INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

# *Project-Team oasis*

# *Objets Actifs, Sémantique, Internet et Sécurité*

*Sophia Antipolis*

THEME COM

Activity Report

2004

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# 1. Team

OASIS *is a joint project with CNRS I3S and University of Nice Sophia Antipolis.*

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Ludovic Henrio [Thesis on 28/11/2003, Teaching Assistant to 31/08/2004, then University of Westminster UK, postdoc position from 01/09/04]
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Luis Mateu [Assistant Professor, University of Chile from 15/10/2004 to 24/10/2004]

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# 2. Overall Objectives

The team focuses its activities on distributed (Grid) computing and more specifically on the development of secure and reliable distributed systems using distributed asynchronous object systems (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 preconditions where this calculus becomes deterministic.
- Internet (I of OASIS): Grid 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 (semantical definitions, equivalences, analyses);
- applied: 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 sense of notions like mobility and security. We believe that we have the skills to be significantly fruitful in this major application domain; more specifically, we aim at producing interesting results for embedded applications for mobile users, Grid computing, peer-to-peer intranet, electronic trade and collaborative applications.

# 3. Scientific Foundations

## 3.1. Object distributed computation

The paradigm of object-oriented programming, although not very recent, got a second youth with the Java language. The concept of object, even universal as intended is clearly not properly defined and implemented: thus notions like inheritance, sub-typing or overloading have as many definitions as there are underlying languages. The introduction of concurrency into objects also increases the complexity. It appeared that, standard Java components such as RMI (Remote Method Invocation) do not help to build in a transparent way sequential, multi-threaded, or distributed applications, by allowing the execution of the same application on a shared-memory multiprocessors architecture as well as on a network of workstations (intranet, Internet), or on any hierarchical combination of both.

The question is thus: how to ease the construction, deployment and evolution of distributed applications ?

We have developed competencies in both theoretical and pragmatic fields, such as an asynchronous calculus with specific properties, automatic distribution of activities using static analysis, and the building of a Java library for parallel, distributed, and concurrent computing.

## 3.2. Static analysis and verification

Programming distributed objects, even with the help of high-level libraries, also increases the difficulty of analyzing their behaviors, and ensuring safety, security, or liveness properties of these applications.

More generally, the formal verification of software systems is an area more recent and more difficult than verification of hardware and circuits. This is true both at a theoretical and pragmatic levels, from the definition of adequate models representing programs, the mastering of state complexity through abstraction techniques or through new algorithmic approaches, to the design of software tools that will hide to the final user the complexity of the underlying theory.

Our approach is to use techniques of static analysis and abstract interpretation to extract finite models from the code of distributed applications. We will use then generic tools for checking properties of this model [9]. We concentrate on behavioral properties, expressed in terms of temporal logics (safety, liveness), of security, of adequacy of an implementation to its specification and of correct composition of software components.

# 4. Application Domains

## 4.1. Electronic business

**Keywords:** *formal methods*, *program analysis*, *proofs*, *security*, *telecommunications*.

By electronic business, we mean distributed applications over the Internet that require safety and security otherwise they would not exist at all, due to highest risks (confidentiality, privacy, integrity, authentication and availability should be guaranteed).

We give examples of such applications:

- Secure commercial trade: programming such applications distributed over networks may uncover very complex behaviors, that may lead to deadlocks, starvation, and many other kinds of reachability or liveness problems. It is then necessary to propose methods for specifying the application behavior (requirements), and tools to check the implementation against those requirements. On the other hand, protection of communications and data are a requirement for the development of commercial applications. These security requirements have to be expressed in a security policy agreed by all partners, including customers.
- Secure collaborative applications: a multi-site enterprise may want to use Internet for the communication between different services and the collaborative building of a particular task, leading to specific problems of election, synchronization, load balancing, etc.
- Mobility for enterprise applications: a mobile worker should be able to run enterprise applications from anywhere, using heterogeneous network, and any device (desktop, laptop, PDA, board computer) in a transparent and a secure manner.

## 4.2. Grid computing

**Keywords:** *Grid*, *Telecommunications*, *distribution*, *fault tolerance*, *group communication*, *mobile object systems*, *peer-to-peer*, *security*, *synchronization*.

As distributed systems are becoming ubiquitous, Grid computing is emerging as one of the major challenge for computer science: seamless access and use of large-scale computing resources, world-wide. The word "Grid" is chosen by analogy with the electric power grid, which provides pervasive access to power and, like the computer and a small number of other advances, has had a dramatic impact on human capabilities and society. It is believed that by providing pervasive, dependable, consistent and inexpensive access to advanced computational capabilities, computational grids will have a similar transforming effect, allowing new classes of applications to emerge.

Another challenge is to use for a specific computation, unused CPU cycles of desktop computers in an Local Area Network. This is intranet Computational Peer-To-Peer.

