, Un. Marne la Vallée, Un. Paris 6, Un. Rennes 1, Inria.

See also: <http://www.spinnaker-rfid.com/>

Abstract: The objective of Spinnaker is to really allow RFID technology to be widely and easily deployed. The role of the OASIS team in this project is to allow the wide scale deployment and management of the specific RFID application servers in the cloud, so to build an end-to-end robust and flexible solution using GCM technology.

## 7.2. European Initiatives

### 7.2.1. FP7 Projects

#### 7.2.1.1. PLAY

Title: Pushing dynamic and ubiquitous interaction between services Leveraged in the future Internet by Applying complex event processing

Type: COOPERATION

Defi: Internet of Services, Software & Virtualisation

Instrument: Specific Targeted Research Project

Objectif: Internet of Services, Software and Virtualisation

Duration: October 2010 - September 2013

Coordinator: FZI (Germany)

Other Partners: EBM WebSourcing (Fr), Inria (OASIS and SARDES) (Fr), France Telecom/OrangeLabs (Fr), ICCS (Gr), Ecole des Mines Albi/Armines (Fr), CIM (Serbia).

Inria contact: Françoise Baude

See also: <http://www.play-project.eu/>

Abstract: The PLAY project aims to develop and validate an elastic and reliable architecture for dynamic and complex, event-driven interaction in large highly distributed and heterogeneous service systems. Such an architecture enables ubiquitous exchange of information between heterogeneous services, providing the possibilities to adapt and personalize their execution, resulting in the so-called situational-driven process adaptivity. The OASIS team is in charge of designing the key element of the PLAY Platform: the Event Cloud that is a publish/subscribe P2P based system, developed using the GCM technology.

#### 7.2.1.2. FI-WARE

Type: COOPERATION

Defi: PPP FI: Technology Foundation: Future Internet Core Platform

Instrument: Integrated Project

Objectif: PPP FI: Technology Foundation:Future Internet Core Platform

Duration: September 2011 - May 2014

Coordinator: Telefonica (Spain)

Others partners: Thales, SAP, Inria

Inria contact: Olivier Festor

See also: <http://www.fi-ware.eu/>

Abstract: FI-WARE will deliver a novel service infrastructure, building upon elements (called Generic Enablers) which offer reusable and commonly shared functions making it easier to develop Future Internet Applications in multiple sectors. This infrastructure will bring significant and quantifiable improvements in the performance, reliability, and production costs linked to Internet applications, building a true foundation for the future Internet.

#### 7.2.1.3. DC4Cities

Type: COOPERATION

Defi: FP7 Smartcities 2013

Instrument: Specific Targeted REsearch Project

Objectif: ICT-2013.6.2: Data Centers in an energy-efficient and environmentally friendly Internet

Duration: September 2013 - February 2016

Coordinator: Freemind Consulting (BE)

Partners: U. Mannheim (DE), U. Passau (DE), HP Italy Innovation Center (IT), Create-Net (IT), ENEA (IT), CESCA Catalonia (ES), Gas Natural SA (ES), Inst. Munic. Informatica Barcelona (ES), Inria (FR)

Inria contact: Eric Madelaine

See also:

Abstract: Data centres play two different and complementary roles in Smart Cities' energy policies: as ICT infrastructures supporting Smart City resource optimization systems - more in general, delivering ICT services to the citizens - and as large energy consumers. Therefore there are huge expectations on data centres being able to run at the highest levels of renewable energy sources: this is the great challenge of DC4Cities project.

The goal of DC4Cities is to make existing and new data centres energy adaptive, without requiring any modification to the logistics, and without impacting the quality of the services provided to their users. Finally new energy metrics, benchmarks, and measurement methodologies will be developed and proposed for the definition of new related standards. DC4Cities will promote the data centres role as an "eco-friendly" key player in the Smart Cities energy policies, and will foster the integration of a network of local renewable energy providers (also interconnected with local Smart Grids and Micro Grids) to support the pursued increase of renewable energy share.

