Chapter 3

Achievements of "Pôle GLC" (Génie du Logiciel et de la Connaissance)

Scientific leader: M. Riveill

We chose to present the scientific activities of GLC pôle's members ("Génie Logiciel et de la Connaissance") into the 5 following axis: Middleware, Software Composition, Semantic Web, Security, Data mining. These scientific axis do not exactly cover the themes of the " teams" belonging to the pôle. The following table summarizes the main contributions of each team into the chosen axis.

Team	RA 1 Middleware	RA 2 Software composition	RA 3 Semantic Web	RA 4 Security	RA 5 Data mining
Keia					X
Kewi			X	X	
Modalis	X	X	x	X	
Rainbow	X	X	x	X	

The Sophi@STIC campus, which is under construction, is organized around four scientific domains:
- Systems and ubiquitous networks,
- Health and Computational Biology,
- Modeling, simulation and technologies for the Environment and Sustainable Development (energy, water, land management),
- Knowledge, services and network usage.

Team	Domain 1 Systems/Networks	Domain 2 Health/Biology	Domain 3 Sustainable Development	Domain 4 Usage
Keia		X	X	
Kewi			X	X
Modalis	X	X		X
Rainbow	X		X	X

The teams of the GLC pôle structure essentially the activities and projects of the pôle and are temporary units. Thus, the remainder of this report does not refer to them directly and focuses instead on the five axis introduced previously (Middleware, Software composition, Semantic web, Security and Data mining) to present the pôle's activities.

Research Areas (RA):

- **RA 1: "Middleware"**
  Key-words: distributed computing, grids, data-parallel problems, ambient computing, software adaptation, autonomic software, workload distribution, probabilistic modeling.
  Computer network capacities and CPU frequency ceiling led to a renewed interest for distributed computing infrastructures. The *middleware* approach adopted consists in inserting a heavy software layer between the distributed resources local management software and the top-level applications exploiting the distributed platform. This intermediate layer addresses challenges of distributed systems programming such as heterogeneous resources management, workload distribution and distributed software consistency. This activity lies at the convergence of the *Services and Components Architectures* and the *High Throughput Computing* research communities which have complementary views on distributed systems.
- **RA 2: "Software composition"**
  Key-words: separation of preoccupations, reuse, model composition, variability.
  The separation of concerns is a way to control the variability and the complexity of software development by enabling multiple experts to work together on the same software with different point of views and according to various contexts. Separation induces Composition. Depending on the elements to compose, different mechanisms are involved to manage the consistency of the systems obtained. We offer several composition mechanisms at different stages of software life cycle.
- **RA 3: "Semantic Web"**
  Key-words: social network, knowledge modeling, knowledge-management, learning systems, collaborative work, ontology
  The design, sharing and access of the information through Internet becomes more and more an important issue. The research activities conducted in this axis provide a theoretical framework for graph-based knowledge management as well as models and tools to put in practice knowledge management supporting means.
- **RA 4: "Security"**
  Key-words: security properties, secure communication protocols, distributed access control, context-aware access control, access control ontology, intrusion detection, IP traceback.
  Concerning security management activity, we propose to manage security from a software engineering point of view, i.e. considering the point of view of a developer who is not expert in security. For this kind of developer, it is not easy to model a system including security and/or to add security to a non-secure system/application because of the complexity of security, the lack of knowledge in security field and the lack of time when designing and developing softwares. Our goal is not to develop new security solutions but to propose solutions that will allow non-security expert application designers to easily and efficiently add and integrate security during the development process.
- **RA 5: "Data mining"**
  Key-words: algorithms, heuristics and meta-heuristics, knowledge pattern extraction, statistics, bioinformatics.
  The recent developments of acquisition and storage technologies, both hardware and software, generate nowadays very large amounts of data stored in databases, knowledge bases, bibliographic repositories, distributed information systems, etc. Analyzing these data has thus become a major challenge for decision support and process optimization, leading to the appearance of new business intelligence approaches and data mining. This research axis aims at the development of semantics, techniques and algorithms for the analysis of very large sets of heterogeneous data, that can be structured, semi-structured or unstructured, and their applications for decision support. The focus is on approaches for both knowledge patterns extraction and discovered patterns exploitation, and for the integration of expert background knowledge in the data mining process.

3.1 Members (01/2006-06/2010)

The GLC pôle is young and under staffed concerning professors and 'HDR' members. Over the period, we had only one departure (MC HDR→PR) for 4 arrivals (1 IE, 3 MC) and 2 locals promotion(CR→DR MCF→PR). The single local recruitment is largely justified under disability. All other recruited MCF members are external to the University of Nice-Sophia Antipolis and we want to maintain this recruitment policy. In the last 2 years, the pôle proposed candidates to enter CNRS (CR and DR this year).

The cluster members receive regular CRCT and délégation from CNRS and INRIA (even if we have no common team with INRIA). These periods without teaching loads are needed and have helped members to revive research activities, prepare HDR (Mr Blay-Fornarino, Mr. Collard, I. Mirbel for HDRs supported; P. Collet, N. Pasquier, J-Y. Tigli for HDRs in preparation).

The overall research activity has increased over the years. The end of the period is clearly richer than the beginning. This is due to a better collective organization within the pôle: recovery of research activity, higher efficiency in research contracts and research output improved significantly in terms of quality. Though significant progress can still be made. This is particularly reflected in the fact that the pôle has now more PhD students (29) than the number of theses defended during the period (14).

3.1.1 Permanent members

	position	pedr or pes	teaching dep.	A/D	administrative duties
Blay-Fornarino Mireille	MCF 27 HDR		info.EPU		In charge of AL speciality of IFI Master (2007-)
Boudaoud Karima	MCF 27		R&T.IUT		
Buffa Michel	MCF 27		info.UFR sc.		
Collard Martine	MCF 27 HDR		Info.IUT	/2009	
Collet Philippe	MCF 27	PEDR 2008-	info.UFR sc.		
Crescenzo Pierre	MCF 27		info.UFR sc.		Head of MIAGE, UFR Sc. (2008/-)
Dartigues Christel	MCF 27		STID.IUT	2006/-	
Faron-Zucker Catherine	MCF 27		Info.EPU		In charge of KIS speciality of IFI Master (2007/-)
Gaignard Alban	IE2 CNRS			2006/-	
Lahire Philippe	PR2 27		info.UFR sc.		In charge of L2 in computer science (2006-2009)
Lavirotte Stephane	MCF 27	PES 2009-	IUFM		Head of TICE dept, IUFM (2006-2009) In charge of IAM speciality of IFI Master (2009/-)
LeThanh Nhan	PR1 27		info.UFR sc.		In charge of LPro SIL
Lingrand Diane	MCF 61		info.EPU		
Mirbel Isabelle	MCF 27 HDR		info.UFR sc.		
Montagnat Johan	DR2 CNRS				
Occello Audrey	MCF 27		info.EPU	2008/-	
Pallez Denis	MCF 27		STID.IUT	2008/-	
Pasquier Nicolas	MCF 27		info.UFR sc.		
Pinna-Dery Anne-Marie	MCF 27		info.EPU		In charge of HCI speciality of IFI Master (2007/-)
Renard Helene	MCF 27		info.EPU	2006/-	
Renevier-Gonin Philippe	MCF 27		info.UFR sc.		In charge of L3 MIAGE, UFR sc. (2007/-)
Rey Gaetan	MCF 27		info.IUT	2007/-	Head of first and second year CS dept, IUT Nice (2009/-)
Riveill Michel	PREX 27	PEDR 1994-	info.EPU		Head of CS dept, EPU (2005/2009)
Sander Peter	PR2 27		info.EPU		In charge speciality of IFI Master localized in Vietnam (2008/-)
Tigli Jean-Yves	MCF 27	PEDR 2007-	info.EPU		In charge of IAM speciality of Master (2006/2008)

Arrivals and promotions (MCF → PR and CR → DR) over 01/2006-06/2010

	date	fact	origin
Dartigues Cristel	janv-06	recruitment MC UNS	Lyon 1, LIRIS
Gaignard Alban	déc-06	recruitment IE CNRS	Rennes 1, IRISA
Lahire Philippe	sept-06	promotion MCF 27 -> PR 27	UNS, I3S
Montagnat Johan	oct-09	promotion CR CNRS -> DR CNRS	CNRS, I3S
Occello Audrey	sept-08	recruitment MC UNS	UNS, I3S
Pallez Denis	févr-08	mobility MC UNS	Lyon 1, LIRIS
Renard Hélène	sept-06	recruitment MC UNS	ENS Lyon, LIP
Rey Gaetan	déc-07	recruitment MC UNS	U. Grenoble 1, LIG

Note that Mireille Blay-Fornarino got promoted on a PR position in Sept. 2010.

Departures over 01/2006-06/2010

	date	present position
Collard Martine	août-09	PR 27 University of Antilles-Guyane

« Délégations, détachements, CRCT» over 2006-2010

	delegation, detachement, CRCT	duration (months)	period
Blay-Fornarino Mireille	CRCT	12	10/2005-09/2006
Buffa Michel	delegation INRIA (EPI Edelweiss, Sophia Antipolis)	24	01-2005/12-2006
Collard Martine	detachement INRIA (EPI Edelweiss, Sophia Antipolis)	24	09-2007/08-2009
Collet Philippe	delegation CNRS (I3S)	12	09-2010/08-2011
Faron-Zucker Catherine	CRCT	12	09-2009/08-2010
Lingrand Diane	delegation CNRS (I3S)	24	09-2008/08-2010
Mirbel Isabelle	delegation INRIA (EPI Edelweiss, Sophia Antipolis)	24	09-2007/08-2009
Tigli Jean-Yves	delegation INRIA (EPI Pulsar, Sophia Antipolis)	6	09-2009/02-2010
Tigli Jean-Yves	CRCT	6	03-2010/08-2010

3.1.2 External collaborators

External collaborators are involved in research with pole members while belonging to another structure.

	position	teaching dep.	A/D
CHATEL Marcel	PR Em.	UNS Medecine	03-2010/-
CREMENE Marcel	Assistant	U. of Cluj Napoca	
PASQUIER Claude	CR CNRS (IBDC, Nice)		09-2006/-

3.1.3 Associated Members

Associated members represent researchers without significant research activity.

	position	teaching dep	administrative duties
Begue Jean-Michel	MCF 27	QLIO IUT	
Cavarero Annie	PR 27	QLIO IUT	Head DSI of UNS
Chignoli Robert	MCF 27	info IUT	Member of financial board of UNS
Franchi Paul	PR 27	info EPU	
Gaetano Marc	MCF 27	info EPU	Head of international relationship EPU
Gallesio Erick	MCF 27	info EPU	Vice head of DSI of UNS
Hugues Anne-Marie	MCF 27	info EPU	In charge of IMAFA speciality of CS Master
Lafon Jean-Claude	PR 27	Info EPU	Head of industrial relationship EPU
Miranda Serge	PR 27	info UFR Sc	In charge of MBDS speciality of CS Master
Regourd Jean-Pierre	MCF 27	UFR LASH	In charge LPro UFR LASH
Stromboni Jean-Paul	MCF 27	info EPU	In charge of third year at info.EPU

3.1.4 Visitors (one month or more)

		origin		months
Cremene	Marcel	Univ. Cluj Napoca (Roumanie)	2007	2
Cremene	Marcel	Univ. Cluj Napoca (Roumanie)	2008	4
Cremene	Marcel	Univ. Cluj Napoca (Roumanie)	2009	1
Cremene	Marcel	Univ. Cluj Napoca (Roumanie)	2010	1
Castillo	Sergio	Univ. Bucaramanga (Colombie)	2009	2
France	Robert	Colorado State University (USA)	2009	2
Kniesel	Gunther	Univ. of Bonn (Allemagne)	2006	1
Oukif	Karima	Univ. Tizi Ouzou (Algérie)	2009	1
Takagi	Hideyudi	Univ. Kyushu (Japon),	2008	1
Sakkinen	Markku	Univ. of Jyvaskyla (Finland)	2009	1