There is a need for models and infrastructures for grid and peer-to-peer computing, and we promote a programming model based on communicating and mobile objects and components.

Another related domain of application is to use mobile objects for system and network management, for instance in the setting of OSGi (www.osgi.org) services and platforms (e.g. in industrial or home automation, vehicles, smart phones, etc).

# 5. Software

## 5.1. ProActive

ProActive is a Java library (Source code under LGPL 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 allowing to simplify the programming of applications that are distributed on Local Area Network (LAN), on cluster of workstations, 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 as an asynchronous activity,
- an actor with its own script,
- a server of incoming requests,
- a mobile and potentially secure agent.

and has an architecture to interoperate with (de facto) standards such as:

- Web Service exportation,
- HTTP transport,
- ssh, rsh, RMI/ssh tunneling,
- Globus: GT2, GT3, gsi, ssh,
- LSF, PBS, Sun Grid Engine.

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 (into which a security framework has been defined), the library is itself extensible, making the system open for adaptations and optimizations. ProActive currently uses the RMI Java standard library as default portable transport layer.

ProActive is particularly well-adapted for the development of distributed applications over the Internet, thanks to reuse of sequential code, trough polymorphism, automatic future-based synchronizations, 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.

Many features were highly incorporated to cope with the requirements of the Grid such as

- Deployment infrastructure that supports almost all Grid/cluster protocols: LSF, PBS, SGE, ssh, Globus,...;
- The communication layer that can rely on RMI or HTTP or IBIS, or SOAP or RMI/ssh. This last protocol allows to cross firewalls in many cases [37];
- The component framework [25] is now mature, and provides a graphical user interface to compose and deploy applications;
- The graphical user interface IC2D offers many other views of an application, for instance the Job monitor view, that allow better control and monitoring;
- The ability to exploit the migration capability of active objects, in network and system management [12].

Other features were added

- P2P infrastructure [36];
- Object Oriented SMPD programming model with its API [34].

We have demonstrated on a set of applications the advantages of the ProActive library, and among other we are particularly proud of:

- NQueen challenge, where we equaled the worl record n=24 (227 514 171 973 736 solutions) in 17 days based on ProActive's P2P infrastructure (300 machines).

Still based on ProActive, we organised in October the first Grid Plugtests in collaboration with ETSI, where we received 80 participant from 12 countries. It was a good opportunity to see that more and more people are interested in the Grid and in ProActive, and that some commercial companies start using ProActive in addition to academic research centers (Italy, Chile,...). One part of this event was a contest based on ProActive. The goal was to find the highest number of solutions in the NQueen challenge, using ProActive on a Grid of more than 800 processors. Six teams were competing. Chile team won with very good results.

At last ProActive tutorials were given in several occasions (Pisa, Santiago,Plugtests, ObjectWeb conference [35] ...) and we expect to give many others for the next year.

ProActive is a project of the ObjectWeb Consortium. ObjectWeb 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 (see http://www.objectweb.org). For more information, refer to [8], [17], [13] and to the web page http://www.inria.fr/oasis/proactive.

## 5.2. Bigloo's back-ends

Our work on Bigloo's back-ends, in collaboration with Manuel Serrano of the Mimosa project, is integrated in the Bigloo compiler (http://www-sop.inria.fr/mimosa/fp/Bigloo/).

# 6. New Results

## 6.1. ASP: Asynchronous Sequential Processes

**Participants:** Denis Caromel, Ludovic Henrio, Bernard Serpette.

The objective of ASP is to design an object calculus that allows to write parallel and distributed applications, particularly on wide range networks, while ensuring good properties.

The main characteristics of ASP are:

- asynchronous communications,
- futures,
- sequential execution within each process,
- simple preconditions where strong confluence and determinism properties can be proved.

A first design decision is the absence of sharing: objects live in disjoint activities. An activity is a set of objects managed by a unique process and a unique active object. Active objects are accessible through global/distant references. They communicate through asynchronous method calls with futures. A future is a global reference representing a result not yet computed. Our main result consists in a confluence property and its application to the identification of a set of programs behaving deterministically.

From a practical point of view, ASP can also be considered as a model of the ProActive library.

Our contribution this year are extensions of the basic ASP calculus, concerning mobility, group communication, delegation, non confluent features: non-blocking services, testing request and futures reception, synchronization patterns (Select, Join, etc.), and finally components and reconfiguration.

From the proposed framework, we suggest a path that can lead to reconfigurable components. It demonstrates how to go from asynchronous distributed objects to asynchronous distributed components, including collective remote method invocations (group communications), while retaining determinism.

All ASP results can be found in [7] for the definition of the basic ASP calculus.

