

Contents

1	General presentation	1
2	Team Composition	2
3	Research Themes	4
3.1	Models for test oracles	4
3.2	Test generation	6
3.3	Test assessment	8
4	Application domains and social, economic or interdisciplinary impact	9
5	Contracts and grants	10
5.1	External contracts and grants (Industry, European, National)	10
5.2	Research Networks (European, National, Regional, Local)	13
5.3	Internal Funding	13
6	Principal International collaborations	14
6.1	PHC SAKURA (2007-2008), with Kobe University (M. Nakamura, Japan)	14
6.2	PHC AURORA (2009-2010), with Simula (L. Briand, Norway)	14
6.3	Collaboration with CRIM (Montreal)	15
7	Visibility, Scientific and Public Prominence	15
7.1	Contribution to the Scientific Community	15
7.2	Prizes and Awards	17
7.3	Public Dissemination	17
8	Software and Research Infrastructure	17
9	Educational Activities	18
10	Industrialization, patents and technology transfer	18
11	Self-Assessment	19
12	Perspectives for the research team	19
13	Publications	20

1 General presentation

Scientific and Technological Project

VASCO stands for “Validation of software Systems, Components and Objects”. VASCO’s research is in the field of software engineering and applied formal methods. It is member of the “Software” axis of the LIG, and shares with several teams of this axis the conviction that software engineering tools must be based on models. Our primary concern is validation, which applies to both software and models.

Validation of software corresponds to the various testing activities (unit testing, integration testing, system and acceptance testing) which also include research on testability measurements. Testing activities require the use of an oracle to decide on the success or failure of the test. This oracle often refers to models defined in the early stages of software development (requirements, specifications or design models).

Since testing only assesses the conformance of the software to these models, it is essential to validate these models also. Validation of models usually requires human understanding of these models and may be aided by linking formal models to

graphical ones or the use of animation techniques. VASCO's research themes are thus modelling and testing. They have been applied in various domains, mainly in the context of ANR projects: avionics, smart cards, telecommunication systems, home automation, multimodal interfaces, secure information systems, and airport security regulations.

Applied formal methods are directly related to the development or use of software tools. VASCO develops tools in the fields of automated test generation (Lutess, Tobias, Jarage), and model construction or reengineering (RALT, B2UML, RoZ).

This research is related to the "Security, safety, reliability", "Embedded Systems", "Intelligent building" challenges of LIG scientific programme and the PILSI project. It contributes to the "Sustainable ambient computing" project of the LIG by its contributions to safety, security and software quality.

Projet Scientifique et Technologique

VASCO signifie "VALidation de Systèmes Composants et Objets logiciels". La recherche développée par l'équipe VASCO s'inscrit dans le champ du génie logiciel et des méthodes formelles appliquées. L'équipe appartient à l'axe "Logiciel" du LIG, et partage avec plusieurs de ses équipes la conviction que les outils de génie logiciel doivent être articulés autour des modèles. Notre activité principale est la validation qui concerne tant le logiciel que les modèles.

La validation des logiciels se traduit principalement en diverses activités de test (test unitaire, test d'intégration, tests systèmes et de recette), ce qui inclut également des recherches sur la mesure de testabilité. Le test d'un logiciel suppose aussi que l'on dispose d'un oracle pour décider du succès ou de l'échec du test. Cet oracle fait le plus souvent référence à des modèles décrits dans les phases initiales du développement logiciel (analyse des besoins, spécification, conception).

Le test ne permet que d'établir la conformité d'un logiciel avec son modèle. Il est dès lors essentiel de valider également ces modèles. La validation des modèles passe généralement par leur compréhension par des êtres humains (analystes, clients), et peut être facilitée en liant des modèles formels à des représentations graphiques ou par l'utilisation de techniques d'animation. Les thèmes de recherche de VASCO sont donc la modélisation et le test. Nos recherches ont été appliquées dans des domaines très variés, le plus souvent dans le cadre de projets ANR : avionique, cartes à puce, systèmes de télécommunications, domotique, interfaces multi-modales, systèmes d'information sécurisés et réglementations de la sécurité des aéroports.

Les méthodes formelles appliquées sont par essence reliées au développement ou à l'utilisation d'outils logiciels. VASCO développe des outils pour la génération automatique de tests (Lutess, Tobias, Jarage), et la construction ou réingénierie de modèles (RALT, B2UML, RoZ).