3.1.5 PhD students

		support (*)	A/D	master	duration of PhD	present position
Acher	Mathieu	A	oct-08 / -	UNS		Current PhD
Barrios Hernandez	Carlos Jaime	ETR (Co-Dir. LIG)	avr-06 / oct-09	Univ. Grenoble 1	37	Assistant Univ. Porto Allegre (Brésil)
Berthelon	Franck	BDE-Region/Industry	déc-09 / -	UNS		Current PhD
Bouchada Ben Tekaya	Ahlem	Erasmus Tunisie (Co-Tut. Tunisie)	mai-08 / -	U. El Manar, Tunisie		Current PhD
Bouzidi	Khalil Riad	BDI-CNRS/Industry	nov-09 / -	UNS		Current PhD
Brel	Christian	A	oct-09 / -	UNS		Current PhD
Brisson	Laurent	CIFRE & ATER	sept-03 / déc-06	UNS	40	MCF Telecom Bretagne
Cerezo	Nadia	A	oct-09 / -	INP ENSIMAG, Grenoble		Current PhD
Chang	Hervé	A	oct-04 / déc-07	UNS	39	Post-doc university Milan
Cheung Foo Wo	Daniel	BDI CNRS/Industry	oct-04 / mars-09	UNS	54	private, CDI au CSTB
Chirila	Ciprian-Bogdan	(Co-Dir. Roumanie)	oct-02 / févr-10	Univ Timisoara (Roumanie)	90	Assistant Univ. Timisoara (Roumanie)
Corniglion	Sébastien	CIFRE SICTIAM	oct-08 / août-09	UNS		Current PhD elsewhere
Delettre	Christian	CIFRE Vivadia	déc-09 / -	UNS		Current PhD
Ereteo	Guillaume	CIFRE France Telecom	déc-07 / -	UNS		Current PhD
Fathallah	Sana	ANR	oct-09 / -	ENIT, Tunisie		Current PhD
Ferry	Nicolas	BDE-Region/Industry	oct-08 / -	UNS		Current PhD
Glatard	Tristan	A	oct-04 / nov-07	Ecole Centrale Lyon	38	CR CNRS CREATIS
Gomez	Laurent	Industry SAP	oct-09 / -	UNS		Current PhD
Hassan	Marwa	ETR, Gvt libannais (Co-Tut. Liban)	juin-10 / -	Univ Beyrouth, Liban		Current PhD
Hourdin	Vincent	CIFRE Préceptel then CIFRE MobileGov	févr-07 / -	UNS	41	Current PhD
Ishkina	Eugeniya	EIFFEL (Co-Tut. Russie)	oct-07 / -	UNS		Current PhD
Joffroy	Cédric	contract DGE MPUb	oct-07 / -	UNS		Current PhD
Kalawa	André	BDE-Region/Industry	oct-09 / -	Univ. Yaoundé (Cameroun)		Current PhD
Krikava	Filip	ANR	nov-09 / -	faculté de transport, Prague		Current PhD
Le Duc	Bao	CIFRE France Telecom (Co-Dir. LIP6)	déc-08	IFI, Hanoi (Vietnam)		Current PhD
Limpens	Freddy	INRIA	sept-07 / -	Göteborg		Current PhD
Maheshwari	Ketan	ANR	juil-07 / -	Univ. d'Amsterdam (Pays Bas)		Current PhD
Martinez	Ricardo Xavier	ETR & ATER	juil-03 / juil-07	Univ Paris XI	49	privé, CDI au WHO/OMS, Geneva (Suisse)
Mondal	Kartick Chandra	EMMA (Erasmus Mundus Mobility for Asia)	oct-09 / -	Univ. Kalyani (Inde)		Current PhD
Moreno	Andrés	contract DGE Mpub, Co-tutelle	sept-09 / -	Univ Los Andes, Colombie		Current PhD
Mosser	Sebastien	A	oct-07 / -	UNS		Current PhD
Nemo	Clementine	BDE Région/Industry & ATER	oct-06 / -	UNS		Current PhD
Nguyen	Thi-Dieu-Thu	ETR	nov-03 / mai-08	INP Hanoi (Vietnam)	55	Assistant INP Hanoi
Nobelis	Nicolas	BDE Région/Industry & ATER	oct-04 / déc-08	UNS	51	private, CDI Stuttgart
Occello	Audrey	A & ATER	oct-02 / juin-06	UNS	45	MCF UNS - I3S
Ozanne	Alain	Telecom sud Paris (Co-Dir. UPMC)	déc-04 / nov-06	UPMC	36	Ingénieur de recherche Telecom-Sud Paris
Pham	Thi anh le	ETR	nov-03 / janv-08	ENS Hanoi (Vietnam)	51	MCF ENS, Hanoi
Rojas Balderrama	Javier	ANR	sept-07 / -	INP Grenoble		Current PhD
Tayari	Imen	Erasmus Tunisie (Co-Tut. Tunisie)	oct-08 / -	UNS		Current PhD
Truong Huu	Trâm	ANR	nov-07 / -	IFI DE HANOI (Vietnam)		Current PhD
Tundrea	Emanuel	ETR (Co-Dir. Roumanie)	oct-02 / janv-09	Univ Timisoara (Roumanie)	77	Assistant Univ. Timisoara (Roumanie)
Vu	Viet Hoang	CIFRE Factory Production + other support	déc-03 / -	UNS		Current PhD
Yurchyshyna	Anastasiya	CIFRE CSTB	nov-05 / févr-09	UNS	40	Post-doc Univ Genève

(*)
A : allocataire de recherche
ETR : étranger
AMN : alloc. Moniteur

3.1.6 Others (Post-doctoral fellows, contractual engineers. . .)

	position	support	A/D	origin
CARAMEL Benjamin	Engineer	DGE	janv-09 / -	UNS
COROS Mihai	Engineer	DGE	sept-09 / -	U. Cluj Napoca (Roumanie)
GAUTIER Mélaine	Engineer	ANR/ValorPACA	juil-09 / -	INRIA Sophia Antipolis
HOURDIN Vincent	Engineer	ANR	juil-10 / -	MobileGov
HUSSON Guillaume	Engineer	ANR ISICIL	déc-09 / nov-11	UNS
KAMEL Michel	Post-doc	I3S	sept-09 / oct-10	IRIT
LAGUERRE Michael	Engineer	DGE	nov-08 / -	UNS
LEITZELMAN Mylène	Post-doc	ANR ISICIL	févr-09 / janv-10	Telecom Paris Tech
MERCIER Annabelle	Post-doc	I3S	sept-06 / août-07	Ecole Mines St-Etienne
VAN TRANG Tran	Post-doc	I3S	sept-07 / mars-08	U. Lille 2

3.2 Scientific achievements

The software engineering is one of the major sector of economic activity; successes are impressive if we consider the continuous evolution of the size, complexity and quality of the software which are produced. But on the counterpart the analysis of the state of the art of the practices shows that the cost and the deadlines are not always enforced (on average there is an exceeding of: 90% of the costs and 50 % of the time). The life of a software of large scale is between ten and twenty years and the maintenance absorbs 2/3 of the costs. The difficulty is neither the conception or the development of a large-scale software but it is to control daily its evolution in order to adapt it to the user needs (that may change along the time) and to the resources which are available at runtime.

Members of the Pôle covers a large scope of competencies. Interactions between parts of the members are strong and steady; they allow an efficient participation to large-scope collaborative research programs. For improving the consistency of the group, one-day seminars are regularly organized (between two and three every year) and their contents may differ according to the context: state of progress of current PhD thesis, selection of the research projects to which we have to participate, planification of the investments. . . For example, the last seminar-day held on June 18th and it focused on the finalization of the activity report whereas the next one (September 30th) is dedicated to the presentation of the current research activities of every PhD students.

One of the characteristics of the research activities carried out by the members of the Pôle is the realization of real prototypes and to ensure their dissemination within the research community but also towards the industrial partners. Some of these softwares are also used for teaching (See Section 3.7 for more details)

3.2.1 Middleware

Contributors *P. Collet, A. Gaignard, P. Lahire, D. Lingrand, J. Montagnat, H. Renard, G. Rey, M. Riveill, J.-Y. Tigli*

Main results Over the past decade, several independent, yet converging, factors led to a vivid renewed interest for distributed computing infrastructures. The reliability and drastic performance increase of network made production distributed computing environment a reality. The increasing complexity of integrated IT solutions led to the need of proper modularization and later on distribution of the service

platforms. The regular CPU performance increase rate that prevailed before the 2000's reached a ceiling and led to compute load distribution needs. Finally, the emergence of legions of heterogeneous, mobile devices led to ambient computing platform that are distributed by nature.

Building on its experience with Software Engineering, a significant effort has been invested at I3S-GLC in the research of new methods for the design and the implementation of state-of-the-art distributed systems. The *middleware* approach adopted consists in inserting a heavy software layer between the distributed resources local management software and the end applications exploiting the distributed platform. This intermediate layer addresses challenges of distributed systems programming such as A) resources heterogeneity management, B) enforcing consistency of the distributed software assembly created, C) performance optimization and D) data-intensive parallelism. The middleware software layer role is to facilitate and validate complex distributed applications development.

The broad panel of challenges addressed in the *middleware* activity reflects the variety of skills of people involved. Two well separated communities have significantly contributed to the development of distributed systems: the community of *Services and Components Architectures* put focus on the design of flexible and agile distributed platforms while the community of *High Throughput Computing* put efforts on performance tuning. Both communities are represented among the participants to this activity (topics A) and B) primarily belong to the SCA community while topics C) and D) primarily belong to the HTC community). This made a convergence between the strength of each community possible over the last year. This convergence effort will be strengthened in the coming years.

The work detailed in the next sections also benefits from the availability and the exploitation of large scale distributed computing instruments used for experimentation and modeling in realistic environments. In particular, the Grid'5000 national grid infrastructure dedicated to research, the EGEE European production grid infrastructure and the *Ubiquarium* ambient computing experimental platform have to be mentioned. The participants to this activity are active contributors of these infrastructures development.

A) Software adaptation

Many middlewares have appeared in the ambient computing world, and even more in pervasive or sensors networks, dedicated to adapt software architectures to context-changes at runtime. A first limitation of the existent solution is that the majority of the context-aware platforms are not taking into account the context dynamic discovery. A middleware must be able to integrate intelligent devices that may appear and disappear dynamically, at runtime. We introduce our WComp middleware to allow to design ambient computing applications and some kind of scheme of self-adaptation to maintain the main functionalities of the application (what we call service continuity) in spite of the evolution of the infrastructure of devices. WComp middleware model federates three main paradigms (figure 3.1): *event based web services*, *a lightweight component-based approach to design dynamic composite services* and *an adaptation approach using the original concept called Aspect of Assembly*. These paradigms lead to two ways to dynamically design ambient computing applications. The first implements a classical component-based compositional approach to design higher-level composite Web Services and then allow to increment the graph of cooperating services for the applications. This approach is well suited to design the applications in a known, common and usual context. The second way uses a compositional approach at runtime for adaptation using Aspect of Assembly, particularly well-suited to tune a set of composite services in reaction to a particular variation of the context or changing preferences of the users.

This activity gained significant visibility today. Lot of research laboratories used our WComp middleware platform in their own development. We can cite for example, in France, LIIHS research group of IRIT, HADAS et IIHM research groups of LIG (in CONTINUUM ANR VERSO project, we lead), and University of Cluj Napoca, TMSI of National University of Singapore (in Ubi-Flood project of ICT Asia program), University of Keraouan, and Lebanese University. This activity has also led a large number of collaborations with several industrial companies (MobileGov, GFI Informatique, Bewave).

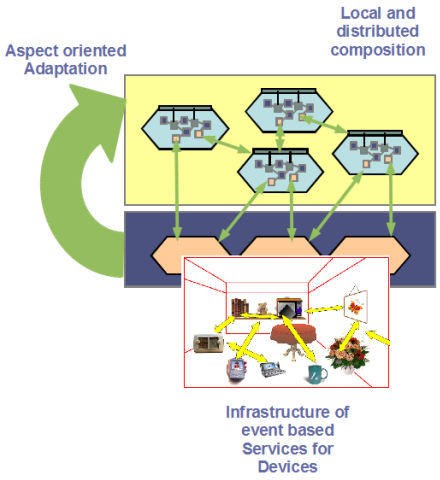


Figure 3.1: WComp Middleware

B) Adaptation control

Developing and maintaining large scale software architectures is getting more and more complex because of their size, their distributed nature, their diversity and the continuous and large-span changes they undergo. It is thus crucial to provide solutions to master this complexity while reconciling reliability and flexibility of these infrastructures. During the considered period, we have gone further in the previously developed *contract*-based approach, while starting a new line of research on *autonomic* computing.

Contract-based approach. This approach basically consists in the specification and verification of some properties that are attached to software artifacts, while assigning each artifact well-defined responsibilities in a contract. This comes down to create architectures and systems to best exploit specification and verification techniques according to targeted properties and platforms.

We first deepen the development and research results of ConFract, a contracting system previously built and transferred to France Télécom R&D (one of telco world leader). This system went beyond other approaches by taking into account hierarchical decomposition of components in contracts and dynamic reconfigurations at runtime. In its first version, the ConFract system only uses executable assertions to express specifications. A formal basis, relying on the *Assume-Guarantee* logic, has been first developed to reason on the different kinds of contract. A general contracting framework [IC-38] was then designed to enable software architects to integrate on the one hand several specification formalisms [IC-36] that are adapted to express QoS or synchronization properties (languages based on process algebra, temporal logic), and on the other hand, to adapt itself to different software architectures (component or service oriented), as well as to compositionally reason on contracts and architectures [IC-35]. Moreover, in order to take into account non functional properties and their fluctuation, we also provided mechanisms that are adapted to contract negotiation on hierarchical software components. Inspired by negotiation processes in multi-agent systems, concession and effort oriented policies were determined [NJ-5]. This system also relies on a compositional model of non functional properties [IJ-3]. This work was supported by two research collaborations with France Télécom and resulting prototypes were transferred [So-21, So-4], then reused internally and externally by several academic institutions under NDA. Finally it will be released as free software by the end of 2010.

These results were also reused and extended in the ANR funded FAROS project, which applied model driven engineering techniques to provide a process that abstracts from components and services platforms to specify contracts from constraints on business models [NC-37]. This project also put together several approaches (separation of concerns, MDE) and platforms (Adore, ConFract, WComp)

developed in the pôle (see Section 3.2.2).

Going autonomic. First results [IC-26] in autonomic computing were obtained by connecting contracts to self-adaptive feedback control loops so that they architect autonomic managers. Subsequently we initiate and currently lead a large ANR project (SALTY), putting together french academic leaders in the field (UPMC, INRIA) as well as a large industrial partner (Thales). The main objective is the provision of an autonomic computing framework for large-scale distributed systems, with a specific focus on service oriented architectures. The project will result in a coherent integration of models, tools and runtime systems to provide an end-to-end support to the development of autonomic SOA/SCA applications in a model-driven way. This will include never-covered aspects such as the monitoring requirements, the decision-making model, and an adaptation model tackling large-scale underlying managed components. We are directly involved in the monitoring part of the framework with our expertise, as well as in one of the two validation use cases, which focus on autonomic capabilities for grid middleware [IC-34] This latter enables us to put together different expertises in the research area, i.e. SCA and HTC. This line of research already enables us to develop collaboration with international leaders in the field, such as University of Wisconsin, and at short term, we also expect strong synergy inside the pôle members through this work.

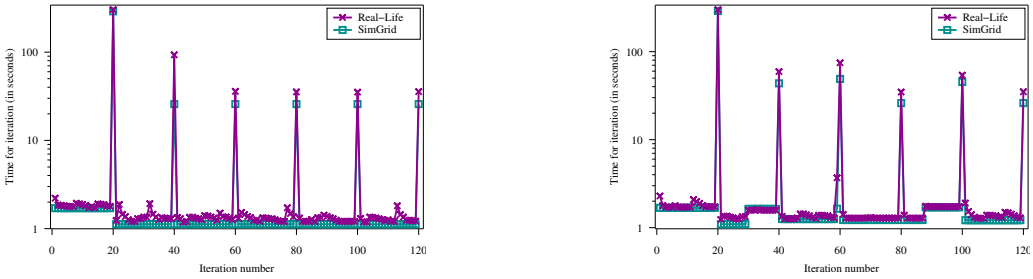
C) Performances optimization

Production grid infrastructures are complex systems assembling unprecedented amounts of distributed computing resources interconnected through wide area networks, operating highly heterogeneous middleware stacks, and servicing concurrently many users. Consequently, grids exhibit non-stationary workloads and high failure rates. Their behavior is difficult to comprehend, often leading middleware developer to face sub-optimal exploitation of resources and users to adopt ad-hoc usage strategies. Accurate models are needed both to optimize system exploitation and assist users in finding efficient parameters for their applications.