### 7.2.2. Collaborations in European Programs, except FP7

Program: EIT ICTLabs

Project acronym: Activity 13 052 from Intelligent Mobility and Transportation Systems action line (IMS), renamed Future Urban Life and Mobility (ULM) mid 2013

Project title: Multimodal Mobility

Duration: 2013, January to December

Coordinator: F. Baude and B. Kwella (Fraunhofer Gesellschaft)

Other partners: Inria, BME (Hungary), TUBerlin, U. Bologna, Telecom Italia, Siemens/VMZ (Germany), DFKI (Germany)

Abstract: The activity seeks to specify the building blocks, a platform and a prototype for the provision of multimodal mobility. The main motivation is to facilitate the use of ICT to support the efficient organization of Accessible Mobility (support for people with special needs, economical optimization of mobility and transportation, trip planning, information on available transport modes, etc). It therefore provides the basis for sustainable future mobility

## 7.3. International Initiatives

### 7.3.1. Inria Associate Teams

#### 7.3.1.1. DISSIMINET

Title: Web-Service approaches for simulation

Inria principal investigator: Olivier Dalle

International Partner (Institution - Laboratory - Researcher):

Carleton University (Canada) - Advanced Real-Time Simulation Laboratory - Gabriel Wainer

Duration: 2011 - 2013

See also: <http://www.inria.fr/en/teams/dissiminet>

This Franco-Canadian team will advance research on the definition of new algorithms and techniques for component-based simulation using a web-services based approach. On one hand, the use of web-services is expected to solve the critical issues that pave the way toward the simulation of systems of unprecedented complexity, especially (but not exclusively) in the studies involving large networks such as Peer-to-peer networks. Web-Service oriented approaches have numerous advantages, such as allowing the reuse of existing simulators, allowing non-computer experts to merge their respective knowledge, or seamless integration of complementary services (eg. on-line storage and repositories, weather forecast, traffic, etc.). One important expected outcome of this approach is to significantly improve the simulation methodology in network studies, especially by enforcing the seamless

reproducibility and traceability of simulation results. On the other hand, a net-centric approach of simulation based on web-services comes at the cost of added complexity and incurs new practices, both at the technical and methodological levels. The results of this common research will be integrated into both teams' discrete-event distributed simulators: the CD++ simulator at Carleton University and the simulation middle-ware developed in the MASCOTTE EPI, called OSA, whose developments are supported by an Inria ADT starting in December 2011.

#### 7.3.1.2. DAESD

Title: Distributed/Asynchronous, Embedded/synchronous System Development

Inria principal investigator: Eric Madelaine

International Partner (Institution - Laboratory - Researcher):

East China Normal University (ECNU) Shanghai - SEI - Yixiang Chen

Duration: 2012 - 2014

See also: <http://team.inria.fr/DAESD>

The development of concurrent and parallel systems has traditionally been clearly split in two different families; distributed and asynchronous systems on one hand, now growing very fast with the recent progress of the Internet towards large scale services and clouds; embedded, reactive, or hybrid systems on the other hand, mostly of synchronous behaviour. The frontier between these families has attracted less attention, but recent trends, e.g. in industrial systems, in "Cyber-Physical systems", or in the emerging "Internet of Things", give a new importance to research combining them.

The aim of the DAESD associate team is to combine the expertise of the Oasis and Aoste teams at Inria, the SEI-Shone team at ECNU-Shanghai, and to build models, methods, and prototype tools inheriting from synchronous and asynchronous models. We plan to address modelling formalisms and tools, for this combined model; to establish a method to analyze temporal and spatial consistency of embedded distributed real-time systems; to develop scheduling strategies for multiple tasks in embedded and distributed systems with mixed constraints.

#### 7.3.1.3. SCADA

Title: Safe Composition of Autonomic Distributed Applications

Inria principal investigator: Ludovic Henrio

International Partner (Institution - Laboratory - Researcher):

University of Chile (Chile) - NIC Chile Research Labs - Javier Bustos

Duration: 2012 - 2014

See also: <http://team.inria.fr/scada>

The SCADA project aims at promoting the collaboration between NIC LABS (Santiago - Chile) and OASIS team (Inria Sophia Antipolis - France) in the domain of the safe composition of applications. More precisely the project will extend existing composition patterns dedicated to parallel or distributed computing to ease the reliable composition of applications. The strong interactions between formal aspects and practical implementation are a key feature of that project, where formal methods, and language theory will contribute to the practical implementation of execution platforms, development and debugging tools, and verification environments. The composition models we focus on are algorithmic skeletons, and distributed components; and we will particularly focus on the programming and verification of non-functional features. Overall, from formal specification and proofs, this project should lead to the implementation of tools for the design and execution of distributed and parallel applications with a guaranteed behavior.