Nos recherches s'inscrivent dans les défis "Sécurité, sûreté, fiabilité", "Systèmes embarqués" et "Bâtiment intelligent" du projet scientifique du LIG et du projet PILSI. Elles contribuent au projet "informatique ambiante et durable" du LIG par ses contributions en sûreté, sécurité et qualité du logiciel.

2 Team Composition

<i>Permanent Researchers</i>				
Name	First name	Function	Institution	Arrival date
du Bousquet	Lydie	Associate Professor	UJF	Sep 00
Groz	Roland	Full Professor	GINP	Sep 02
Idani	Akram	Associate Professor	GINP	Oct 08
Jacquet	Paul	Full Professor	GINP	before 84
Ledru	Yves	Full Professor	UJF	Oct 93
Oriat	Catherine	Associate Professor	GINP	Sep 96
Ouabdesselam	Farid	Full Professor	UJF	Jan 80
Richier	Jean-Luc	Research Scientist	CNRS	Sep 84

<i>Post-docs, engineers and visitors</i>				
Name	First name	Function and % of time	Institution	Arrival date
Delaunay	Michel	ITA IR	CNRS	Jan 77
Madani	Laya	Expert engineer, then post-doc	UJF, UPMF	Mar 08
Rajan	Ajitha	Post-doc	UJF	Oct 08
Vega baez	German Eduardo	ITA IR (50%)	CNRS	Dec 07

<i>Doctoral Students</i>				
Name	University	Supervisors	Funding (sources and dates)	Date of first registration
Falcone Y.	UJF	Fernandez Jean-Claude (Vérimag), Richier Jean-Luc, Mounier Laurent (Vérimag)	MESR (06-09)	Sep 06
Haddad A.	GINP	Potet Marie-Laure, Ledru Yves	Other Sep 05 - Aug 09 (thesis stopped)	Sep 05
Irfan M.	GINP	Groz Roland, Oriat Catherine	Foreign Oct 08 - Sep 11	Feb 09
Labiadh M. A.	UJF	Ledru Yves, Idani Akram	ANR contract Jun 09 - Dec 11	Jun 09
Papailiopolou V.	UJF	Ouabdesselam Farid, Parissis Ioannis	Industrial contract Nov 06 - Nov 09	Nov 06
Qamar M.	UJF	Ledru Yves, Idani Akram	INRIA grant Feb 08 - Jan 11	Feb 08
Shaheen M.	UJF	Ouabdesselam Farid, du Bousquet Lydie	Foreign Sep 06 - Sep 09	Sep 06

<i>Habilitation Theses defended during period</i>				
Name	First name	Defense date	University	Current position
Parissis	Ioannis	Dec 2007	UJF	PR GINP/Esisar (Valence)

Past team members

<i>Past Members Oct. 2005-Oct. 2009</i>						
Name	First name	Position	Employer	Arrival date	Departure date	Current position
Berlioux	Pierre	Associate Professor	GINP	before 84	Sep 08	retired
Bert	Didier	Research Scientist	CNRS	before 84	Sep 07	retired
Boulmé	Sylvain	Associate Professor	GINP	Sep 01	Dec 07	joined Vérimag
Parissis	Ioannis	Associate Professor	UJF	Sep 99	Sep 08	PR GINP/Esisar (Valence)
Potet	Marie-Laure	Full Professor	GINP	89	Dec 07	joined Vérimag
Reynaud	Jean-Claude	Research Engineer	CNRS	before 84	07	retired

<i>Past Doctoral students</i>					
Name	Date of first registration	Date of departure	University	Supervisor	Current position
Bontron P.	2000	Mar 05	UJF	Ledru Yves, du Bousquet Lydie, Potet Marie-Laure	Engineer
Darmaillacq V.	Oct 02	Dec 07	UJF	Groz Roland, Richier Jean-Luc	Engineer at CEA/LIST
De Ruyter T.	02	Jun 07	GINP	Potet Marie-Laure	Engineer
Griche K.-C.	2000	Jul 05	UJF	Ouabdesselam Farid, Ioannis Parissis	Engineer
Hadam P.	02	June 05	GINP	Duda Andrzej (Drakkar), Jean-Luc Richier	Engineer
Idani A.	Sep 03	Nov 06	UJF	Ledru Yves, Bert Didier	Associate Professor GINP
Kermarrec A.	Sep 03	Sep 06	GINP	Groz Roland	Engineer
Lakehal A.	Nov 02	Sep 06	UJF	Ouabdesselam Farid, Ioannis Parissis	Engineer
Madani L.	Sep 03	Dec 07	UJF	Ouabdesselam Farid, Ioannis Parissis	Post-Doc UPMF
Maury O.	Sep 00	Dec 05	UJF	Ledru Yves, Oriat Catherine	Engineer
Ruiz Barradas H.	Nov 02	Dec 06	GINP	Didier Bert	Post-Doc
Seljimi B.	Nov 04	Jul 09	UJF	Trilling Laurent, Parissis Ioannis	
Shahbaz M.	Oct 05	Dec 08	GINP	Groz Roland	Engineer
Stouls N.	Dec 03	Dec 07	GINP	Potet Marie-Laure, Boulmé Sylvain	Associate Professor INSA Lyon