We have investigated two modeling approaches. A *deterministic* approach is used in the case the system is of controlled size and well known. Today this is typically the case for set of resources co-allocated out of the grid pool of resources (*e.g.* cloud or Grid'5000 reservation). A *probabilistic* approach is used to model large scale complex systems such as the EGEE production grid.

Deterministic infrastructure with ring interconnection topology. Earlier work on the design of load balancing and data distribution algorithms was based on the modeling of a set of hosts communicating along a ring-topology network. The algorithms are proven optimal in the case of uni-directional communications and nearly optimal (within bounded range) in the case of bi-directional communications. This work was further evaluated in collaboration with LaBRI [IC-71, NC-41] by comparing the results obtained on a distributed heat propagation application using load balancing as obtained through the SimGrid simulator versus real runs on Grid'5000 (see Figure 3.2(a)). The results obtained [IC-71] show that the behavior observed through simulation is very close to the real runs under smooth execution conditions. The largest difference between the two curves (30 seconds for SimGrid against 92 seconds for the Grid'5000 execution) was observed when a network incident (DNS failure) occurred.

Deterministic infrastructure with uncontrolled topology. The emergence of cloud computing and the capability to allocate an arbitrary amount of resources on-the-fly created a shift in the distributed system resources management strategy: a share of the resources is pre-allocated for a fixed period of time rather than letting a scheduler dynamically decide of the resources usage. Although convenient for infrastructure vendors, this strategy delegate to the end-user two important decisions: the reservation range (amount of resources and duration), and the application-level scheduling strategy to exploit these resources. We have addressed both problems simultaneously in the context of the ANR CIS HIPCAL



(a) No platform variation.

(b) With platform variation
(3 platform variations, once every 29 iterations).

Figure 3.2: Time needed (in seconds) for each iteration on the real-life and the simulated platform: five sites platform.

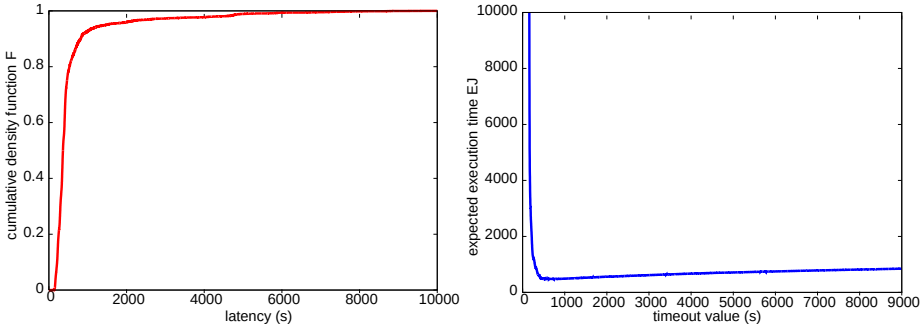


Figure 3.3: Left: cumulative density function of latency computed from probe jobs. Right: expectation of the job total latency (in seconds), including resubmission, with respect to the timeout value t_∞ (in seconds). The minimum of this curve gives the best timeout value. Here, the best timeout is $t_\infty = 556s$ giving $E_J = 479s$.

project. We contributed to the top-level layer of the HIPerNET middleware architected to manage virtual host reservations on a grid infrastructure [IC-143]. Our approach is to analyze workflow applications that are commonly used for grid scientific computing (see §D). Taking advantage of the formal description of the application parallel logic described through the workflow language, and using additional information on the application modules execution properties, we designed a workflow planner algorithm transforming a workflow execution specification into executable temporal series of virtual infrastructure allocation strategies [IC-139]. The workflow planer specifies infrastructure descriptions to be allocated through a dedicated description language [IC-79]. This work is still in progress and the workflow planer needs to be extended to complex workflow cases.

Probabilistic approach. In the probabilistic approach, we have focused our effort in reducing the latency (time between job submission and jobs starting execution) which highly impact performances and is typically characterized by heavy-tailed probability law [IC-67, IC-69, IC-64, IC-66, IC-63]. We have modeled three different strategies [IC-87] and compared their performance and cost on experimental traces obtained using probe jobs submitted on the EGEE production grid. Figure 3.3 shows the expectation of total latency including resubmissions in the case of the single resubmission strategy. This curve presents a minimum corresponding to the optimal parameter of the model.

We have refined our single resubmission strategy including the latency for failure detection and made

an *a posteriori* study on exhaustive traces obtained on the EGEE grid through collaborations with the Real Time Motoring (Imperial College London) and the Grid Observatory (LRI) [IC-88, IJ-13]. Early results show interest into the study of relevant parameters from the execution context [IJ-12] and should be further studied using the Grid Observatory data.

This activity that started in 2006 gained significant international visibility today. It is part of and benefitting to the EU EGEE project, the ANR TLOG NeuroLOG project, the CNRS PEPS Grid Observatory project and the IdG-INRIA pre-project SimGlite. Back in 2006, it was pioneering work with hardly any competitors. Today, an ever larger community studies production grid usage traces using statistics and probability methods. Major competitors such as the ANL (Chicago) or the Louisiana State University are now in place.

D) Data intensive computation

Distributed computing infrastructure such as grids and clouds are particularly efficient to handle large-scale coarse-grain data-parallel problems such as embarrassingly parallel applications, bags of tasks, or more generally SPMD kind of applications. This fact is implicitly recognized in the use of the term *High Throughput* (opposed to *High Performance*) Computing, measuring the number of data items processed per unit of time rather than the unit computation time. We have acknowledged early this fact (first publication in 2005), researching distributed data-driven workflow techniques to describe and efficiently enact such applications on the grid [IJ-19, IJ-8]. Closely associated to the data-dominated workflow development is the design of distributed data repositories that can be exploited for data-parallel executions. The competitors in the area of workflow research are too many to be listed here. However, few existing workflow systems have adopted a data-driven approach. An important early player and competitor is the University of Manchester which developed the *Scufl* workflow language and the *Taverna* workbench for workflow design and enactment. We inspired part of our work on *Scufl* and we had regular interaction with U. Man., although this language specification is not sound and we had to develop our own generalization language. A strong limitation of *Taverna* until recently (2008) was it inability to properly exploit distributed computing resources asynchronously. The University of Manchester mostly fixed this problem in the latest releases, presumably pushed by our competing engine *MOTEUR* [So-17] as well as part of its users' community. This lead to a complete re-architecturing of *Taverna* software.

Distributed data-driven workflows. Workflows is a well known paradigm to describe modular applications composed with coarse-grain heterogeneous data processing tools. It decouples the high-level application logic, implemented through the workflow language, from the low-level unit data processing tool, implemented using external language(s). In the context of distributed computing, workflows are a well-adapted generic methodology to describe a large class of scientific applications. Workflows make application decoupling at a coarse-grain level trivial. In addition, workflows implicitly represent processing parallelism (unrelated workflow graph branches can be executed asynchronously). Using a proper representation language, workflows can also implicitly represent data parallelism, which is usually the major source of performance improvement in scientific distributed applications. This significantly lowers the barrier to access distributed computing infrastructure for non-distributed programming experts. Although distributed programming is a recognized difficult task, workflow description can be as simple as visual programming. To achieve this result, we have developed a new data-driven workflow language dedicated to data-intensive applications design [IC-108]. It is based on extensions *Scufl* [IC-62, IC-107] and the adoption of *array programming* principles. The language is semantically well-defined and close to the functional programming paradigm. This work was initiated in the ACI AGIR project and continued in the ANR MDCA GWENDIA from 2007.

Distributed data repositories. Distributed data sets representation and storage is a critical part of any data-intensive computing infrastructure. We have designed distributed data repositories dedicated to radiology image manipulation, on top of the low-level generic distributed file system available in the

grid middleware. The choice of the medical image analysis community is justified by the fact that (i) it has been a strong driver for the development of production grid infrastructures, (ii) it has stringent security requirements hardly addressed in a generic middleware and (iii) it exhibits complex data sets description requirements [IC-68, IC-65, IC-70]. Early work in collaboration with CERN led to the design and development of a distributed medical data management system integrated in the gLite middleware stack from the EU EGEE project [IC-109, IJ-18, So-23]. Security requirements was particularly studied [IC-142]. This work was extended in the context of the ANR TLOG NeuroLOG project dedicated to computational neurosciences. A complete multi-centric federative environment is being designed for NeuroLOG [IC-106, So-10]. The data management layer design is a corner stone in this software architecture [IC-101]. It integrates non-intrusively heterogeneous legacy neuroradiological data stores, composed of radiology images and associated relational metadata. To achieve this result, a domain ontology is designed and a global relational metadata schema is derived. Each federated center aligns its local data schema to the global ontology through dynamic relational mappers. Advanced relational and semantic query tools can be used to describe relevant data sets to be processed through workflows. The NeuroLOG data management layer is deployed and exploited among five partners today (I3S, IRISA, IFR49, GIN and INRIA Sophia Antipolis).

3.2.2 Software composition

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Main results The pôle GLC offers approaches to master the complexity of software development. The general purpose of this section is to support separation of concerns and provide tools to automatically compose them into a consistent system. The selected works rely on model driven development.

In this report we have chosen to present our work by focusing on the composition to support A) the separate expression of concerns; B) reuse and C) variability and evolution.

A) Separation of concerns

Composition-oriented approaches are available for various application domains : Software Product lines, orchestration composition, Ambient computing, Human-Computer Interactions/interactive systems (ICI), Data and control flows.

For each following work we precise the application domain, the metamodel characterizing the elements to which the compositions apply, the composition algorithms and the consistency rules to guarantee the composition result.

Software Product Lines. An area of interest is the description of families of complex systems (product lines) with a separation of concerns. Each concern corresponds to one model and two approaches are proposed: the first one (SmartAdapters [1]) relies on the description of EMOF models (*e.g.* EMF) and provides the ability to attach families of composition protocols. The second approach uses the Feature Models formalism for the description o families of concern and it is associated with the Domain Specific Language called *FAMILIAR*) for the handling of the composition of concerns. The two approaches propose a set of operators dedicated to their corresponding formalism (i.e. EMF or Feature Models). The application domain includes families of services for medical imaging on the grid and intelligent video-surveillance applications. More generally we are interested into modeling of systems of systems

1. See `https://nyx.unice.fr/projects/SmartAdapters` for the composition of Java source code and `http://modalis.i3s.unice.fr/softwares/smartadapters/home` for the composition of EMF models.

(*Multiple Software Product Line*). Results materialize with papers such as [IC-80], [IC-6], [IC-2] or [IC-7] and the development of prototypes and demonstrators [2].

Composition of Orchestrations. Web Services Oriented Architectures (WSOA) provide a way to implement scalable Services Oriented Architectures (SOA) using web services as elementary services, and orchestrations as composition mechanisms. To deal with WSOA orchestrations evolutions, we propose the ADORE system focusing on behavioral evolutions. Our originality is to use the same model to represent the behavior of orchestrations and evolutions. This work is founded on a generic approach of activity composition [HDR-1].

The meta–model is defined as *"A meta–moDel suppOrting oRchestration Evolution"*. Using ADORE, one can model complete business processes as an *orchestration* of services. Using the same formalism, an incomplete process can also be modeled, called a process *fragment*. ADORE supports the integration of fragments into processes through the usage of several **composition algorithms**[IJ-20, IC-114]. On the same metamodel, composition by merging of orchestrations have been studied [IC-118].

Consistency is handled by *(i)* conflict detection rules and *(ii)* shared join point handling. The ADORE formalism is built upon first–order logic, and consistency rules (*e.g.*, no concurrent access, no dead path) are defined using the expressiveness of logical formulas. The underlying logical engine executes such predicates and identifies model inconsistencies through predicate satisfaction. ADORE's shared join pointhandling philosophy does not rely on a–priori aspect ordering like existing AOP methods or frameworks. We defend a default merge function $\mu : Fragments^{\star} \rightarrow Fragment$ which merges fragments applied on a shared join point [IC-115]. The designer is informed of such a decision, and can choose to keep the merged artifact or use fragment weaving to order aspects following usual AOP mechanisms. ADORE's orchestrations may then be transformed into standard BPEL processes [3]. A more complete description of the ADORE modeling language can also be found on the project web site [4].

We apply this approach to build a legacy SOA called SEDUITE [5][IC-116] (validation platform for the French national research project FAROS) and a Car Crash Crisis Management system (CCCMS, a comparison research project FAROS) and a Car Crash Crisis Management system (CCCMS, a comparison referential for Aspect Oriented Modeling techniques)[IJ-20, IC-113].

Data and control flows. As detailed in §A of Section 3.2.1) (*middleware for data intensive computation*), the description of parallel data flows eases the efficient enactment of data-intensive scientific applications on large-scale distributed systems [IJ-19, IC-92]. From an end-user perspective, an important aspect of the data-driven workflow language designed in the context of the ANR MDCA GWENDIA project [IC-108, IC-62, IC-107] is to separate the application description logic (end-user role) from the data flow composition and optimization task (automated by the workflow engine). This is a very active research area in the grid computing community today. Many well-established workflow systems have been designed such as *Pegasus* (University of Southern California), *Triana* (University of Cardiff), *Askalon* (University of Innsbruck), or *P-GRADE* (MTA STZAKI). Our workflow composition engine *MOTEUR* [IJ-8, IC-64, So-17] has reached a high visibility level and it is today involved with the partners mentioned above in the SHIWA I3 EU project which aims at achieving workflows system interoperability. In addition, we had some collaboration work with the University of Manchester (developing *Taverna*) and we are currently starting some common work with the CONDOR group in the University of Madison (developing *DAGMan*).

The originality of our approach lies in the data-centric nature of our workflow language (only competed by *Taverna*) and the design of abstractions to express data-parallelism, together with data flow description operators. It results in a compact and highly expressive language that includes no explicit

2. See website: `http://modalis.polytech.unice.fr/softwares/start`
3. This transformation needs to introduce technical details such as data structure descriptions of service URLs.
4. `http://www.adore-design.org`
5. `http://www.jseduite.org`

parallelism construct although the associated enactor is implementing maximum asynchronous execution of processes. The GWENDIA language models the applications logic through business processors with inter data-dependencies and the adoption of the *array programming semantics*. Each business processor is automatically and concurrently iterated over as many data segments as sent to its inbound data dependency links. Advanced array data structures nesting and decomposition strategies are used to implement different workflow semantics. They behave as implicit data synchronization and data-parallel execution control structures respectively [IC-108]. In addition, multiple data flows can be combined with iteration strategies that behave as nested data parallel loops over the data items [BC-8]. The semantics of the GWENDIA language is properly defined and ensures the coherency of the workflow written with it. It was also mapped to a script-based approach using the concept of *future variables* which transform an inherently control structures-based script into asynchronous data-driven flows [IC-93, IC-62].