### 7.3.2. Inria International Labs

#### 7.3.2.1. CIRIC Chili

Ciric research line: Telecommunications

Inria principal investigator: Eric Madelaine

Duration: 2012 - 2021

This CIRIC activity is loosely coupled with our SCADA associated team with the Universidad de Chile (UdC). We have had some contacts with a software company in Santiago, and starting exploring some possible collaboration in the area of formal specification of distributed applications for Android systems, and generation of “safe by construction” android code. But the effective involvement of CIRIC manpower in this activity has not yet started.

#### 7.3.2.2. *LIAMA Shanghai*

Liama project: HADES

Inria principal investigator: Robert de Simone

Oasis researchers involved: Eric Madelaine, Ludovic Henrio

Duration: 2013 - 2016

Modern computing architectures are becoming increasingly parallel, at all levels. Meanwhile, typical applications also display increasing concurrency aspects, specially streaming applications involving data and task parallelism. Cyber physical system interactions also add extra-functional requirements to this high degree of concurrency. The goal of best fitting applications onto architectures becomes a crucial problem, which must be tackled from any possible angle. Our position in the HADES LIAMA project is to consider modeling of applications using formal models of concurrent computation, and specialized model-driven engineering approaches to embody the design flow for such models (analysis, verification, mapping allocation, representation of non-functional properties and constraints). We build on various previous domains of expertise : synchronous languages for embedded system design, asynchronous languages for high-performance cloud computing, and real-time specification languages for cyber-physical interaction aspects.

In 2013, HADES and the DAESD associated team organised a joint “Spring School” at ECNU Shanghai, held in conjunction with the official inaugural LIAMA Shanghai Open day.

## 7.4. International Research Visitors

### 7.4.1. *Visits of International Scientists*

**Participant:** Ass. Pr. Xavier Défago.

Date: from 16 Sep. 2013 to 31 Jan. 2014

Institution: Dependable Distributed Systems Lab., Japan Advanced Institute of Science and Technology (JAIST), Nomi, Ishikawa, Japan

This visit is founded by CNRS and shared between the OASIS and COATI teams.

**Participant:** Pr. Gabriel Wainer.

Date: from 14 Jun. to 13 Jul. 2013

Institution: Carleton University, Ottawa (CA)

This visit is in the context of our DISSIMINET associated team

**Participant:** Pr. Yixiang Chen.

Date: 14-17 Oct. 2013

Institution: East China Normal University, Shanghai (CN)

This visit is in the context of our DAESD associated team

**Participant:** Ass. Pr. Min Zhang.

Date: 11-16 Sep. 2013

Institution: East China Normal University, Shanghai (CN)

This visit is in the context of our DAESD associated team

**Participant:** Elena Giachino.

Date: 27-29 Mar. 2013

Institution: Univ. of Bologna

Subject: Collaborative work on deadlock analysis for ABS and ASP

**Participant:** Pr. Mizuhito Ogawa.

Date: 26-29 Mar. 2013

Institution: Dependable Distributed Systems Lab., Japan Advanced Institute of Science and Technology (JAIST), Nomi, Ishikawa, Japan.

Subject: Collaborative work on fundamental aspects of distributed computing and theorem proving techniques.

#### 7.4.1.1. Internships

**Yanwen Chen**

Subject: Programmation d'applications hétérogènes embarquées et distribuées

Date: from Jan. 2013 until Jun. 2013

Institution: East China Normal University (China)

This visit is in the context of the cotutelle PhD of Yanwen Chen, under the direction of E. Madelaine.

**Dongqian Liu**

Subject: Generation of behavioural models in the VerCors platform

Date: from Oct. 2013 until Dec. 2013

Institution: East China Normal University (China)

This visit is in the context of the DAESD associated team.