## 6.2. Hierarchical grid components

**Participants:** Françoise Baude, Denis Caromel, Matthieu Morel, Romain Quilici.

We propose a parallel and distributed component framework for building Grid applications, adapted to the hierarchical, highly distributed, highly heterogeneous nature of Grids. We have enriched ProActive by extending and implementing an existing hierarchical and dynamic component model, named Fractal, so as to master the complexity of composition, deployment, re-usability, and efficiency of Grid applications. This defines a concept of Grid components, that can be parallel, made of several activities, and distributed. These components communicate using typed one-to-one or collective invocations.

This component model is defined and implemented within ProActive, see [25]. This work is part of a very active research area which aims at easing Grid programming by introducing powerful but efficient programming component-based models (see for instance a general presentation of this arena : [23] and [22]).

Further work is now to extend the IC2D tool so as to add interactive aspects related to components: composition, deployment, and dynamic rebinding and redeployment. Composition is now avalaible, as a smooth extension of the GUI composition tool available in standard in Fractal. The inclusion of this graphical tool within IC2D remains to be achieved.

## 6.3. Fault Tolerance for Grid applications

**Participants:** Françoise Baude, Denis Caromel, Christian Delbé, Ludovic Henrio.

We have launched a PhD thesis on the very challenging following subject, which is undoubtedly critical for grid computing: fault tolerance of distributed object-oriented based applications running on a grid.

A rollback-recovery fault-tolerance protocol has been developed and improved during this year. Although this protocol includes additionnal mechanisms which deal with ProActive specificities, its failure-free execution overhead remains low compared to classical procotols (about 5%) (see [14]) . This feature allows ProActive applications to restart automatically after the failure of one (or more) of the active objects, while preserving the work done until this failure. There is no need to modify nor recompile an application to make it fault tolerant : fault-tolerance is fully transparent.

The correctness of this protocol has been also formally studied and proved in [31]. This proof is based on the *consistent enough global states*, which is introduced in [24].

This work first targets applications running on a single cluster ; we are currently designing a global protocol based on this work for large applications running on the Grid.

## 6.4. Improving the performance of ProActive with an optimised communication layer

**Participants:** Denis Caromel, Fabrice Huet.

Fabrice Huet was awarded an INRIA Grant to work as a post-doc in prof. Henri Bal's research group at the Vrije Universiteit, Amsterdam.

The aim of this work was to replace the sun RMI layer used by ProActive for its communications by Ibis, a high performance middleware. Its main advantage is that is offers a RMI-like interface which simplifies the development of applications. In previous work, the good performance of Ibis was demonstrated, however this was only done through micro-benchmarks and whether or not an application would benefit from it was still an open question.

After stacking ProActive and Ibis, we have ran extensive benchmarks using Jem3D [18] as our test application. Comparing the execution time using ProActive/RMI and ProActive/Ibis, we have shown that we can reduce it by 20 to 50%. Another important result is that the application scales much better with Ibis. It was possible to achieve a speedup close to a Fortran version, albeit still 3 times slower. Using high level features of ProActive like deployment and group communications, we were able to deploy Jem3D on 150 nodes on the DAS-2 virtual cluster [26].

## 6.5. Securisation of object oriented applications

**Participants:** Isabelle Attali, Denis Caromel, Arnaud Contes, Felipe Luna del Aquila.

Grid applications must be able to cope with large variations in deployment: from intra-domain to multiple domains, going over private, to virtually-private, to public networks. As a consequence, the security should not be tied up in the application code, but rather easily configurable in a flexible and abstract manner. Moreover, any large scale Grid application using hundreds or thousands of nodes have to cope with migration of computations, for the sake of load balancing, change in resource availability, or just node failures. To cope with those issues, we propose a high-level and declarative security framework for object-oriented Grid applications. We define in a rather abstract manner, a hierarchical policy based on various entities (domain, host, JVM, activity, communication, ...) in a way that is easily adaptable and configurable on a given deployment. The framework also accounts for open and collaborative applications, multiple principles with dynamic negotiation of security attributes and mobility of computations. This application-level security relies on a Public Key Infrastructure (PKI).

This security model is implemented within ProActive, (see [32]) and we focused on the fact that security policies are expressed outside the application source code, in domain policy files, and application deployment descriptor. This is the main feature that allows for scalability and dynamicity.

We are also interested in security problems found when information flows in object-based applications meant to be shared and distributed. The security problems are briefly stated to be the existence of unauthorized flows (or disclosure of information) and information leakages (existence of covert channel).

We have designed a precise security model for the secure information flow in asynchronous and distributed objects, see [33].

The object model used in this work is based on the object-oriented paradigm, and because services are mostly intended to operate in an asynchronous mode, our work is based on the ASP (Asynchronous Sequential Processes) calculus [7]. We extend the formal semantics of ASP with predicate conditions that provide then a formal definition to our model and, at the same time, makes it possible to dynamically check for unauthorized accesses. Finally, in order to prove the correctness of our security model, an intuitive secure information flow property is defined and proved to be ensured by the application of access control model.