The GWENDIA abstraction and the separation of business and data flow concerns also facilitate the manipulation of workflow structures for automatic checking and transformation of the resulting application. Non-functional concerns related to parallel extension [IC-114] and multiple workflows compositions [IC-119] could thus be experimented.

Ambient Computing. Our goal is the dynamic composition of services for devices in Ambient Computing and dynamic adaptation of this type of application to change of the devices infrastructure by separation of concerns.

The composition of services for devices is then based on assembly of lightweight components according to the architectural meta-model SLCA we defined in [IC-72, IJ-26]. The dynamic adaptation by separation of concerns corresponds to fragments of compositions of services for devices modeled as aspects of assembly [IC-31, IJ-24] that may be woven on SLCA architecture.

This work is during the application runtime [IC-55] and then allows to adapt it to changes in the infrastructure of services for devices in a coherent (logical properties validated during weaving) and reactive [IC-57] (figure 3.4) (response time adaptation cycle to validate) manner.

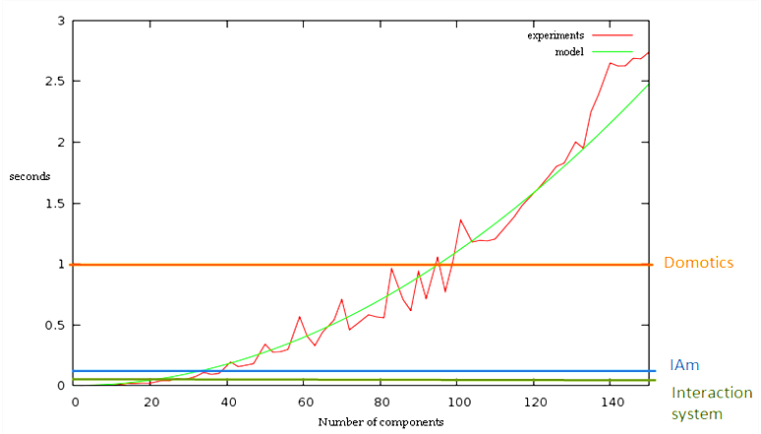

Figure 3.4: response time adaptation cycle

Besides the articles mentioned below, we have developed a middleware for ambient computing *WComp* used in research contracts (CONTINUUM, GERHOME, UBIQUARIUM) and by several other research laboratories (IRIT, LIG. . .)

Human Computer Interface. Our objective is to compose all the aspects of an application from the functional core to its presentation. Composing applications impacts the composition of functional core (FC) (services, components) as well as User Interface (UI) elements and interactions. Our approach is based on the following separation of concerns assumption: architectural decoupling of the functional part

and of the UI [NJ-2]. This decomposition is the basis of complete composition of applications including UI. This decomposition underlines the interactions that exist between UI and FC. In order to deduce a UI composition corresponding to FC composition, the *Alias* approach [IC-75] relies on such interactions and on the way FC are composed to form a new application. This way former UI are reused instead of being dropped down and replaced by a brand new one built from scratch (see §B). All along the composition process we check the consistency within UI/FC interactions: the UI of the composed application must enable users to interact with the application without data loss, conflicts or redundancies. The results are based on logic deductions using merging composition operators [NC-11] and the composition process is sustained by metamodeling and transformation techniques [IC-123, IC-124]. This work is applied to applications (interactive systems) built with components platforms or services for the FC part. Our case studies concern travel reservations and emergency alerts applications. Besides the articles mentioned previously, we have exploited our research results in the research contract (MPUB.

Other work. Other work not detailed here also addresses the separation of concerns. Thus the introduction of policies into a process of construction of component assemblies (*e.g.* security concerns) tackles the problem of ensuring consistencies of various concerns all along the development cycle [NC-38, CwP-22]. In the same vein, the introduction of safety properties into a process of component assembly adaptations tackles the problem of ensuring consistencies of various concerns all along the application execution and adaptation [IC-125, IJ-21].

B) Software reuse techniques

Software composition amongst other things aims at facilitating the re-use of the modelled elements. We focus here on original approaches of re-use based on composition mechanisms : model reuse driven by composition, interactions reuse according to the context, UI reuse based on functional core composition, legacy code reuse inside workflows.

Reuse of composition based on variability handling. To provide tools for taking into account the variability leads to the improvement of reusability. One of the SmartAdapters main objectives is to improve the reusability of EMF models through the association of a family of composition protocols. Then when the models are composed the stake-holder may set the remaining choices, i.e to choose the protocol among the family.

The expressiveness of FMs for describing the variability leads to a better reuse of the common parts into each variant of the family. The DSL *FAMILIAR* improves the reuse of the description of composition of FMs thanks to a set of dedicated operators ensuring an efficient handling of FMs. Moreover, because the language provides the ability to put the description of the composition into different parameterized modules, part of complex compositions may be reused more easily. In addition of the following papers: [IJ-10], [NJ-9], [NJ-1], [IC-3], we developed prototypes (*SmartAdapters* and *FAMILIAR*).

Reuse for composition and adaptation in ambient computing. Reuse is based on two approaches used for composition and adaptation in ambient computing. The composition mechanisms allow local design and encapsulate composite services for reuse by other composition nodes. Similarly, aspects of assembly are designed [IC-30] [IC-31] to be reused as many adaptation schemes according to the configuration of the service infrastructure for devices.

Reuse and composition of UI from the functional core composition. In case of applications based on the Service-Oriented Architecture (SOA) for example, orchestrations of services manage the functional core but the presentation level is not considered. Composing services implies proposing a new User Interface (UI) for user interactions with the resulting application. In this context, developers usually

need to apply a complete development cycle (from requirement analysis to tests through design and programming) to obtain the UI from scratch; they can't use former UI or pieces of them [NJ-3]. Our goal is to reduce the reengineering efforts needed to build the UI by deducing it as a function of the way services are composed reusing each existing UI [IC-11, IC-132]. The nature of the reuse is about the UI first sketch design: the UI obtained by deduction is technically usable but not ergonomically usable already. This means that the UI designer gains some time because he does not have to redefine the models that express user interactions, application usage, UI structure skeleton and UI/FC interactions. Instead, he works directly on the deduced UI that defines all these aspects and he just has to define the layout of his choice and to choose the adequate interactor support for each UI element in order to create the final ergonomic UI.

Reuse of legacy application codes. Workflow programming is a coarse-grain software reuse framework in which existing business codes are composed in according to different use patterns for execution. In the context of distributed computing, the embedded business codes are often regular, sequential, non-instrumented codes (developed as command line applications) which integration, reuse, and relocation on remote computing resources is non trivial. Especially when considering manipulation of complex data structures as introduced in §A (*data and control flows*), the specific command line interface to each scientific code needs to be mapped to a pivot data schema and exposed through standard remote invocation mechanisms. Accomplishing the complete integration of command-line business code into a service-oriented environment is possible through the jGASW generic code wrapping mechanism into Web Services that was designed for this purpose [So-22, IJ-7, IC-60]. Each legacy business code is described through a standard data mapping schema that is manually documented by the code provider. From this document, Web Services stubs and skeleton are auto-generated and compiled. The legacy code is packaged in a self-contained relocatable web archive bundle that includes the code, the WS interface description, stubs and skeletons, additional grid submission interface code, and all dependencies specified. This archive can be hot-deployed in any WS container.

By fully integrating legacy business codes into Service-Oriented bundles capable of self-submission to remote grid infrastructure upon invocation, our wrapping framework implements a convergence between the traditional Service-Oriented Architectures, focussing on flexible but pre-deployed interacting distributed services, and High Throughput Computing, focussing on remote concurrent execution of business code [IC-135]. In addition, the code auto-generation mechanism adopted makes specific service instrumentation possible. We have thus deployed access controlled application services [IC-58] and we are targeting additional non-functional concerns integration such as grid performance improvement (see resubmission strategies in §C of Section 3.2.1) and semantic data manipulation. Similar wrapping framework have been designed by concurrent research institutes, in particular *GEMLCA* (developed by MTA STZAKI) and *SoapLab* (developed by the University of Manchester). GEMLCA is non-service oriented and dedicated to the P-GRADE workflow manager. SoapLab is Web Services-based. However it targets the Taverna workflow manager and cannot map the hierarchical array structures that are fundamental in our language. In the context of the SHIWA I3 EU project, a collaboration will start with MTA STZAKI on the interoperability of GEMLCA and jGASW. Many user communities are also benefitting from the jGASW toolkit, including groups at INRIA, INSERM and the Amsterdam Medical Center.

C) Variability and evolution

The handling of variability allows addressing several problematics: i) the productivity thanks to the description of software families instead of a stand-alone mechanism, ii) the incrementality of the approach and therefore its evolution capabilities, iii) the consistency of the description of various elements belonging to one or several families (in the case of systems of systems).

We consider the handling of variability according to two point of views : the variability addresses either the concern itself or the description of its composition with other concerns. Moreover the description of the variability may be associated to one or more stages in the development process. To better

address the latter case, our approach is able to specify the interactions between these stages thanks to dependency or mutual exclusion constraints. For example it is possible to model the interactions between the variability of the problem specification, the variability of the implementation platform and the variability of the deployment context. Finally, the description of interactions allows also to handle traceability within the various stages of the development process.

To identify concerns represented by large FMs, to adapt them incrementally and to compose them as it is possible with the DSL *FAMILIAR* requires tools for managing consistency and providing user assistance. This is the reason why we introduce within our DSL operators for checking at any step of the composition or adaptation process, the validity of FMs and of their configurations. In addition to the following papers : [IC-111], [IC-110], [IC-1], [IC-4], [Re-1], we developed an interpretor of *FAMILIAR* and a weaver for SmartAdapters.

The handling of families of workflow requires the use of concepts which do not exist in the paradigm of the FMs such as the description of sequence or concurrency of treatments. Then FMs are not sufficient for handling both the description of a workflow and functional or extra-functional concerns that may be associated to the various elements of the workflow. We propose to use two formalisms altogether: EMF to describe a workflow and FMs to describe the variability of the various concerns. The latter are composed with the workflow. We use this approach in the domains of medical imaging and video surveillance. In addition to the paper [IC-5], we developed a demonstrator in order to validate the approach (See `http://modalis.polytech.unice.fr/softwares/manvarwor`):

3.2.3 Semantic Web

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Main results Researches in the I3S GLC Semantic Web axis aim at offering a theoretical framework for graph-based knowledge management as well as models and tools to put in practice our knowledge management supporting means.

During the last four years, our contributions to support Semantic Web application development focused more specifically on (i) graph-based knowledge representation and reasoning models, (ii) support to distributed knowledge bases and (iii) reflexive models of Semantic Web applications.

As a proof of concept on our theoretical proposals, we also contributed to methods and tools to infer, search, navigate, and help users to take advantage of Semantic Web language and models to enhance their activities. During these four years, we focused more specifically on (i) social network modeling, (ii) modeling of technical and regulatory knowledge, (iii) knowledge-based adaptive learning systems and (iv) knowledge modeling for web service discovery.

In the following we detail each of these contributions.

Graph-based Knowledge Representation and Reasoning Models. During these four years and in the continuation of previous results, one of our main research topic tackle with graph-based knowledge representation and reasoning models for the Semantic Web. The idea of a graph model for the Semantic Web is gradually being adopted but four years ago this approach was quite original in a context where the community of description logics was imposing its standards (OWL) and the community of conceptual graphs was still ignoring the Semantic Web challenges. During this period we focused on reasoning mechanisms and algorithms for both querying knowledge graph bases and processing graph-based inference rules [IJ-4, IC-39]. We also addressed the particular problem of the representation of contextual knowledge [IC-40, IC-28]. This is of prime importance for supporting user-centered approaches in knowledge modeling. Our most important contribution is the generalization process we conducted over various graph models and query languages. In 2008, we participated to the GRIWES color project which collectively provided a preliminary study of a generic model [IC-8]. In the continuation of this project and

in collaboration with the Edelweiss team at INRIA we recently proposed an abstract knowledge graph machine [IC-41] [NC-14] interpreting an abstract query language. This language is a generalization of the SPARQL query language for any graph model [NC-15].

Distributed Knowledge Bases. The first PhD thesis [Th-12] sought to answer the question: how to organize a distributed knowledge base in the most effective way and without loss of semantic? Therefore we first studied the mechanisms of decomposition of an initial ontology into a set of sub-ontologies with good properties expected. We have at hand introduced a set of basic elements of the theory of decomposition, called decomposition overlay, that supports the transformation of an ontology expressed with description logics into a set of sub-ontologies still specified in distributed description logics [BC-17]. We have shown that our proposal preserve semantics and inference [BC-18], and proposed specific decomposition algorithms that meet optimization criteria [IJ-23]. The originality of our work is to consider the decomposition as a technique for obtaining, from the design phase of the ontology, an optimal organization of a set of ontologies.

The second PhD thesis[Th-8] sought to answer the question: How to transform the systematic patterns of relational database schemas into ontological schemes? Therefore, it proposed an approach based on a combination of ontology-based schema representation and description logics. A new web ontology language and its logic foundation have been proposed in order to capture the semantics of relational data sources while still assuring a decidable and automated reasoning over information from the sources [IC-121]. An automatic translation of relational models into ontologies has been introduced to allow capturing the data semantics without laboriousness and fallibility. This PhD thesis provides a foundation for further investigations of data integration from relational sources into the Semantic Web [BC-15].

Reflexive Models of Semantic Web Applications. In 2005 we developed SweetWiki [BC-3] [IJ-2] [IC-49], an example of application reconciling two trends of the future web: a semantically-augmented web and a web of social applications where every user is an active provider as well as a consumer of information. SweetWiki makes heavy use of Semantic Web concepts and languages, and demonstrates how the use of such paradigms can improve navigation, search, and usability. By semantically annotating the resources of the wiki and by reifying the wiki object model itself, SweetWiki provides reasoning and querying capabilities. All the models are defined in OWL capturing concepts of the wikis (wiki word, wiki page, forward and backward link, author, etc.) and concepts manipulated by the users (users folksonomy, external ontologies). These ontologies are exploited by an embedded semantic search engine (CORESE) allowing us to support the life-cycle of the wiki, *e.g.*, pages restructured, to propose new functionalities, *e.g.*, semantic search, user-profile-based monitoring and notification, and to allow for extensions, *e.g.*, support for new medias or integration of legacy software. SweetWiki is Open Source (CECILL-C Licence) and has been used in several projects to share information among participants. These communities use it as the collaborative platform mainly for coordinating researchers work (European project Palette, ANR project E-Wok, private company Robosoft, etc.). SweetWiki has been one of the first Semantic Wikis and one of the three that achieved a high level of development and stability (along with Semantic Media Wiki and IkeWiki). It was the first to propose a reflexive model, a wiki ontology, and has been considered the one with the most advanced semantic model (see the PhD thesis of Fabrizio Orlandi, that compares the four semantic wikis that had a noticeable impact on the community)

SweetWiki is still under development, as one of the tool proposed by the ISICIL ANR project (`http://isicil.inria.fr`).