**Michel Jackson de Souza**

Subject: Distributed coherent snapshot solution for the P2P CAN-based EventCloud

Date: from July 2012 until Aug. 2013

Institution: UFBA Federal University of Bahia (Brasil), Science sans Frontière brazilian mobility program

This visit is organized after spontaneous contacts, as a complementary work for the student bachelor studies.

## 8. Dissemination

### 8.1. Scientific Animation

- Françoise Baude: member of the editorial board of the Techniques et Sciences Informatique French journal from feb 2011, program committee member of HPCS 2013, ISPA 2013, reviewer for HPCS 2012 special issue journal Concurrency Practice and Experiment to be published in 2013, for JPDC, PC member for Compas 2014, ISPA2014 and CCGrid 2014, University of Nice official representative within the KIC EIT ICT Labs, including the Master school, from 2012.
- Olivier Dalle: member of the Steering Committee of SIMUTools (since 2009), member of the Program Committee of the Conferences DEVS/TMS'2013, WSC'2013, ACM SIGSIM PADS'2013, HPC&S 2013, Omnet++2013, reviewer for SIMULATION (SCS), ACM TOMACS, SIMPRA (Elsevier) and JOS (Palgrave).
- Ludovic Henrio: program committee member of FESCA'13, FOCLASA'13, ICE'13 and reviewer for the journal SCP (Science of Computer Programming), DIST, and STVR.
- Fabien Hermenier: program committee member of VTDC and PDP (energy efficiency track) and reviewer for IEEE Transactions on Computers, IEEE Transactions on Cloud Computing, IEEE Transactions on Network and Service Management, Journal of Software: Practice and Experiment, Journal of Systems and Software.
- Fabrice Huet : program committee member of HPDC 2013, CCGrid 2013, Big Data 2013.
- Eric Madelaine: member of the steering committees of the FACS and FMCO symposia, member of the program committee of FACS'13, and of the Science of Computer Programming (SCP) journal.

## 8.2. Teaching - Supervision - Juries

### 8.2.1. Teaching

- Master : Françoise Baude and Ludovic Henrio, Distributed systems: an Algorithmic approach, 17 H + 17 h eqTD, niveau M2, Polytech'Nice Sophia/UFR Sciences, UNS, France
- Master : Françoise Baude, Applications Réparties, 45 H eqTD, niveau M1/SI4, Polytech'Nice Sophia, UNS, France
- Licence : Françoise Baude, Algorithmique et Programmation en Java, 70 H eqTD, niveau L2, Polytech'Nice Sophia, UNS, France
- Licence : Olivier Dalle, Systèmes d'Exploitation, 60h eq. TD
- Licence : Olivier Dalle, Initiation Framework Programmation Serveur, 70h eq. TD
- Licence : Olivier Dalle, Algorithmique, 12h eq. TD
- Licence : Olivier Dalle, Projet Scientifique Informatique, 37h eq. TD
- Licence : Fabien Hermenier, Algorithmique et Programmation en Java, 70 H eqTD, niveau L2, Polytech'Nice Sophia, UNS, France
- Licence : Fabien Hermenier, Introduction à Internet, 103 H eqTD, niveau L2, Polytech'Nice Sophia, UNS, France
- Licence : Fabien Hermenier, Outils pour le Génie Logiciel 14 H eqTD, niveau L3/SI3, Polytech'Nice Sophia, UNS, France

### 8.2.2. Supervision

- PhD in progress: Laurent Pellegrino "Pushing dynamic and ubiquitous event-based interaction in the Internet of services: a middleware for event clouds", since Sept 2010, advisor Françoise Baude, Fabrice Huet.
- PhD in progress: Nuno Gaspar "Integrated, Autonomic, and Reliable Deployment and Management for SaaS composite applications", since Nov 2011, advisor: Eric Madelaine
- PhD in progress: Michaël Benguigui, "Modèles de programmation pour l'analyse de données sur machines multi-cœurs, grilles et clouds", since Dec 2011, advisor Françoise Baude.