The solution is mainly founded on three cornerstones: the concept of flow of information, security levels attached to activities, and the definition of security rules to be applied to all communications. The proposed security model heavily relies on security policy rules with mandatory enforcements for the control of information flow. The combination of mandatory and discretionary rules allows to relax the strict control imposed by the sole use of mandatory rules.

This security model is implemented as dynamic checks in the ProActive middleware, which may, in a non-intrusive manner, provide and ensure security services to upper-level applications. This is currently under evaluation on real-size examples for scalability and flexibility.

## 6.6. Analysis and Verification Environment for Distributed Java

**Participants:** Isabelle Attali, Tomas Barros, Rabéa Boulifa, Javier Bustos, Denis Caromel, Ludovic Henrio, Éric Madelaine, Christophe Massol, Alejandro Vera.

We develop methods and tools for the automatic verification of behavioral properties of distributed applications. We are interested by temporal properties concerning the message exchanges between distributed components, in particular safety properties (deadlock, reachability, ordering of events) or liveness, and conformance (of a component interface, of the global application) to a specification. Some kind of security properties (access to resources, confidentiality) can also be treated with similar techniques.

Our previous results on generation of finite behavioral models for ProActive distributed applications were constrained in several ways because of their "finite abstraction" approach: in order to ensure the finiteness of the generated model, we relied on user's annotations to provide finite interpretations of the data domains of his application.

We propose a new approach, based on very expressive "parameterized hierarchical models" framework, that we presented in [19]. In this approach, we can express both value passing messages and parameterized topologies of processes. We have described in [19] and in R. Boulifa's PhD thesis [11] how these models allow us to generate parameterized models for ProActive applications, and to verify their safety and liveness properties with standard model-checking tools, based on finite abstractions of the data domains of the parameters.

Based on the same parameterized models, we have proposed a graphical specification langage for the behavior of distribued applications, and have used this langage in the analysis of a real size case-study in [30] and [16]. The full sources for this case study, and the tools required for its analysis (including the parameterized models instanciation tool from Tomas Barros) are available on our Web pages: http://www-sop.inria.fr/oasis/Vercors/.

Christophe Massol has continued his implementation of the static analysis front-end for ProActive source, and has integrated in this tool the dataflow analysis required for the generation of parameterized models. This prototype is not yet fully usable, but already provides the construction of extended method call graphs for a small kernel of ProActive.

Alejandro Vera has implemented a prototype of a graphical editor for parameterized networks of labelled transition systems, that will allow us to experiment with our specification langage.

## 6.7. Static Analysis

**Participants:** Denis Caromel, Ludovic Henrio, Bernard Serpette.

The work on the .NET backend for the Bigloo's platform ends up with two publications,: [20] and it's journal version [15]. This work was done in collaboration with Yannis Bres and Manuel Serrano of the Mimosa project.

A work on implementation and proof on an imperative rho-calculus ends up with a publication [27]. This task was done with Luigi Liquori of the Miro project.

A work on the specification of fair threads inside the Bigloo's platform ends up with a publication: [28]. This was done with F. Boussinot and M. Serrano of the Mimosa project.

# 7. Contracts and Grants with Industry

## 7.1. ARCAD

ARCAD (http://arcad.essi.fr) is acronym for *Architecture Répartie extensible pour Composants ADaptables*. It is a RNTL contract, started in 2001, ended in June 2004, involving 130 kEuros.

Members of this contract are: Rainbow (I3S CNRS UNSA), DTL/ASR (France Télécom R&D), Sardes (INRIA Rhône-Alpes) and OCM (École des Mines de Nantes).

Details of our contribution for this contract are developed in 6.2.

## 7.2. GRID RMI : Programming the Grid with distributed Objects

GRID RMI (http://www.irisa.fr/Grid-RMI) is a software project of the French *Action Concertée Incitative* (ACI) *Globalisation des ressources informatiques et des données* (GRID) of the Ministry of Research. This project started in 2002, for 2 years, involving 38 kEuros.

The goal of this project is to promote a programming model for computing Grids. This model combines both parallel programming models and distributed programming models. It is based on the concept of distributed objects and software components for the distributed programming. This project targets the design and the experiment of a high performance communication software framework enabling both efficient communication between objects or components and parallel programming.

Members of this project are: IRISA, LIP ENS-Lyon/LABRI Bordeaux, INRIA, I3S, LIFL, and EADS.

## 7.3. OSMOSE

OSMOSE (http://www.itea-osmose.org) is acronym for *Open Source Middleware for Open Systems in Europe*. It is a project, started in 2003, for 2 years, involving 60 kEuros.

The overall technical goal of the OSMOSE project is focused on the development, enhancement, and validation in defined test-beds of a comprehensive adaptable Open Source middleware to be hosted by the ObjectWeb consortium http://www.ObjectWeb.org.