Social Network Modeling. Our contributions in the social network application domain focused more precisely on social tagging and semantic social network analysis [BC-10] [BC-6].

With regards to social tagging, our approach aims at leveraging social tagging practices with socio-technical systems including semantic tools carefully designed after an analysis of the knowledge ex-

change practices of online communities [IC-85] [IC-84]. Social tagging is a successful mean to involve users in the life-cycle of the content they exchange, read or publish online. However, folksonomies resulting from this practice have some limitations, in particular, the spelling variations of similar tags and the lack of semantic relationships between tags that hinder significantly the navigation within tagged corpora. One way of tackling these limitations is to semantically structure folksonomies. This can help navigate within tagged corpora by (1) enriching tag-based search results with spelling variants and hyponyms, or (2) suggesting related tags to extend the search, or (3) semantically organizing tags to guide novice users in a given domain more efficiently than with flat list of tags or occurrence-based tag clouds. We designed a tagging-based system which integrates collaborative and assisted semantic enrichment of the community's folksonomy. We proposed the SRTags and NiceTags ontologies and methods to support diverging points of view regarding the semantic of tags and to efficiently combine them into a coherent and semantically structured folksonomy. Having a semantically rich model of the tags used by a community of users can in turn be an efficient way to build and analyze social networks, using the tripartite nature of the tag-user-resource graph (if two users used the same tag, they share the same interest, if a document has been tagged by two users with different tags, theses tags are related, etc.).

Social Network Analysis (SNA) provides graph algorithms to characterize the structure of social networks, strategic positions in these networks, specific sub-networks and decompositions of people and activities. Online social platforms like Facebook form huge social networks, enabling people to connect, interact and share their online activities across several social applications. We extended SNA operators using Semantic Web frameworks to include the semantics of these graph-based representations when analyzing such social networks and to deal with the diversity of their relations and interactions. We presented the results of this approach when used to analyze a real social network with 60,000 users connecting, interacting and sharing content [IC-50]. We use the RDF graphs to represent social networks, and we type those using existing ontologies together with specific domain ontologies if needed. Some social data are already readily available in a semantic format (RDF, RDFa, μformats, etc.). However, today, most of the data are still only accessible through APIs (flickr, Facebook, etc.) or by crawling web pages and need to be converted. To annotate these social network representations with SNA indices, we designed SemSNA, an ontology that describes SNA notions, *e.g.*, centrality. With this ontology, we can (1) abstract social network constructs from domain ontologies to apply our tools on existing schemas by having them extend our primitives; and we can (2) enrich the social data with new annotations such as the SNA indices that will be computed. These annotations enable us to manage more efficiently the life cycle of an analysis, by pre-calculating relevant SNA indices and updating them incrementally when the network changes over time. On top of SemSNA we proposed SPARQL formal definitions of SNA operators handling the semantics of the representations. The current tests use the semantic search engine Corese that supports powerful SPARQL extensions particularly well suited for SNA features such as path computations. Our main contributions are the two ontologies SemSNA and SemSNI along with proving that the Sparql query language can be used to implement the main algorithms of the SNA, in a more convenient way that can exploit the richness of the multiple relationships between actors along with polymorphism and inferences. We also contributed on Sparql extensions that deal with path extractions, that have been implemented in the CORESE engine.

These contributions have been conducted within the ISICIL ANR Project (`http://isicil.inria.fr`).

Modeling of Technical and Regulatory Knowledge. The modeling of the technical and regulatory knowledge involved in the Building industry is a research topic we address for four years in the framework of a collaboration with the French Scientific and Technical Center on Building (CSTB) that has funded two PhD fellowships during the period (one PhD defended at the beginning of 2009 [Th-14] and one PhD starting at the end of 2009). We worked on the assistance and partial automation of the control of conformity of a construction project with regards to building standards [IJ-29]. This first implied the modeling of the domain knowledge through ontologies which was four years ago quite innovative for the building domain [IC-148]. Based on these domain ontologies, we modeled the constraints expressed in regulatory standards as a repository of semantic queries representing rules. This means the reification

of constraints and the capitalization of a query repository [IC-150]. A building project is thus validated by matching its model against the queries of the repository. By scheduling these queries during the control checking process we take into account usages and therefore represent the control process itself as it is performed by human experts [IC-151].

Knowledge-based Adaptive Learning Systems. During these four years and in the continuation of previous results, one of our research topic has been the modeling of the knowledge involved in a learning system. This work was conducted in collaboration with a PhD student of the Edelweiss team at INRIA (who defended his PhD in 2007) and a PhD student of the university of Annaba in Algeria (who defended her PhD in 2009). We addressed the problem of modeling both the domain to be learned, the learner using the learning system, the pedagogical approach adopted in the learning system and the learning system itself. Our ontology-based approach enables the coexistence of these different kinds of knowledge. We argued that the annotation of learning resources enables their reuse from one learning repository or one learning system to another learning system [IC-48]. We reified and modeled the learning system and the navigation processes it enables through a base of semantic queries over the knowledge modeled [IC-47, IC-145]. We adopted Semantic Web models and technologies and we proposed a Semantic Web-based learning system [BC-23]. Our modeling enables to adapt the system to a chosen pedagogical approach and/or a specific learner profile [IJ-27]. We further adapted the navigation possibilities of a user by measuring the relevance of a learning resource to the learner in context with a semantic distance [IJ-28].

Knowledge Modeling for Web Services Discovery. Our research work on knowledge modeling for web services discovery was initiated two years ago. It particularly focusses on the neurosciences domain in the framework of the ANR NeuroLOG project. Although semantic web services is a very researched area, the application to a specific business domain requires significant effort to develop domain specific ontologies and makes the semantic technologies accessible to non-specialized end-users [IC-106]. In addition, there currently exist very few approaches to manage distributed semantic information. Recently, significant effort has been invested in the domain of bioinformatics to semantically annotate and discover services (UK *e.g. myGrid* project developing the *BioCatalog* or *BioMoby*). In the domain of medicine, quite extensive anatomical ontologies exist. However, in neurosciences a more targeted ontology addressing both domain concerns (imaging, brain anatomy and function...) and technical image processing concerns is needed and an interface accessible to non-ontologists is key for practical exploitation of the tools developed [IC-101]. We are currently interested by (i) capturing semantic information related to image processing pipelines operationalized by workflows of services, (ii) providing means to exploit semantic information at runtime, for instance to infer provenance of data or types of data and (iii) deriving at design time web service workflows from neuroscientists image processing pipelines descriptions. In this context our contributions were twofold: at design time and at runtime. Contribution at design time focused on service selection. We provided (i) a semantic based classification of neuroscience services, (ii) semantic based means to suggest meaningful assemblies of services and (iii) a semantic and intention-driven approach to improve capitalization and sharing of know-how about the operationalization of image processing pipelines with web services [NJ-14]. Our contributions at runtime focused on means to semantically check the coherency of a workflow and to infer knowledge based on pre-defined domain-specific semantic rules [NC-21]. A prototype to produce RDF annotations of neuroscience web services has been developed and the NeuroLOG web services repository is being extended with a semantic classification of services [So-11]. The semantic repository is extensible to receive new knowledge inferred during processing pipeline runs. Problems related to scalability and semantic reasoning computational complexity start being addressed.

Summary. In conclusion, during these four years and in agreement with what was stated in the previous evaluation report, we refocused our research activities on Semantic Web and contributed both on theoretical framework and their implementation. To do so, we reinforced our collaboration with leading team EDELWEISS at INRIA (through two COLOR actions and two years of delegation for 2 members of

GLC) and collaborations with companies, such as CSTB and France Telecom R&D, to anchor our work into real life problems.

3.2.4 Security

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Main results Security management is a wide and complex research area. Thus, before summarizing the work we have done in this domain, we will explain briefly which part of security we are interested in and our vision for managing security.

In our work, we focus on protection of data (that can be documents, messages and data flow) and services (or applications) against attacks and more specifically we consider six security properties for protecting these data and services which are: confidentiality, integrity, authenticity, access control, non-repudiation and availability.

In our team, we propose to manage security from a software engineering point of view, i.e. considering the point of view of a developer who is not expert in security. As software engineering researchers, we know that security is an important issue that must be taken into account in order to guarantee that a software application can't be attacked by "bad" users or programs. Moreover, we know that powerful security mechanisms exist and are designed continuously by security experts. However, application designers have difficulties to reuse and integrate these mechanisms when developing secure applications. For these designers (or developers) it is not easy to model a system including security and/or to add security to a non-secure system/application because of:

- their lack of knowledge in security field
- the complexity of security
- the lack of time when designing and developing softwares

Our goal is not to develop new security solutions but to propose solutions that will allow non-security expert application designers to easily and efficiently add and integrate security during the development process. Thus, our approach is to offer a framework (or middleware) where security properties can be easily accessible and used by:

1. adding and integrating them in the application as *autonomous security components* or *aspect of assemblies*
2. *embedding* them in the software components (or resources) of the application to design

Now the first question is where security is important for a software application? In our work we consider that security and particularly the five first security properties (i.e. *confidentiality, integrity, authenticity, access control and non-repudiation*) are important at different steps of the life cycle (i.e. *design, development, execution*) of an application, depending on the kind of application to secure (and the kind of data managed by the application). Concerning the sixth security property, i.e. *availability*, we have taken into account this property for the execution environment of the application and in this context proposed some solutions for attack detection.

Now, the second question is what are the different solutions that we propose? To respond to this question, we have decided to describe our work by specifying which security properties have been used and how, more specifically by responding to four sub-questions: the application context, i.e. kind of application/data concerned, etc. the life cycle steps of the application, the security properties to add to the application and how these properties are added (i.e. the security properties design: autonomous security components, aspect of assemblies, embedded).

In this report, we will distinguish the work done to secure software applications (i.e. at the application level) and the work done to secure the execution environment of the application (i.e. at the network level). At the application level, we have proposed four solutions that will be described in the next sections:

1. *Security for communication protocols from a user point of view*
2. *Security for grids computing from a health applications point of view*
3. *Security for ambient computing from a context point of view*
4. *Security for collaborative web sites from an ontology point of view*

At the network level, we have proposed two solutions for:

1. *Collaborative attack detection and incident management in distributed networks*: This work has been done in the context of the FASTMATCH project. The aim of this project was to propose a layered and agent-oriented framework to enable delivery of multiple pattern-based and behavior-based scanning, filtering and detection functions at much higher speeds than realized by existing intrusion detection systems. This framework had to be robust in the sense to constantly adapt and react to changing security threats in the longer term. The proposed framework was divided in three layers: a hardware layer where some scanning, filtering and detection functions have been implemented in FPGAs; a management station layer were more sophisticated detection algorithms have been deployed on PCs to detect known and unknown attacks occurring in one network and learn unknown ones and finally a knowledge layer were a multi-agent system has been proposed to detect collaboratively distributed attacks occurring in distributed networks and to manage incidents occurring in these networks. Our role in the project was to design the last layer i.e. the knowledge layer and to propose a model for automatic generation of worm signatures.
2. *Collaborative backtracking of fault packets in autonomous systems*: This work has been done in the context of the METROSEC project. The aim of this project was to design mechanisms that jointly provide guaranteed QoS and security despite of ruptures in the traffic due to denial of service attacks. In this context, metrology and signal processing based mechanisms have been proposed to identify the nature of a given rupture particularly those due detect denial of service attacks. As detecting these kinds attacks is not sufficient to maintain a high enough QoS, it was necessary to identify and eliminate the constitutive packets of an attack. In this context, our role in the project was to propose a solution to identify the source of attack, more specifically the real source of packets responsible of denial of service attacks in order to eliminate them.

These solutions have been proposed in the context of two research projects: the ACI security called MetroSec and the European project called FASTMATCH. We would like to underline that the network security management activity was related to these projects and no more work in this area is planned for the moment.

A) Secure electronic transfer of documents

Keywords: electronic documents, secure communication protocols

Life cycle steps: design, development and execution; **Security properties**: integrity, confidentiality, authenticity, access control and non-repudiation; **Design**: autonomous components

With the growth of the information society, different actors (companies, administrations and individuals) use the Internet to transfer their documents. To ensure a secure electronic transfer of these documents, several security properties (*e.g.* confidentiality, integrity, authenticity of the sender and recipient, access control, non-repudiation, traceability) can be required. These properties depend on the kind of entities involved in the transfer and more specifically on the application scenario [CwP-25] that can be for instance C2C (Consumer to Consumer), B2B (Business to Business) and B2C (Business to Consumer) for material and digital goods. To satisfy these scenarios, numerous *secure communication protocols have been developed*. During their life cycles, the existing communication protocols can be managed (created, deployed, and used) by three user groups: *end users*, *protocol developers* and *system administrators*, each of them having different objectives and facing different problems such as selecting the right protocol for the end user, using the suitable security library for the *developer* knowing

that there is no clear match between a security property and a cryptographic mechanism provided by a library or for the *administrator* modifying the security library implemented by the *developer*.

The aim of this work that has been done in the context of Nicolas Nobelis' PhD thesis [Th-9] was to help these three kinds of users find a solution to their problems by more precisely taking into account their needs and points of view. We propose an architecture called ADEPT (Architecture for electronic DocumEnt Plus their Transfers) that is oriented towards theses users and thus defined as a *user-centric*, architecture [IC-122]. In the context of this work, we focussed mainly on identifying the different problems that the *developer*, *administrator* and *end user* are faced with, defined the different elements of ADEPT and show how this architecture addresses the users' problems.