- PhD in progress: Yanwen Chen, “Formal model and Scheduling for cyberphysical systems”, since Dec 2011, advisors Eric Madelaine and Yixiang Chen (ECNU Shanghai)
- PhD in progress: Alexandra Savu, “Design, specification, and verification of parameterized topologies of distributed components”, since Oct. 2012, advisor Eric Madelaine
- PhD in progress: Maeva Antoine, “Plateforme élastique pour le stockage et la notification d’Evènements”, since Oct. 2012, advisors Eric Madelaine, Fabrice Huet
- PhD in progress: Oleksandra Kulankhina, “Model-driven environment for the development of safe component-based distributed applications”, since Oct. 2013, advisor Eric Madelaine
- PhD in progress : Vincent Kerbache, “Resource Management in a Cloud Supplied with Renewable Energies”, since Sep. 2013, advisors Eric Madelaine, Fabien Hermenier
- PhD in progress: "Programming model and middleware support for distributed and concurrent applications", since Oct. 2013, advisor Ludovic Henrio
- PhD in progress: Sophie Song, "Publish-Subscribe Models for Large Scale Data Analysis Frameworks", since Feb. 2013, advisor Fabrice Huet, Frédéric Margoulés (ECP)
- PhD in progress: Damian Vicino, "Simulation-based Open Science in the Cloud", since Jan. 2013, advisors Françoise Baude, Gabriel Wainer (Carleton University, Canada), Olivier Dalle.

### 8.2.3. *Juries*

Françoise Baude participated in PhD evaluations as

- PhD reviewer and jury member: PhD of Francisco Alvares on 9th April 2013, Ecole des Mines de Nantes (ASCOLA EPI); PhD of Erwan Daubert on May 24th 2013, at INSA Rennes (TRISKELL and MYRIADS EPIs); PhD of Denis Morand on November 5th 2013, Université de Grenoble.
- PhD examiner: PhD of Gauthier Berthou on 21th January 2014, Université de Grenoble; PhD; PhD of Pierre-Louis Aublin, Université de Grenoble, on the same day.

She participated in the recruitment committee for a Professor at ENSEIRB, in May 2013. She evaluated one project for Programme ANR Blanc in 2013.

Ludovic Henrio evaluated one project for Programme ANR: INS 2013.

Olivier Dalle participated in PhD evaluations as

- PhD jury member for the PhD of Imran Mahmood, Feb. 26 2013, Royal Technological Institute of Sweden (KTH), Stockholm.

Fabrice Huet participated in PhD evaluations as jury member for the PhD of Giang Ngo Hoang on 16th December 2013.

## 8.3. Popularization

- Françoise Baude is in charge since September 2011 of the set up and animation of an educational program *Cordées de la Réussite*. She leads as Polytech’Nice Sophia member, and in connection with MASTIC activities at Sophia-Antipolis, two *Cordées pour la Science à Sophia* groups (one with Lycée Vinci Antibes, the other with Lycée Tocqueville Grasse). Since 2013, she is in charge of the AVOSTII-STI2D program implementation for Polytech’Nice Sophia, requiring advertising high-school pupils for engineering studies, in particular in ICT.
- Rencontres Inria Industrie:  
The 11th of June 2013, we took advantage of the Inria-Industry national meeting to expose our works on the American basket option pricing. Our strategy relies on a two-level CPU/GPU parallelization of the Picazo algorithm, combining dynamic strategies to fully exploit distributed resources. During the event, we presented the difficulty to price such instruments in reasonable time, and highlight our solution through multiple tests on Grid’5000, of our pricing engine.  
A Video is available here: <http://www.inria.fr/centre/saclay/innovation/rii-modelisation-simulation-calcul-intensif/demos/pricing-d-options-sur-panier-de-type-americain-en-utilisant-des-clusters-equipes-de-gpus>

- This year, Fabrice Huet gave a seminar to high school students about the inner working of computers. He also leads the ISN *Informatiques et Sciences du Numérique* courses for the academia of Nice. These courses were given to high school teachers who volunteered to offer a Computer Science option to their students.