The members of the project belong to 8 different European countries: Belgium, Czech Republic, France, Greece, Ireland, Netherlands, Spain and Switzerland. The project is built around three sets of partners: 6 large industrial companies (Bull, France Télécom, Philips, Telefonica, Telvent and Thales), 6 SMEs (Bantry Technologies, iTEL, Kelua, Lynx, VICORE and Whitestein Technologies), and 7 academic partners (CharlesUniversity, EPFL, INRIA, INT, LIFL, LSR and Universidad Politécnica of Madrid).

## 7.4. Data Grid Explorer

Data Grid Explorer is a project of the French *Action Concertée Incitative* (ACI) *Masse de données* of the Ministry of Research. This project started in 2003, for 3 years, involving 7 kEuros.

The project Data Grid Explorer aims at experimenting on large scale distributed systems on different features such as : fault tolerance, localization and performance.

Members of this project are: IMAG, LaRIA, LRI, LASSI, LORIA, LIP ENS Lyon, LIFL, LIP6, LABRI, IBCP, CEA and IRISA.

## 7.5. Fiacre

Fiacre stands for "FIabilité des Assemblages de Composants REpartis: Modèles et outils pour l'analyse de propriétés de sécurité et de sureté"; Fiacre is a software project of the French *Action Concertée Incitative* (ACI) *Security* of the Ministry of Research. This project started in september 2004, for 3 years, involving 97 kEuros.

Gathering teams specialized in behavioural specifications of components, languages and models for distributed, mobile, and communicating application programming, and methods and tools for compositional verification, the goal of FIACRE is to design methods and tools for specification, model extraction, and verification of distributed, hierarchical, and communicating components. We would like the collaboration to result in a software prototype applicable to realistic applications.

Members of this project are: INRIA (Oasis/Vasy), Feria/SVF, and ENST/ILR.

## 7.6. Accessing and Monitoring the Grid using Web Services

This is a project supported by Microsoft Research in 2004 for an amount of 25 kEuros. We propose to design and develop a SOAP-based communication layer inside a grid-oriented Middleware for accessing, publishing and monitoring resources over the Grid using Web Services and OGSA (GGF standard).

During this project, we addressed two important features related to security and interoperability. ProActive applications separated by firewalls may need to communicate. The issue is that using RMI communication, more than one port must be opened on these firewalls. We improved a new communication layer based on HTTP in order to use only the usual opened port. Users can also monitor ProActive applications from any web services enabled languages thanks to the ability to export an active object as a web service.

## 7.7. Extending the Fractal model for Grid computing

This is a CRE (Contrat de Recherche Externalisée), supported by France Telecom RD, starting in october 2004, for two years, for an amount of 128 kEuros.

We study how the Fractal Model for components is appropriate to the programming of Grids. We wish to define parallel and hierarchical components, collective actions that would allow for a easier building of Grid applications. We also want to experiment on large-scale applications (one thousand nodes). Altogether, this research should provide tools for programming and deploying Grid applications, including the packaging of legacy code.

# 8. Other Grants and Activities

## 8.1. National Collaborations

### *8.1.1. ARC Concert*

Concert (*Compilateurs Certifiés* http://www-sop.inria.fr/lemme/concert) is an ARC (2003-2004) aiming at producing a realistic certified compiler, i.e. accompanied by a Coq equivalence proof between the source code and the generated code.

A work on the specification and some proofs for a parallel move algorithm is currently in a submission process. This task was done, inside the ARC concert, with Laurence Rideau of the Lemme project.

## 8.2. European Collaborations

### *8.2.1. SSA GridCoord*

GridCoord ( *Era Pilot on a Coordinated Europe-wide Initiative in Grid Research*) is a Specific Support Action (SSA) of the Sixth Framework Programme of the European Community.

Our objectives are to (1) overcome fragmentation and dispersion accross EU to reinforce impact of national and Community research and (2) strengthen Europe's position on Grid Research and its exploitation.

This project started in july 2004, for 18 months, involving 94 kEuros.

### *8.2.2. NOE CoreGRID*

CoreGrid ( *the European Research Network on Foundations, Software Infrastructures and Applications for large scale distributed, GRID and Peer-to-Peer Technologies*)

The CoreGRID Network of Excellence (NoE) aims at strengthening and advancing scientific and technological excellence in the area of Grid and Peer-to-Peer technologies. To achieve this objective, the Network brings together a critical mass of well-established researchers (119 permanent researchers and 165 PhD students) from forty-two institutions who have constructed an ambitious joint programme of activities. This joint programme of activity is structured around six complementary research areas that have been selected on the basis of their strategic importance, their research challenges and the recognised European expertise to develop next generation Grid middleware.

This project started in september 2004, for 18 months, involving at least 65 kEuros.