B) Security for grids computing from a health applications point of view

Keywords: Distributed access control, grids computing, health applications

Life cycle steps: design, development and execution; **Security properties**: confidentiality, authenticity and access control; **Design**: autonomous components (accessible by WebService interface)

Grids are key technologies to federate data distributed in multiple radiology centers, thus enabling large scale multi-centric studies. However, the take up of these technologies is slow due to the difficulty to manipulate sensitive medical data in an open environment and the recognized risk of federated sites to loose control over their valuable data. In the context of the ANR TLOG NeuroLOG project, we developed a distributed data access control policy, enabling the federation of existing neuroradiology data stores, where local security policies prevail, to support multi-centric neuroscience studies. It achieves a compromise between enabling collaborative work through data sharing and preventing unauthorized access to data in a competitive environment.

The NeuroLOG platform relies on a standard "Public Key Infrastructure" (PKI) which allows for multi-sites connectivity needed in the setup of multi-centric neuroscience studies. Sensitive medical data protection is achieved through secured communication channels (SSL protocol) between mutually authenticated client and servers. Earlier work focussed on secure radiological data file access and transfer (DICOM protocol) [IJ-18]. Our recent contribution is focussed on the design and implementation of a decentralized access control policy [IC-58]. State-of-the-art role-based access control (RBAC) systems, such as the grid VOMS (*Virtual Organization Management System*), are usually centralized and simultaneously manage (i) the assignment of *roles* to *users* and (ii) the assignment of *roles* to *resources* through *permissions*. This is not suitable in a distributed platform where no "super-administrator" is defined and where local policies must prevail. Our contribution consist in decoupling those two activities:

- Site administrators are capable of creating federation-wide roles, as many as needed to describe their access control policies.
- The creator of a role controls the assignment of all system users to that role: the management of a particular role is centralized on one of the sites.
- Each site administrator controls the assignment of federation-wide roles to per- missions related to their local resources.

This system is agile and preserves radiology centers autonomy. It has been implemented within the NeuroLOG platform [So-10] through secured and collaborative Web Services, and is actually deployed to allow secured collaboration between five neuroscience data stores. This production phase will provide user feedback on the usability and manageability of the security policies designed.

C) Security for ambient computing from a context point of view

Keywords: context-aware control of interactions, ambient computing, aspect of assembling

Life cycle steps: execution; **Security properties**: access control; **Design**: aspect of assembling

In ambient computing, context is key. Computer applications are then extending their interactions

with the environment. New inputs and outputs are used, such as sensors and other mobile devices interacting with the physical environment. Middlewares, created in distributed computing to hide the complexity of lower layers, are then supported by new concerns, such as context awareness, adaptation of applications and security.

During the preparation of the Vincent Hourdin Ph. D., in collaboration with MobileGov company, we have introduced a model taking into account the context both in security and distribution. Access control must evolve to incorporate a dynamic and reactive authorization, based on information related to environment or simply on the authentication information of entities [IJ-25] [IC-73] [IC-74]. Contextual information evolves with its own dynamic, independently of the application. Thus, it is also necessary to detect context changes to reassess the authorization.

We are experimenting this context-awareness targeting interaction control with the experimental framework WComp, derived from the SLCA/AA (Service Lightweight Component Architecture / Aspects of Assembly) model. SLCA allows to create dynamic middlewares and applications for which functional cutting is not translated into layers but into an interleaving of functionalities. Aspects of assembly are a mechanism for compositional adaptation of assemblies of components. We use them to express our non-functional concerns and to compose them with existing applications in a deterministic and reactive manner. For this purpose, we have introduced context-aware interaction control rules that will allow the middleware to adapt, according to context, the behavior of the application for the security concern.

D) Security for collaborative web sites from an ontology point of view

Keywords: Access Control Management, Ontological Approach

Life cycle steps: design and execution; **Security properties**: access control; **Design**: embedded (in resources)

One of our research activity in security recently addressed the problem of access control in collaborative web sites and social networks with a knowledge engineering approach and semantic web models and technologies [NC-8]. In the framework of the ANR ISICIL project, we have developed the Application Model Ontology (AMO) which consists both in a set of classes and properties dedicated to the annotation of resources whose access should be controlled and in a base of inference rules modeling the access control policy to carry out. When applied to the annotations of the resources whose access should be controlled, these rules enable to manage access according to a given policy. This modeling with ontology-based inference rules is flexible, extendable and ensures the adaptability of the AMO ontology to any access control policy.

E) Collaborative attack detection and incident management for distributed networks

Keywords: distributed security management, intrusion detection, distributed attacks, incident management

A multi-agent system of attack detection and incident management: The multi-agent system layer that we have proposed in the context of FASTMATCH project, to detect distributed attacks and manage incidents, is decomposed of three plans: *user, network* and *intelligence plans*. The *user plan* represents the interactions between the administrator and the multi-agent system through user interfaces allowing specification of *security policies*. The *network plan* represents the interactions between the multi-agent system and the management station layer (designed by the other partners of the project to detect local attacks) through *detection rules, reaction rules* and *security related data* (alerts, and events to confirm potential attacks). The *intelligence plan* represents the different agents and interactions between the agents located in the same domain or those located in different domains. These agents interact through different kinds of data: *detection, reaction, privacy* and *updating policies, security data services, incidents, reaction actions, suspicions, goals* and *attack patterns*. To represent this last kind of data, that represent the heart of our information model, we have specified a language named

Event and Attack Pattern Language (EAPL). This language inspired from the event-based model proposed by boudaoud & mccathienevile [6] allows detection by the multi-agent system layer of distributed attacks (that we have called *meta-attack patterns*) composed of simple attacks (called *attack patterns*) that are detected locally by the FPGA and management station layer.

Concerning the architecture of our multi-agent system [Re-2], in this project we have specified:

1. The organizational model of the multi-agent system: i.e. roles, groups and agents required to share security data between domains, detect distributed attacks and react against them. Globally, we have proposed three agent groups: *policy management, data sharing* and *detection/ reaction* agent groups. The *policy management* group is composed of four kinds of agents that interact directly with the administrator to manage detection and data sharing policies. The *data sharing* group consists of four kinds of agents to exchange *incidents* and *attack patterns* and to interact directly with the administrator to receive his requests (creation of new services or collection of incidents and attack patterns). The *detection/ reaction* group composed of two roles to exchange *detection goals, reaction goals, suspicions* and *distributed attack alerts*.
2. The internal architecture of all agents (*security policy manager agent, knowledge seeker agent, knowledge provider agent, knowledge manager agent, global detection manager agent* and *domain detection agent*.
3. The synchronization of attack patterns knowledge bases of the agents deployed on different domains.
4. The communication and interaction protocols that will be used by the multi-agent system.
5. The most suited platform for the development of our agent types, which is DIMA that has been chosen after studying existing platforms and comparing it with JADE, JACK, MadKit, MAGIQUE platforms.

Automatic generation of worm signatures: The spreading of worms, particularly in high-speeds networks, requires systems able to generate, as soon as possible and automatically, signatures characterizing new worms. In this context, several systems have been designed. The signatures generated by these systems are content-based, i.e. focus on finding one or several sets of bytes repeated in the code. Usually, hackers use mechanisms that can change the content of a worm to avoid its detection by systems using content-based signatures. However, when a hacker changes the code content of a worm, he doesn't change its behavior. Thus, what is needed is to define signatures based on the behavior of the worm rather than on its content. Consequently, in our work, we have proposed a model, which generates automatically a new kind of signatures, that we call: *behavior-based signatures* in order to detect worms that can not be detected easily by content-based signatures [IC-24].

F) Efficient collaborative backtracking for autonomous systems

Keywords: IP traceback, Logging, autonomous systems,

One of the major problems due to denial of service (DoS) attacks that target the Internet is the identification of the attack source, more precisely the real source address of fault packets (i.e. packets responsible of the attack). To resolve this problem, several *IP traceback* methods aiming to trace the packets to their origin have been defined. However, implementing these methods in the real context of Internet is not an easy task. Actually, most of the proposed solutions assume that they are applied in a network managed by the same administrative authority, which is clearly not the case of the Internet that is constituted of a set of autonomous systems (ASs) under the control of different administrative entities. In the context of this work, we have focussed on the deployment of *traceback* mechanisms between several ASs to identify the source AS of fault packets, i.e. the AS from where the fault packets are originated.

6. Karima Boudaoud, Charles McCathieNeville. "An Intelligent Agent-based Model for Security Management" in Proceedings of the Seventh IEEE Symposium on Computers and Communications (ISCC), IEEE, Taormina, Italy, 1-4 july 2002

The efficiency of a *traceback* mechanism in ASs depends on the kind of collaboration established between ASs, which can be: *strong, weak* or *non- collaboration*. Assuming that we have either *strong collaboration* or *weak collaboration* between ASs, we can have three cases: (i) implementation of the same *traceback* method in all ASs with a *strong collaboration*, (ii) implementation of the same *traceback* method in all ASs with *weak collaboration* and (iii) implementation of a different method in each AS with a *weak collaboration*. The aim of our work was to identify the most efficient method in the third case that seems to us to be the most interesting case. After comparing the different *IP traceback* mechanisms, we have proposed an *AS-traceback* (i.e. *traceback* between ASs) method that is more realistic and can efficiently be deployed in the context of Internet (i.e. the real network of ASs) to trace back the AS source of packets as this information can be transmitted is the case of a *weak collaboration* [IC-16].

3.2.5 Data mining

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Main results Researches conducted in the data mining workgroup of the I3S-GLC pôle aim at the development of semantics, techniques and algorithms for the analysis of very large sets of heterogeneous data, that can be structured, semi-structured or unstructured, and their applications for decision support. These works concern approaches for both knowledge patterns extraction and discovered patterns exploitation, and for the integration of expert background knowledge in the data mining process. We present in the following subsections works conducted in the data mining workgroup of I3S-GLC in the domains of the development of Algorithms for Data Mining A), Bioinformatics B) and Evolutionary Computation C).

A) Algorithms for knowledge patterns extraction and background knowledge integration

Keywords: heuristics, closed itemset lattice, data structures

The data mining workgroup of I3S-GLC is interested in two main aspects of the data mining domain: the development of efficient algorithms and statistics for the extraction of relevant knowledge patterns and the integration of background domain knowledge in the data mining process. Works conducted on algorithmic aspects are mainly based on the closed itemset lattice theoretical framework. This framework, based on the closure of the Galois connection of a finite binary relation, was shown to be particularly well-adapted for the development of efficient association rule extraction and filtering algorithms [BC-16]. Recent works conducted in the data mining workgroup showed that it is also particularly well-adapted for the definition of clustering approaches, as the Galois closure operator can be used to define efficient methods for grouping data. These works on this topic concerned the extension of this framework to hierarchical conceptual clustering, that is a bi-clustering approach for extracting clusters at different levels of abstraction in a single process. They led to the development of the GENMINER algorithm [So-14] that simultaneously extracts equivalence classes, representing hierarchical overlapping clusters with associated characterization, and informative bases of association rules [IC-95, IJ-15]. These works were conducted in parallel with the study of objective and subjective interestingness measures used to identify relevant and irrelevant knowledge patterns [IC-33].

Concerning the integration of background domain knowledge, initial studies concluded that the integration could be performed in the three main phases of the extraction process, that are data preprocessing, patterns extraction and patterns post-processing, in order to optimize the efficiency of the extraction and to improve the relevance of extracted patterns [IC-18]. However, the development of approaches to integrate this prior knowledge must take into account the different types of knowledge. Hence, formalized knowledge, such as represented in knowledge bases and ontologies, and non-formalized knowledge, such as knowledge related to know-how or methodologies for example, cannot be integrate in the process in the same manner. The ExCIS (Extraction using a Conceptual Information

System) methodology [So-1] for knowledge patterns and models extraction [IC-19, IC-20] was developed in the context if the PhD Thesis of M. Laurent Brisson defended in December 2006 [Th-2]. This ontology-based data mining methodology enables the integration of both formalized and non-formalized expert background knowledge in a data mining process [NC-7, Re-3]. Its originality is to build a specific Conceptual Information System related to the application domain in order to improve dataset pre-treatments and extracted knowledge patterns interpretation. This information system relies on an ontological representation of knowledge that enables efficient manipulations (abstraction, specialization, etc.) of the information stored [NJ-7] and can also benefit from semantic web techniques and treatments developed for applications using ontologies in various domains [IC-130, Ed-7, IJ-6]. The ExCIS methodology is a further development of the KEOPS approach [Re-4, IJ-1] that was developed in the context of a collaboration with the french organism of allowances (CAF). KEOPS is a CRISP-DM compliant methodology that integrates a knowledge base and an ontology to represent background domain knowledge and model end-user choices in the process of data mining. In KEOPS, a part-way interestingness measure integrating both objective and subjective criteria is used to evaluate the relevance of extracted patterns according to expert background knowledge. In complement with these works, several events on the semantical aspects of data mining, such as background knowledge integration and ontological representations of knowledge, have been organized by the data mining workgroup of I3S-GLC [Ed-7, Ed-6, Ed-10].

B) Bioinformatics and bio-data mining

Keywords: algorithms, background knowledge integration, statistics, gene expression data

Bioinformatics is a recent research domain originating from the need to analyze the huge amounts of data generated by the current advances in cellular and molecular biology, such DNA microarrays, mass spectrometry and pyrosequencing. In parallel, a great amount of biological knowledge is now accessible in millions of research papers, in several annotated bibliographic repositories and in many heterogeneous knowledge bases spread across the web. Nowadays, knowledge discovery and data mining techniques are widely used to analyze and explore, automatically or semi-automatically, this data in order to discover models, patterns, rules and clusters that are relevant to the biologists [IC-94]. The discovered knowledge contributes to the process of identifying genes and proteins, their functions, interactions and structures, of modeling biological processes and interaction networks, and to support medical diagnosis and treatment optimization [IJ-14, IC-77]. Recently, the integration of biological background knowledge (gene, transcriptome and protein annotations, regulation and interaction networks, etc.) has become a major topic to improve the analysis of gene expression data. Integrating this knowledge enables to both enhance the data mining process and improve the relevance of extracted patterns by taking into account the specificities of biological data and knowledge and the requirements of biologists.