<i>Past post-doctoral researchers, engineers and visitors</i>					
Name	First name	Function	Date of arrival	Date of departure	Home Institution (if appropriate)
Dadeau	Frédéric	Post-doc	Oct 06	Sep 07	GINP
Darmaillacq	Vianney	Post-doc	Jan 08	Sep 08	GINP
Idani	Akram	Expert engineer	Sep 08	Sep 08	GINP
Janvier	Romain	Post-doc	Sep 07	Sep 08	GINP
Messina	Ulysse	Expert engineer	Dec 07	Nov 08	GINP
Petrenko	Alexandre	Visitor	Apr 06 Sep 07	Jun 06 Oct 07	LIG
Schobbens	Pierre Yves	Visitor	Jan 09	May 09	UJF
Shahbaz	Muzammil	Expert engineer then postdoc	Nov 08	Jun 09	GINP, UJF

Evolution of the team:

The size of the team was significantly reduced since 2005. Three members did retire (P. Berlioux MCF, D. Bert CR CNRS, J.C. Reynaud IR CNRS), one was promoted to professor in another geographic site (I. Parissis), two left to another laboratory (M.L. Potet PR, S. Boulmé MCF). Moreover, F. Ouabdesselam was elected as President of UJF. In the mean time, we recruited one MCF (A. Idani) and one IR2 engineer (German Vega), shared with the Adele team.

3 Research Themes

3.1 Models for test oracles

A first set of research themes is related to the construction and validation of models. Most of our models are executable or animatable specifications, which can be linked to testing (testing the models or testing some implementation against the models).

3.1.1 Integration of graphical and formal specifications

List of participants: Yves Ledru (PR), Didier Bert (CR), Akram Idani (MCF), Mohamed Amine Labiadh (PhD student), Nafees Qamar (PhD student)

Scientific issues and positioning of the team: The complementarity of formal and graphical specifications has been stated for years, and numerous proposals have been made in order to integrate such specifications. Graphical notations are usually perceived as more intuitive and are linked to many requirements engineering methods. Formal specifications allow detailed analysis of the models, the generation of tests, or the animation of models. In the past, the VASCO team has developed the RoZ tool which translates UML specifications into the Z formal language. And the use of such translation technologies was underlying the ACI EDEMOI project, which aimed at modelling international standards for airport security.

Experiments within this project revealed the need to take into account non-standard extensions of the graphical language, e.g. the use of a security profile in UML diagrams [100], and the difficulty to address real-size models with the current translation tools.

Key references: [68], [131], [8], [56], [7], [102], [97], [58], [59], [44], [9], [82], [95], [100], [24], [106].

Major results Jan. 2005-Oct. 2009: A new approach to the integration of graphical and formal methods was explored during the thesis of A. Idani [131]. It studied the construction of graphical views from formal specifications, using reverse engineering techniques. Starting from B specifications, produced by the EDEMOI project, class diagrams and state transition diagrams are produced, using our B2UML tool. The use of concept formation techniques, instead of syntax level transformation rules, produces diagrams which capture the underlying structure of the specification, and help specification understanding. This work led to several journal publications [8], [7], [102].

Another contribution of the EDEMOI project was the definition of an approach to model and analyze security regulations, and evidence that such a modelling activity can improve the design and evolution of regulations [44], [95]. The approach includes a goal-driven requirements engineering method [9], and has recently been applied to the domain of air transport safety regulations [82].

Other results in this domain include the evolution of the RoZ tool to generate specifications compatible with animation tools [58].