## 8.3. International Collaborations

### *8.3.1. Oscar*

Oscar ( *OSCAR : Objets et Sémantique, Concurrence, Aspects et Reflexion*) is a bilateral collaboration (équipe associée) between CONICYT and INRIA. We aim at gathering expertise on meta-object protocols, concurrency, transparent distributed programming, and verification of distributed systems. Contributions are related to modeling and verifying distributed software [19] [16] [29], and safe concurrency [21] (http://www.inria.fr/oasis/oscar).

A Chilean team successfully participated to the ETSI Grid Plugtests, that we organized in October 2004 [38].

## 8.4. Visits, schools and conferences

- Visits:
  - Eric Tanter (PhD at University of Chile) (from 21 June to 1st of July).
  - Luis Mateu (University of Chile). (from 15 to 24 of October).
  - Visit of associate professor Léandro Rabindranath Léon (University of los Andes, Merida Venezuela)ECOS-Nord scientific cooperation with Venezuela from 2 to 23 of October.
  - Furmento Nathalie Research Associate, London E-Science Centre Department of Computing, Imperial College London, from 01/09/2004 to 31/08/2005.
- Thematic schools:
  - Matthieu Morel attended the school for young researchers: "Ecole Jeunes Chercheurs en Programmation" from May 24th to June 4th, Nantes - Le Croisic, France. This school is organized each year and holds around forty participants, all of them, first year PhD (computer science) students.
  - Christian Delbé attended the school "Ecole Jeunes Chercheurs en Programmation" from May 24th to June 4th, Nantes - Le Croisic, France.
  - Félipé Luna del Aguila attended the school "Ecole Jeunes Chercheurs en Programmation" from May 24th to June 4th, Nantes - Le Croisic, France.

- Conferences:

  – Denis Caromel, Ludovic Henrio and Isabelle Attali took part in POPL'2004 (January, Venise Italy) and presented an article ("Asynchronous and Deterministic Objects").
  – Bernard Serpette took part in JFLA 2004 (January, Sainte-Marie-de-Ré) and presented an article "Algorithmes et complexités de la réduction statique minimale" Ludovic Henrio, Bernard Paul Serpette, Szabolcs Szentes.
  – Bernard Serpette took part in workshop CASSIS 2004 Construction and Analysis of Safe, Secure and Interoperable Smart devices (March, Marseille).
  – Francoise Baude took part in the Atelier Franco-Japonais on the Grid (March, Paris)
  – Isabelle Attali took part in ETAPS 2004 - LDTA - Fourth Workshop on Language Descriptions, Tools and Applications (April, Barcelone).
  – Presentation by Tomas Barros on *Formal Description and Analysis for Distributed Systems* [29] at the Integrated Formal Methods conference (doctoral symposium) IFM'04 (April, Kent, UK).
  – Romain Quilici took part in "Journées Académiques Microsoft Research" (April, Chantilly).
  – Denis Caromel took part in IPDPS 2004 - 18th International Parallel & Distributed Processing Symposium - (April, Santa Fe - New Mexico) and presented an article : "Parallel Object-Oriented Application for 3D Electromagnetism" (Laurent Baduel, Françoise Baude, Denis Caromel, Christian Delbé, Nicolas Gama, Said El Kasmi and Stéphane Lanteri, University Nice Sophia Antipolis).
  – Denis Caromel has been invited and he gave a talk in the Grid Computing au IV International Meeting : "Meeting Science, Culture and Education on the Research and Development Global Network" (May, Santiago - Chili).
  – Denis Caromel and Isabelle Attali has been invited at JAOO SYMPOSIUM 2004 (May, Cannes). Presentation an article by D. Caromel "Programming, Composing, Deploying, for the GRID".
  – Presentation by Isabelle Attali and Katia Pijarowski of the project DLP Mobility (Challenge Jeunes Pousses - May, Sophia Antipolis).
  – Fabrice Huet took part in UBIMOB'04 - Premières Journées Francophones : Mobilité et Ubiquité 2004 (June, Essi Sophia Antipolis) and presented an article "Un mécanisme de communication adaptatif pour objets mobiles", writers Caromel and Huet, INRIA-I3S-CNRS&Vrije Universiteit.
  – Denis Caromel took part in ECOOP 2004 - 18th European Conference on Object-Oriented Programming (June, Oslo) and presented an article about 'Associate Team OSCAR' "Sequential Object Monitors", writers Caromel, Mateu and Tanter.
  – Christian Delbé took part in DSN 2004 - The International Conference on Dependable Systems and Networks (June, Florence) and presented an article at the student Forum "Causal Ordering of Asynchronous Request Services".
  – Francoise Baude participated in the ICS 2004 workshop on Component Models and Systems for Grid Applications (June, St Malo) and presented the paper [25].
  – Presentation by Eric Madelaine on *Models for the Verification of Distributed Java Objects* at the OSMOSE Behavior workshop (Prague, July).