The Bio-Mining project conducted in the data mining workgroup of I3S-GLC aims at the development of new theories, frameworks, algorithms and approaches for the integration of biological background knowledge to improve the process of gene expression data mining [IJ-22]. This project was conducted in collaboration with the IDBC (Institut de Biologie et Développement du Cancer, UMR-6543 UNS/CNRS) of the University of Nice Sophia-Antipolis. The PhD Thesis of M. Ricardo Xavier Martinez [Th-7] defended in july 2007 was achieved in this context and led to the development of the CGGA (Co-expressed Gene Groups Analysis) algorithm [So-15] for the extraction of bi-clusters of co-expressed and co-annotated genes [IJ-17, NJ-12] and the NORDI algorithm [So-13] for normalized discretization of gene expression data [IC-96]. The specifity of the CGGA algorithm is that a gene rank hierarchy is first constructed using SAM F-Scores and then the CGGA calculus is applied to cluster co-expressed genes. The NORDI algorithm is a statistical approach to efficiently preprocess noisy numerical gene expression data: outliers are ignored for the computation of the gene under-expression and over-expression cutoff thresholds and a user defined parameter sets the confidence level for the discretization. These algorithms were first applied for the analysis of the *Saccharomyces cerevisiae gene expression dataset from Derisi* et al. and the integration approach developed with the IDBC was used to integrate biological annotations from Gene Ontology and KEGG Pathways, Promoters, Interaction annotations, Phenotypes and Pubmed bibliographic annotations in the process [NC-31, IC-97]. This work was then extended and

applied for the analysis of the *Yeast Saccharomyces cerevisiae dataset from Eisen* et al. containing a selection of genes involved in cell cycle, sporulation, temperature shock and diauxic shift biological processes. Biological annotations from Gene Ontology and KEGG Pathways, Transcriptional Regulators, Phenotypes and Pubmed bibliographic annotations were integrated in the analyze. These experiments showed that the integration of biological background knowledge enables to discover new interesting knowledge patterns that could not be detected otherwise and to improve the relevance of extracted association rules and clusters from the viewpoint of the biologists [IJ-16].

In the domain of bioinformatics and bio-data mining, the data mining workgroup of I3S-GLC also participated to the ANR Immunosearch project. This project aims at the development of an *in vitro* test, as an alternative to experimentation on animals, to evaluate the sensitizing and allergen properties of molecules produced by cosmetic and perfumery industries. This project, supported the Pôle de Compétitivité PASS (Parfum, Arômes, Senteurs et Saveurs), was achieved between 2006 and 2009 in the context of an industrial partnership contract. It was performed by IMMUNOSEARCH, Grasse, France, and involved the Institut de Pharmacologie Moléculaire et Cellulaire (IPMC CNRS/UNSA), the I3S (UMR CNRS-UNSA) and the INRIA Sophia-Antipolis as academic partners, and SkinEthic S.A., MANE & Fils and ROBERTET as industrial partners. Experimental results showed that significant knowledge patterns for modeling irritation, sensitization and genotoxicity potentials of molecules can be extracted from gene expression data by using data mining techniques and background knowledge integration [IC-77, BC-5].

C) Evolutionary computation and stochastic algorithms

Keywords: evolutionary and genetic algorithms, meta-heuristics, multi-objective optimization

Evolutionary Computation (EC) is a stochastic alternative for combinatorial optimization problems. It involves mechanisms inspired from nature: mutation, breeding, natural selection and survival of the fittest (Darwin). Candidate solutions to the optimization problem play the role of individuals in a population, and the cost function, also called "fitness function", determines the environment within which the solutions "live". Evolutionary computation is used when deterministic methods fail, that is to say when search space is too large, non-continuous, or not differentiable. So, it is natural to involve such methods in data mining.

Evolutionary computation is an interesting alternative to deterministic algorithms for the analysis of very large gene expression datasets. Clustering the tissue samples is an important tool for partitioning the dataset according to co-expression patterns and this task is even more difficult when we try to find the rank of each gene (Gene Ranking) according to their abilities to distinguish different classes of samples. Finding clusters of samples and rank for each gene in a specific gene expression data in a single process is always better [IJ-17]. In the literature many algorithms are available for finding the clusters and gene selection or ranking separately. A few algorithms for simultaneous clustering and feature selection are also available. We have proposed a new multiobjective genetic approach to simultaneously cluster the samples and rank the genes [IC-105]. This approach, developed in collaboration with the Department of Computer Science and Engineering of Jadavpur University in the context of the PhD Thesis of M. Kartick Chandra Mondal started in 2009, is based on a novel encoding technique proposed to address this problem and results have been demonstrated for both artificial and real-life gene expression datasets.

Interactive Evolutionary Computation (IEC) is a peculiar class of evolutionary algorithms used when the fitness function is difficult to express explicitly: a human user is then involved in the evolution process [IC-128, CwP-29, IC-137, NC-45]. In the context of data mining, IEC could be used to interactively extract association rules, from numerous rules obtained by classical approaches of data mining methods for example, in order to obtain more relevant rules for the expert or to improve the process of classifier construction by implying the end-user in the process [NC-19]. At the inverse, data mining techniques could also be used to design better EC algorithms. For instance, we applied C4.5 algorithm or SVM approaches on eye-tracker data in order to improve our IEC algorithm [IC-129].

3.3 Some indicators

- Strengthening of industrial collaborations as confirmed by an increasing number of contract including with SMEs and by a participation of the board of the pôle SCS,
- Creation of the VuLog (2006) and SimplySim company (2008),
- Organization of several conferences such as MICCAI-GRID'08, Mobility'09, SARSSI'09 or summer scholl ICAR'08, ISSGC'09,
- Strong effort in formation: several member of the pôle are in charge of M2 specialty.

A selection of papers

[Se-1] L. Brisson and M. Collard. How to semantically enhance a data mining process? *Lecture Notes in Business Information Processing (LNBPI)*, 13:103–116, Apr. 2009. http://rainbow.polytech.unice.fr/publis/brisson-collard:2009.pdf.

[Se-2] M. Buffa, F. Gandon, G. Erétéo, P. Sander, and C. Faron-Zucker. SweetWiki: a Semantic Wiki. *Journal of Web Semantics (JWS)*, 6(1):84–97, 2008.

[Se-3] H. Chang and P. Collet. Compositional Patterns of Non-Functional Properties for Contract Negotiation. *Journal of Software (JSW)*, 2(2):52–63, Aug. 2007.

[Se-4] M. Cremene, M. Riveill, and C. Martel. Autonomic Adaptation based on Service-Context Adequacy Determination. *Electronic Notes in Theoretical Computer Science (ENTCS)*, 189:35–50, July 2007. http://hal.archives-ouvertes.fr/hal-00359274.

[Se-5] G. Erétéo, M. Buffa, F. Gandon, and O. Corby. Analysis of a real online social network using semantic web frameworks ar=17.3%. In *ISWC 2009 Conference (ISWC 2009)*, LNCS 5823, pages 177–192, Washington USA, Nov. 2009. springer-verlag.

[Se-6] T. Glatard, J. Montagnat, D. Lingrand, and X. Pennec. Flexible and efficient workflow deployement of data-intensive applications on grids with MOTEUR. *International Journal of High Performance Computing Applications (IJHPCA) IF=1.109 Special issue on Special Issue on Workflows Systems in Grid Environments*, 22(3):347–360, Aug. 2008. http://hal.archives-ouvertes.fr/hal-00459130.

[Se-7] P. Lahire, B. Morin, G. Vanwormhoudt, A. Gaignard, O. Barais, and J.-M. Jézéquel. Introducing Variability into Aspect-Oriented Modeling Approaches. In *ACM/IEEE 10th International Conference on Model Driven Engineering Languages and Systems (Models 2007) AR=28%, long paper*, volume 4735 of *LNCS*, pages 498–513. Vanderbilt University, springer-verlag, Oct. 2007.

[Se-8] D. Lingrand, T. Glatard, and J. Montagnat. Modeling the latency on production grids with respect to the execution context. *Parallel Computing (PARCO)*, 35(10-11):493–511, Oct. 2009. http://hal.archives-ouvertes.fr/hal-00459261.

[Se-9] D. Lingrand, J. Montagnat, and T. Glatard. Modeling user submission strategies on production grids. In *International Symposium on High Performance Distributed Computing (HPDC'2009) AR=29%*, pages 121–130. Munich, Germany, ACM, June 2009. http://hal.archives-ouvertes.fr/hal-00459073.

[Se-10] D. Lingrand, J. Montagnat, J. Martyniak, and D. Colling. Optimization of jobs submission on the EGEE production grid: modeling faults using workload. *Journal of Grid Computing (JOGC) Special issue on EGEE*, 8(2):305–321, Mar. 2010. ISSN 1570-7873.

[Se-11] R. Martinez, N. Pasquier, and C. Pasquier. GenMiner: mining non-redundant association rules from integrated gene expression data and annotations. *Bioinformatics*, 24(22):2643–2644, Nov. 2008. http://hal.archives-ouvertes.fr/hal-00361418.

[Se-12] R. Martinez, N. Pasquier, and C. Pasquier. Mining association rule bases from integrated genomic data and annotations. *Lecture Notes in Bioinformatics (LNBI)*, 5488:78–90, Apr. 2009. http://hal.archives-ouvertes.fr/hal-00361770.

[Se-13] S. Mosser, M. Blay-Fornarino, and R. France. Workflow Design using Fragment Composition (Crisis Management System Design through ADORE). *Transactions on Aspect-Oriented Software Development (TAOSD) Special issue on Aspect Oriented Modeling*, pages 1–34, 2010. http://www.adore-design.org/doku/examples/cccms/start.

[Se-14] J.-Y. Tigli, S. Lavirotte, G. Rey, V. Hourdin, D. Cheung-Foo-Wo, E. Callegari, and M. Riveill. WComp Middleware for Ubiquitous Computing: Aspects and Composite Event-based Web Services. *Annals of Telecommunications (AoT)*, 64(3-4):197–214, Apr. 2009. ISSN 0003-4347.

[Se-15] J.-Y. Tigli, S. Lavirotte, G. Rey, V. Hourdin, and M. Riveill. Lightweight Service Oriented Architecture for Pervasive Computing. *International Journal of Computer Science Issues (IJCSI)*, 4:1–9, Sept. 2009. ISSN 1694-0784.

3.4 National & international responsibilities

- Director of the GdR ASR (RIVEILL Michel, 2006-2009).
- Head of GDR working group (BLAY-FORNARINO Mireille, IDM Group comon to GDR ASR, GPL and I3 (2006/-), LAHIRE Philippe, COSMAL Group from GDR GPL (2008/-)).
- Member of board of section 07 of CoNRS (RIVEILL Michel, 2004-2008).
- Member of section 27 of CNU (TIGLI Jean-Yves, 2005-2009)
- Scientific delegate of AERES (RIVEILL Michel, 2009-2010).
- Member of the IdG (Institut des Grilles du CNRS) Executive Board (MONTAGNAT Johan, 2010)
- Coordinator of the application communities, at Institut des Grilles du CNRS (MONTAGNAT Johan, 2010)
- Member of the ANR evaluation committee, call DEFIS (MONTAGNAT Johan, 2009)
- Participations to visiting committees of research laboratories: RIVEILL Michel: CEDRIC 03-2010, CITI 01-2010, ERIC 02-2010, INRIA Bx 12-2010, IRIT 2006 et 12-2009, IRISA 2007, LAAS 2005, LABRI 11-2009, LIESP 02-2010, LIFL 2007, LIG 2006, LINA 2007, LIP6 02-2008, LIRIS 01-2010, LIRMM 2006 et 12-2009, LIUPPA 11-2009, SAMOVAR 03-2010 .
- IFIP Working group: MIRBEL Isabelle (WG8.1: Design and evaluation of information systems).
- Member of the GCT Maths-STIC - Intelligence Ambiant Group: TIGLI Jean-Yves (2010-).
- Member of the Allistène GT2: Michel RIVEILL (2010-).
- Member of the experts committee “Informatique Ambiante” of department ST2I du CNRS (2008-): RIVEILL Michel
- Expert for the ANR: BLAY-FORNARINO Mireille, BOUDAOUD Karima, COLLET Philippe, LAHIRE Philippe, MONTAGNAT Johan, PINA-DERY Anne-Marie, OCCELLO Audrey, RIVEILL Michel, TIGLI Jean-Yves.
- Pôle de compétitivité SCS : LAHIRE Philippe (commission d’animation: 2009-) RIVEILL Michel (commission de labellisation: 2006-2009, conseil d’administration: 2010-).

Participations to PhD and HDR jurys

Participations to PhD jurys (not including the theses supervised)
- BLAY-FORNARINO Mireille, 9 PhD jurys (7 times as external referee)
- BUFFA Michel, 1 PhD jury
- COLLET Philippe, 3 PhD jurys (1 time as external referee)
- FARON-ZUCKER Catherine, 2 PhD jury
- LAHIRE Philippe, 11 PhD jurys (6 times as external referee)
- LE THANH Nhan, 4 PhD jurys (1 times as external referee)
- MIRBEL Isabelle, 1 PhD jury (1 times as external referee)
- MONTAGNAT Johan, 1 PhD jury
- RIVEILL Michel, 23 PhD jurys (13 times as external referee)

– TIGLI Jean-Yves, 4 PhD jurys

Participations to HDR jurys
– LE THANH Nhan, 2 HDR jurys (2 times as external referee)
– RIVEILL Michel, 11 HDR jurys (3 times as external referee)

3.5 Leadership within scientific committees

Organisations of workshops and conferences
– BOUDAOUD Karima, co-organizer of the HP Openview University Association Workshop (HPOVUA'2006), Giens, France, May 2006 (`http://rainbow.polytech.unice.fr/hpovua2006/`).
– COLLARD Martine, main organizer of VLDB Workshops on Ontologies based techniques for databases and Information Systems ODBIS 2005 and 2006, international conference on Research Challenges on Information Science RCIS 2010 (`http://www.farcampus.com/rcis2010`).
– LAVIROTTE Stéphane, co-organiser of the 6th ACM International Conference On Mobile Technology, Applications, And Systems 2009 (90 participants).
– LAHIRE Philippe, co-organiser of the fifth international workshop on MechAnisms for SPEcialization, Generalization and inHerItance - MASPEGHI at ECOOP 2010 (`http://www.i3s.unice.fr/maspeghi2010`), main organiser of the first workshop on Composition : Objects, Aspects, Components, services and product lines at AOSD 2010 (`http://www.i3s.unice.fr/Composition&Variability/`, 45 participants).
– MONTAGNAT Johan, co-organizer of the *MICCAI-Grid* workshop in 2008 and the tutorial on *Medical Images Management* in HealthGrid'08. Organizer of the International Summer School on Grid Computing (ESSGC'09 - `http://www.iceage-eu.org/issgc09/index.cfm`).
– REY Gaëtan, co-organiser of the 6th ACM International Conference On Mobile Technology, Applications, And Systems 2009 (90 participants).
– RIVEILL Michel, organiser of the Summer School on "Intergiciel et Construction des Applications Réparties" (ICAR'08 - `http://rainbow.polytech.unice.fr/icar08/pages/accueilpag.html`).