## 9. Bibliography

### Major publications by the team in recent years

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- [3] T. BARROS, R. BOULIFA, A. CANSADO, L. HENRIO, E. MADELAINE. *Behavioural Models for Distributed Fractal Components*, in "Annals of Telecommunications", jan 2009, vol. 64, n<sup>o</sup> 1–2, also Research Report Inria RR-6491 [DOI : 10.1007/s12243-008-0069-7], <http://hal.inria.fr/inria-00268965>
- [4] F. BAUDE, D. CAROMEL, C. DALMASSO, M. DANELUTTO, V. GETOV, L. HENRIO, C. PÉREZ. *GCM: A Grid Extension to Fractal for Autonomous Distributed Components*, in "Annals of Telecommunications", 2009, vol. 64, n<sup>o</sup> 1, pp. 5–24 [DOI : 10.1007/s12243-008-0068-8], <http://hal.archives-ouvertes.fr/inria-00323919/en/>
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- [7] L. HENRIO, F. HUET, Z. ISTVÁN. *Multi-threaded Active Objects*, in "COORDINATION 2013", Firenze, Italy, C. JULIEN, R. DE NICOLA (editors), Springer, 2013, 15th International Conference on Coordination Models and Languages, Florence, Italy, 3–6, <http://hal.inria.fr/hal-00818482>
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- [9] F. HERMENIER, J. L. LAWALL, G. MULLER. *BtrPlace: A Flexible Consolidation Manager for Highly Available Applications*, in "IEEE Transactions on Dependable and Secure Computing", 2013, vol. 10, n<sup>o</sup> 5, pp. 273-286 [DOI : 10.1109/TDSC.2013.5], <http://hal.inria.fr/hal-00916311>
- [10] F. HUET, D. CAROMEL, H. E. BAL. *A High Performance Java Middleware with a Real Application*, in "Proceedings of the ACM/IEEE SC2004 Conference on High Performance Networking and Computing, 6-12 November 2004, Pittsburgh, PA, USA", 2004

## Publications of the year

### Articles in International Peer-Reviewed Journals

- [11] F. HERMENIER, J. LAWALL, G. MULLER. *BtrPlace: A Flexible Consolidation Manager for Highly Available Applications*, in "IEEE Transactions on Dependable and Secure Computing", 2013, vol. 10, n<sup>o</sup> 5, pp. 273-286 [DOI : 10.1109/TDSC.2013.5], <http://hal.inria.fr/hal-00916311>

### Invited Conferences

- [12] O. DALLE. *Using Computer Simulations for Producing Scientific Results: Are We There Yet?*, in "NS3 Workshop", Cannes, France, March 2013, <http://hal.inria.fr/hal-00926967>

### International Conferences with Proceedings

- [13] R. ABID, G. SALAÜN, F. BONGIOVANNI, N. DE PALMA. *Verification of a Dynamic Management Protocol for Cloud Applications*, in "11th International Symposium, ATVA 2013", Hanoi, Viet Nam, Dang Van Hung and Mizuhito Ogawa, 2013, vol. 8172, pp. 178-192 [DOI : 10.1007/978-3-319-02444-8\_14], <http://hal.inria.fr/hal-00863262>
- [14] M. BENGUIGUI, F. BAUDE. *American Basket Option Pricing on a multi GPU Cluster*, in "22nd High Performance Computing Symposium", Tampa, FL, United States, April 2014, pp. 1-8, <http://hal.inria.fr/hal-00927482>
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- [27] F. BONGIOVANNI, L. HENRIO. *Broadcast Algorithms for CAN: Design and Mechanisation*, in "Cinque`mes journees nationales du Groupement De Recherche CNRS du Genie de la Programmation et du Logiciel", Nancy, France, May 2013, <http://hal.inria.fr/hal-00916102>

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- [34] J. ROCHAS. , *Request Scheduling for Multiactive Objects*, Université Nice Sophia Antipolis, July 2013, 53 p. , <http://hal.inria.fr/hal-00916130>
- [35] S. H. TAN. , *Towards Efficient Risk Quantification - Using GPUs and Variance Reduction Technique*, Université de Nice Sophia-Antipolis (UNS) Sophia-Antipolis, September 2013, 51 p. , <http://hal.inria.fr/hal-00932233>

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