- Denis Caromel attended and gave an invited talk "Components for Numerical GRIDs" in ECCOMAS 2004 4th European Congress on Computational Methods in Applied Sciences and Ingineering Centre (July, Jyväskylä-Finland).
- Denis Caromel and Romain Quilici took part in EURO PAR 2004 (september,Pise) Presentation of an invited Tutorial "Open Source Middleware for the Grid: Distributed Objects and Components in ProActive".
- Denis Caromel took part in Workshop on Clusters and Computational Grids for scientific Computing (September, Faverges-de-la-Tour) and presented an article "A High Performance Java Middleware with a Real Application - Beating Fortran MPI with Java ProActive ?".
- Denis Caromel attended and gave an invited talk "Being ProActive about Adaptive Grid Middleware" at the AGridM 2004 Workshop on Adaptive Grid Middleware in conjunction with PACT 2004 (September, Antibes Juan-les-Pins).
- Presentations by Eric Madelaine of a paper *Parameterized Models for Distributed Java Objects* [19] at the Forte'04 conference (Madrid, September).
- Tomas Barros took part in Distributed Systems Research Group, Charles University, Prague (October, Prague) and presentation of two conferences "Parameterized Models for Distributed Java Objects" and "Parameterized Specification and Verification of the Chilean Electronic Invoices System".
- Several members of the project took an active part in the organization of the first ProActive User Group and Grid PlugTests (October, Sophia-Antipolis).
- Seminar Future Generation Grids - FGG 2004 (November, Dagstuhl). Organizers: M. Cosnard (INRIA Sophia Antipolis, FR), V. Getov (Univ. of Westminster, GB), D. Laforenza (CNR - Pisa, IT), A. Reinefeld (K. Zuse Zentrum Berlin, DE). Invited presentation of the Denis Caromel "Distributed Components for the GRID".
- Participation of Rabea Boulifa at the FMCO Symposium (November,Leiden - Holland).
- Demonstrations of ProActive on the INRIA booth, by Laurent Baduel and Fabrice Huet at SuperComputing 2004 (November, Pittsburgh).
- Participation of Tomas Barros (speaker), Denis Caromel, Eric Madelaine at the XXIV International Conference of the Chilean Computer Science Society (SCCC'04, Arica, Chile, November), and presentation of an article *Formalisation and Proofs of the Chilean Electronic Invoices System* [16] .
- Presentations by Denis Caromel: Hierarchical components for the GRID, Eric Madelaine: Verification of Distributed Applications and Tomas Barros: Towards a tool-set for distributed system verification, at the OSCAR workshop (Santiago, Chile, nov 2004).
- Tutorial ProActive and Grid technologies by Romain Quilici at University of Chile (November, Santiago).
- Igor Rosenberg took part in IST 2004 (November, the Hague) for the booth CoreGrid.
- Arnaud Contes took part in EC-Bridge Europe-China Scientific & Technological (December, Shanghai). He gave a presentation and a demontration of the ProActive and the Grid programming.
- Francoise Baude and Laurent Baduel will attend the workshop Grid organized by NII, in Tokyo (December, Japan).
- Isabelle Attali and Denis Caromel has been invited Ecole RISCMAP (December, Matara Ski-Lanka) and Collaboration with "Department of Mathematics, University of Ruhuna".
- Francoise Baude and Matthieu Morel will take part in the 4th annual ObjectWeb conference (January 17-19 2005, Lyon).General presentation of ProActive [35], and a tutorial.

# 9. Dissemination

## 9.1. Dissemination of scientific knowledge, responsabilities

- Rabéa Boulifa, Tomas Barros and Felipe Luna have presented their research in the INRIA Sophia-Antipolis "Séminaire Croisé", april 2004

## 9.2. Scientific Animation

- Rabéa Boulifa, Tomas Barros and Felipe Luna have presented their research in the INRIA Sophia-Antipolis "Séminaire Croisé", april 2004

## 9.3. Teaching

- Françoise Baude
  - is member of the *commission de spécialistes 27ème section* at UNSA.
  - was in charge of coordinating the Licence Informatique at UNSA, until October 2004.
  - coordinated and was in charge of the courses on "Concepts of operating systems" in the Licence d'Informatique at UNSA and in the DESS Telecommunications at UNSA until June 2004.
  - gave a course on XML technologies in the Licence MIAGE at UNSA, march-may 2004.
  - gave courses on Java programming in the Licence informatique at UNSA, march-may 2004.
  - gives courses on "Distributed Algorithms" in the DEA RSD at Unsa.
  - gives courses on "Parallel Functional Programming" in the DEA RSD and DEA Informatique at UNSA.
- Denis Caromel
  - coordinates the "Distributed Systems" track of the DEA RSD (Réseaux et Systèmes Distribués) at UNSA, in collaboration with CMA, CNET, Eurécom, INRIA Sophia Antipolis.
  - is in charge of coordinating the DESS Télécommunications, within the département d'Informatique from UNSA.
  - coordinates the course on "Concurrent, Parallel and Distributed Programming Languages" in the DEA RSD and DEA Informatique at UNSA.
  - coordinates and is in charge of the courses on "Distributed Programming" in the Maitrise d'Informatique at UNSA.
- Rabéa Boulifa
  - gives a course on "Calculabilité et complexité informatiques" in the Maitrise Informatique at UNSA.
- Laurent Baduel
  - has given one course on Computer Systems in DEUG Math-Info, second year.