Chair of workshops and conferences
– BLAY-FORNARINO Mireille, PC Chair for IDM'09 [Ed-3] (`blay-fornarino-zendra:2009`), LMO'O8 [Ed-2] (`http://lmo-conference.org/2008/index`).
– BOUDAOUD Karima, PC Chair for SARSSI'09 [Ed-4] (`http://sarssi.enseeiht.fr/FR/committees.php`).
– COLLARD Martine, PC Chair for international conferences on Research Challenges on Information Science RCIS 2008 (`http://www.farcampus.com/rcis2008`) and RCIS 2009 (`http://www.farcampus.com/rcis2009`), VLDB workshops ODBIS-SWDB 2007 (`http://lsdis.cs.uga.edu/swdb-odbis07/`) and ODBIS 2008 (`http://conferences.enst-bretagne.fr/odbis08/`).
– LAHIRE Philippe, Demo Chair for ACM SIGPLAN AOSD 2010, Publicity chair of TOOLS conference (2007-2009).
– LINGRAND Diane, proceedings editing for the MICCAI-Grid Workshop 2008 [Ed-13]
– MONTAGNAT Johan, PC Chair for the MICCAI-Grid Workshop 2008 [Ed-13].
– RIVEILL Michel, PC Chair for the CLCAR'10 (`http://gppd.inf.ufrgs.br/clcar2010/`).
– TIGLI Jean-Yves, PC Chair for ACM Mobility'09 [Ed-14].

Scientific Committees (SC) of workshops and conferences
– BLAY-FORNARINO Mireille, Special issue of the IEEE Software Magazine entitled "Realizing Service Centric Software Systems" 07; PC member for IDM'05, 06, 07 and 08, LMO' from 01 to 09,

JFDLPA'04, 05 and 07, EWAS'06, journées composants 05 and 06, Wisme'05, Workshop OCM-SI' from'02 to 05, Eclipse workshop eTX/oopsla'03, DeViNT from 03 to 09, MoDSE-MCCM'09 and 10 workshop.

- BOUDAOUD Karima, TPC Member of SAR-SSI'08 and 10, IFIP/IEEE BCN'10, IEEE MACE'09 and 10, LANOMS'09, ACM Mobility'09, IEEE GIIS'09, IEEE MUCS'09 and 10, IEEE ICC'06 and ICC-CISS'09, HiPC'08, IEEE/IFIP NOMS 08, HPSUA or HPOVUA'06, 07 and 08.
- COLLARD Martine, PC member for DEXA 2009 (http://www.dexa.org/previous/dexa2009/index.html), ECML/PKDD PRICKL 2007 (http://keg.vse.cz/prickl07/), EGC 2008 (http://www-sop.inria.fr/axis/egc08/), EGC 2009 (https://lsiit.u-strasbg.fr/egc09/), EGC 2010 (http://www.projets.rnu.tn/egc2010/), RCIS 2007 (http://www.farcampus.com/rcis2007).
- COLLET Philippe, PC member for SERA'08, '09 and '10, LMO'06, '07, '08 and '10, Majestic'06, OCM-SI'06 Workshop.
- FARON-ZUCKER Catherine, PC member for KEOD'10, SEMELS'09, ODBIS'08, IC'09 and 10.
- LAHIRE Philippe, PC member for SC'10, TOOLS'07,08,09, AOM'2009 Workshop, Model@runtime'09.
- LAVIROTTE Stéphane, PC member for ACM Mobility'09. Reviewer for Journal of Ambient Intelligence and Smart Environments, UIC'09, Revue RSTI-ISI.
- LINGRAND Diane, PC member for CAMS'06, CAMS'07, MICCAI-Grid'08, MICCAI-Grid'09. Reviewer for FGCS (Future Generation Comp. Systems).
- MONTAGNAT Johan, PC member: DAPSYS'08, JETIM'06, MICCAI-Grid'08 and 09, WORKS'06, 08 and 09. Reviewer for JoGC (Journal of Grid Computing), FGCS (Future Generation Comp. Systems), IEEE TMI (transactions on medical images), MedIA (Medical Image Analysis), IEEE TIP (Transactions on Image Processing), CCGrid (Cluster, Clouds and Grids), CBMS (Computer Based Medical Systems), MICCAI (Medical Image Computing and Computer Assisted Intervention), WORKS (Workflows in Support of Large-Scale Science), BioGrid, HealthGrid, FIMH (Functional Imaging and Modeling of the Heart).
- MIRBEL Isabelle, PC member: CAISE'08, 09 and 10, Web2touch Workshop'10, ICEIS'09, ME'07, RCIS'07 and 08, SREP'07, EJC'07
- PASQUIER Nicolas, PC member for AGS 2009 (http://www710.univ-lyon1.fr/~ags/), EGC 2008 (http://www-sop.inria.fr/axis/egc08/), EGC 2009 (https://lsiit.u-strasbg.fr/egc09/), EGC 2010 (http://www.projets.rnu.tn/egc2010/), ODBIS 2006 (http://www.i3s.unice.fr/odbis2006/), PKDD 2006 (http://www.ecmlpkdd2006.org/), VLDB ODBIS 2006 (http://www.i3s.unice.fr/odbis2006/), VLDB ODBIS-SWDB 2007 (http://lsdis.cs.uga.edu/swdb-odbis07/).
- RENARD Hélène, PC member for 3PGCIC'10.
- REY Gaëtan, PC member for ITS'09 and 08, ACM Mobility'09, ADI'09, IHM'09.
- RIVEILL Michel, PC member for IFIP DOA'07, 08, 09 and 10, CLCAR'09 and 10.
- TIGLI Jean-Yves, PC member for AINA'11, UIC'10 and 09, ANT'10, ACM Mobility'09, Ubimob'08. Reviewer for Mobile Networks and Application Journal.

Editorial boards

- COLLET Philippe, L'Objet (2007-)
- DARTIGUES Cristel, journal of Intelligent Information Management (2010-)
- LAHIRE Philippe, Scientific Bulletin of "Politechnica" University of Timisoara (2006-)
- MIRBEL Isabelle, Revue Ingénierie des systèmes d'information (2010-)
- MONTAGNAT Johan, special section of Future Generation Computing System (FGCS, Elsevier), volume 26 issue 4.
- PASQUIER Nicolas, Data & Knowledge Engineering (2004-2007), Knowlegde and Information Systems (2004-2010), Transactions on Knowledge and Data Engineering (2005-2008)
- PINNA-DERY Anne-Marie, Revue des sciences et technologies de l'information
- RIVEILL Michel, Scientific Bulletin of "Politechnica" University of Cluj Napoca (2008-)

3.6 National & International collaborations, contracts & industrial partnership

Invitations (2 weeks or more)

- BLAY-FORNARINO Mireille: 2 weeks, July 2006, U. of Bonn ; 2 weeks, August 2009, Don Batory, U. of Texas (Austin); 2 weeks, Nov. 2009, U. of Lille.
- LAHIRE Philippe: 2 weeks, June 2008, U. of Bonn ; 2 weeks, September 2009, Colorado State University (USA).
- LINGRAND Diane: 3 weeks, August 2006, Diliman University, Manila, Philippines.
- MONTAGNAT Johan: 3 weeks, August 2006, Diliman University, Manila, Philippines; 2 weeks, August 2007, Diliman University, Manila, Philippines; 2 weeks, University of Southern California, Information Sciences Institute, August 2008, Los Angeles, USA.
- RIVEILL Michel, 2 weeks, september 2008 and october 2009, U. Cluj Napoca (Romania); 2 weeks, June 2008 and August 2010, U. of Santander (Colombie).
- TIGLI Jean-Yves, 2 months, 05-2008/06-2008, U. Al Manar & ENIT, Tunis, (Tunisie).

Networks and exchange programs

- Diliman University, Manila, The Philippines (IMAMIS joint-master with UNS)
- U. of Danang, Viet-Nam, (joint master with UNS)
- PHC Brancusi (01-2005/12-2006, 01-2009/12-2010), U. Cluj-Napoca (Romania)
- ECO-NET (01-2008/12-2009), U. Macédoine (Macédoine), U. Cluj-Napoca (Romania)
- University of Timisoara, Romania (PhD. ERASMUS agreements)
- International Summer School on Grid Computing (ISSGC'09) as organized in Sophia Antipolis (`http://www.iceage-eu.org/issgc09`)

Unformalized Academic or Industrial collaboration

- Algérie: U. Anaba
- Brazil: UFRGS (Porto Allegre), UFSM (Santa Maria)
- Colombia: U. Los Andes (Bogota), U. Industrial of Santander (Bucaramanga)
- India: U. Jadapur
- Lebannon: U. Libanaise (Beyrouth)
- Romania: U. of Timisoara
- Singapore : TMSI of the U. of Singapore
- Tunisie: ENIT, U. of Kairouan
- Other activities: member of the pôle created "DEVINT (DEficient VIsuel et Nouvelles Technologies `http://devint.polytech.unice.fr/`)" annual conference allowing blind people, students, researchers, industry and general public to come together around this issue (6th edition in 2010, more than 130 participants). A national network of researchers/teachers has been created to promote project creation about accessibility. Membre of the pôle are also the source of the "Nuits de l'info" (`http://www.nuitdelinfo.com`) (4th edition in 2010)
- Industrielle: Doriane

Contracts within academic or industrial partnerships

Type / Project name	Duration	Budget for I3S (k€)	Beforehand	2006	2007	2008	2009	2010	Afterward
ANR									
MOBIVIp	36	91							
Ergodyn	24	19							
Metrosec	36	40							
Agir	41	30							
Faros	46	315							
NeuroLOG	48	170							
Gwendia	42	156							
Hipcal	42	139							
Isicil	36	190							
Continuum	36	263							
VIP	36	127							
Salty	36	177							
TOTAL				**139**	**227**	**218**	**360**	**337**	
European funding									
Fastmatch	19	154							
Egee II	25	137							
Egee III	36	56							
TOTAL				**147**	**123**	**34**	**19**	**19**	
National funding									
Immunosearch	36	39							
M-Pub	30	360							
STM3 (nat. Funding)	36	66							
TOTAL				**1**	**13**	**73**	**156**	**181**	
Industrial funding									
Factory Productions	36	4							
CSTB	36	9							
Ernest & Young	36	11							
France Télécom	36	29							
France Télécom	36	127							
CSTB	36	9							
DCNS	36	12							
France Télécom	36	20							
Vivadia	36	36							
CSTB	36	15							
TOTAL				**63**	**65**	**31**	**10**	**23**	
Local funding									
Gerhome	19	11							
CREA06	24	3							
CREA06	12	2							
STM3 (PACA)	36	69							
TOTAL				**1**	**9**	**5**		**19**	
TOTAL PER YEAR				**351**	**437**	**361**	**545**	**579**	

GLC members lead 6 of the 12 ANR contracts obtained by the pole (AGIR, CONTINNUM, GWENDIA, MOBIVip, NeuroLOG, SALTY).

Incubation The pôle GLC thanks to its numerous industrial collaborations participate closely to the creation of companies or giving support to several of them.

- Start-up : SimplySim (born in 04-2008, contract being signed, `http://www.simplysim.net/`), VU Log (born in 05-2006, contract signed `http://www.vulog.fr/`),
- Incubation : Bewave (03-2010/-, contract being drafted), MovingPlayer (03-2010/-),

Software A particularity of pôle GLC is to invest significantly in software development to validate the research activity conducted. Most of these development costs are supported through research contracts, although the life-cycle and diffusion of this software extends far beyond the seminal contracts duration. Several software products are no longer simple demonstration prototypes. For instance, the following software artifacts are disseminated beyond the partners of the contracts they are originating from:

- *Adore:* framework defines a compositional approach to support complex business processes modeling, using the orchestration of services paradigm (RNTL FAROS). jSeduite is an information system to broadcast news created using Adore.
- *Moteur and jGASW:* a grid-enabled workflow manager designed to specify data-intensive scientific

workflows in an abstract language (EU-FP7 EGEE). Moteur is used in the NeuroLOG platform software and will be integrated in the EU-FP7 SHIWA platform.
– *SweetWiki:* a wiki application designed for a semantic web annotation framework.
– *WComp:* a middleware for Ambient Intelligence (ANR CONTINUUM). Wcomp is used inside the Ubiquarium, an experimentation environment dedicated to demonstrate Ambient Intelligence applications.

Software	source lines of code (SLOC)
NeuStemStore	5.000
jSeduite	70.000
WComp	80.000
jGASW	14.300
Confract	41.800
Amui	15.700
SweetWiki	20.000
Moteur	48.500
Ubiquarium	60.000
AAComp	55.500
NeuroLOG Platform	47.100
Interact	19.600
Adore	14.000
Noah	25.500
Total	**517.000**

These software artifacts cumulate more than half a million source lines of codes (SLOC) among which 75% are still maintained and used daily (see table). The software development tasks are therefore a heavy time and resources investment. However, it also helps in assembling new partnerships through a wide distribution. For instance, MOTEUR led to the establishment of new scientific partnerships with CREATIS (CNRS, Lyon), AMC (Amsterdam) and University of Madison (USA). Similarly, WComp was the basis to a collaboration with the University of Lebanon which yielded a joint PhD supervision and a collaboration with the TMSI laboratory (STIC-Asia, Singapore). Other external Universities also use these software artifacts in their research cycle (*e.g.* WComp is exploited by IRIT laboratory in Toulouse and LIESP in Lyon).

Our research results are also valorized through the dissemination and the exploitation of the derived software for learning. Two concrete examples can be mentioned: use in specialized public schools (École Clément Ader and IRSAM) and use in Research Master programs, in France and abroad (Tunisian schools: ENIT, ESPRIT).

The software production also eases interaction with enterprises for knowledge transfer and/or dissemination of scientific research led by pôle GLC. Partnerships with enterprises have thus evolved along two directions: some specific research contract (not related to ANR or EU calls) signed with industries (Orange, CSTB, GFI Informatique) and the emergence of new SMEs exploiting some, or a part of a software produced by pôle GLC (*e.g.* Vu Log, SimplySim...).

Finally, the software artifacts are distributed using different license schemes depending on the usage planed (CeCILL, GPL, LGPL, for non-profit under NDA, specific licenses with fees...). In order to better protect well achieved and valuable software products, several of them have been (or are being) registered at the Agence de Protection des Programmes (APP) : Noah, WComp, Ubiquarium, VuLog soft, jSeduite.

3.7 Scientific production: publications, softwares & patents

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