  - has given courses on programming languages in the License Informatique - UNSA.
- Ludovic Henrio
  - has given one course on Security in Java Card in DESS Télécommunications, within the département d'Informatique from UNSA.
  - gives courses on system programming at ESSI school - UNSA.
- Arnaud Contes
  - gives a course on "Theory of languages" in the Licence Informatique at UNSA.
  - gives a course on "Introduction to the Gimp" in the DEUG Informatique at UNSA.
  - gives a course on "Introduction to UNIX" in the DEUG Informatique at UNSA.

# 10. Bibliography

## Major publications by the team in recent years

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[2] I. ATTALI, D. CAROMEL, S. O. EHMETY, S. LIPPI. *Semantic-based visualization for parallel object-oriented programming*, in "Proceedings of OOPSLA'96, San Jose, CA", ACM Sigplan Notices, vol. 31, 10, ACM Press, October 1996.

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[5] D. CAROMEL, F. BELLONCLE, Y. ROUDIER. *The C++// System*, in "Parallel Programming Using C++", ISBN 0-262-73118-5, MIT Press, 1996.

[6] D. CAROMEL. *Towards a Method of Object-Oriented Concurrent Programming*, in "Communications of the ACM", vol. 36, n° 9, September 1993, p. 90–102.

[7] D. CAROMEL, L. HENRIO, B. SERPETTE. *Asynchronous and Deterministic Objects*, in "Proceedings of the 31st ACM Symposium on Principles of Programming Languages", ACM Press, 2004, p. 123–134.

[8] D. CAROMEL, W. KLAUSER, J. VAYSSIERE. *Towards Seamless Computing and Metacomputing in Java*, in "Concurrency Practice and Experience", vol. 10, n° 11–13, November 1998, p. 1043–1061.

[9] E. MADELAINE. *Verification Tools from the Concur project*, in "EATCS Bulletin", n° 47, 1992.

[10] B. SERPETTE. *Approximations d'évaluateurs fonctionnels*, in "Proceedings of WSA (Workshop on Static Analysis)", Bigre, 1992, p. 79–90.

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[11] R. BOULIFA. *Génération de modèles comportementaux des applications réparties*, Ph. D. Thesis, Université de Nice - Sophia Antipolis – UFR Sciences, December 2004.

[12] E. REUTER. *Agents Mobiles: Itinéraires pour l'administration Système et Réseau*, Ph. D. Thesis, Université de Nice - Sophia Antipolis – UFR Sciences, May 2004.

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[13] L. BADUEL, F. BAUDE, D. CAROMEL, A. CONTES, F. HUET, M. MOREL, R. QUILICI. *Grid Computing: Software Environments and Tools*, To appear, chap. Programming, Composing, Deploying, for the Grid, Springer Verlag, 2005.

[14] F. BAUDE, D. CAROMEL, C. DELBÉ, L. HENRIO. *Un protocole de tolérance aux pannes pour objets actifs non préemptifs*, in "Technique et Science Informatiques", à paraître.

[15] Y. BRES, B. SERPETTE, M. SERRANO. *Bigloo.NET: compiling Scheme to .NET CLR*, in "Journal of Object Technology, 3(9)", 2004.

## Publications in Conferences and Workshops

[16] I. ATTALI, T. BARROS, E. MADELAINE. *Formalisation and Proofs of the Chilean Electronic Invoices System*, in "in proc. of the XXIV International Conference of the Chilean Computer Science Society (SCCC'04), Arica, Chili", IEEE, November 2004, http://www-sop.inria.fr/oasis/Vercors.

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[18] L. BADUEL, F. BAUDE, D. CAROMEL, C. DELBE, N. GAMA, S. E. KASMI, S. LANTERI. *A Parallel Object-Oriented Application for 3D Electromagnetism*, in "IEEE International Symposium on Parallel and Distributed Computing, IPDPS", april 2004.

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[25] FRANCOISE BAUDE AND DENIS CAROMEL AND MATTHIEU MOREL. *On Hierarchical, parallel and distributed components for Grid programming*, in "Component Models and Systems for Grid Applications - ICS2004 Workshop on COmponent Models and Systems for Grid Applications", V. GETOV, T. KIELMAN (editors)., ISBN 0-387-23351-2, Springer, June 2004.

[26] F. HUET, D. CAROMEL, H. E. BAL. *A High Performance Java Middleware with a Real Application*, in "SuperComputing 2004".

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