Perspectives: With the advent of UML profiles, and especially user-defined extensions to the graphical formalisms, comes the need for more flexible transformation frameworks. Such frameworks should allow user-defined rules, and the opportunity to tailor the choice of translation rules to each model, e.g. to take into account the size of the model and choose adequate structuration. We are currently working on such a framework [106].

Within the new ANR Selkis project, this framework will be instantiated to UML security profiles. Specific research will be conducted in order to explore potential translation rules which address specific aspects of security identified, e.g., in the RBAC models.

3.1.2 Service testing and interaction

List of participants: Lydie du Bousquet (MCF), Jean-Luc Richier (CR), Yves Ledru (PR), Catherine Oriat (MCF), Farid Ouabdesselam (PR), German Vega (IR), Ajitha Rajan (Post-doc), Pierre-Yves Schobbens (Invited Professor), Mickael Pruvost (CNAM student)

Scientific issues and positioning of the team: Since the beginning of the nineties, telecom industry has to face a critical problem. New services are likely to interact with existing ones, such as call forward, or call screening: a new service can change the behaviour of pre-existing ones, break them, or even crash the system. This is a well known problem in the telecommunication industry known as the “feature interaction problem”. A large set of solutions has been proposed to tackle this problem, but none of them is completely satisfactory. At the end of the nineties, VASCO proposed an off-line approach based on testing executable specifications.

Nowadays, ubiquitous/pervasive computing allows to deploy value-added services at home, to provide more convenient and comfortable living for home users. For practical use of such services, it is essential to be able to add services in the home dynamically. In this context, one should guarantee the correctness, the safety and the security of the services. Like telecommunication services, home services can badly interact. This type of systems offers new challenges in terms of validation for two reasons. First, configurations of services and appliances in each home can vary even worst than configurations in telephony systems. Second, those configurations can evolve quicker than in telephony.

Key references: [52] [39] [1] [54] [10] [65]

Major results Jan. 2005-Oct. 2009: During the last four years, VASCO studied the problem of service interaction in telephony and home systems. A way to detect new type of service interactions (due to unsatisfied liveness properties) was proposed in [65] and [54].

A collaboration with Nara and Kobe universities was started in 2006 on home services validation (PHC Sakura project 2007-2008). A method to specify and validate home services was proposed and experimented. First, safety properties are identified and inserted in the code as executable assertions written in the Java Modelling Language. It allows both off-line and on-line validation thanks to testing or verification [52], [39], [1]. The iPOTEST project, founded by the UJF, focuses especially on the validation of such services in the context of dynamicity [10].

Thanks to this work, VASCO was involved in the *International Conference on Feature Interaction* as member of the program committee in 2005, president of the program committee in 2007, and president of the steering committee in 2009.

Perspectives: The framework for home service validation is going to be improved. Some solution to valid liveness properties has to be proposed (for now, only safety properties are studied). Moreover, it has to be evaluated.

As a second direction, one should notice that the validation framework is efficient only if *all* the safety properties are identified. To do that, VASCO and the Kobe university have proposed a solution based on a systematic identification of risks and semi-automatic safety property generation. A CNRS-PICS project proposition has been submitted in June 2009 to develop and evaluate this solution.

3.1.3 Machine inference for integration testing

List of participants: Roland Groz (PR), Catherine Oriat (MCF), Keqin Li (PostDoc), Muzammil Shahbaz (PhD), Audrey Kermarrec (PhD), Muhammad Naeem Irfan (PhD)

Scientific issues and positioning of the team: Distributed software architectures integrate components coming from various

sources that may be more or less reliable. Typically, a distributed service would be based on the interaction between components (e.g. portals, databases etc) within a company and other components outside the scope of the company. We are addressing the validation of such systems with the goal to ensure a reliable enough execution of software based on the specific and limited way it uses other components. The approach is based on a partial specification of the components, and incremental integration testing. In most realistic settings, no formal specification of software components is available; therefore a partial formal model has to be derived from the observations made during the tests.

We work with models based on finite state machines, extended with variables and parameters on input-output interactions. We have addressed the identification of faulty configurations through the computation of discriminating test sequences to identify classes of configuration faults.

We have mostly worked on the reverse engineering of finite state models from testing black box components. We enriched existing machine learning algorithms to deal with parameterized machines. This led to the development of the RALT tool (Rich Automata Learning Tool).

We developed an integration approach combining incremental inference of models with analysis of faults and discrepancies between models and actual systems.

This work has been done in collaboration with France Telecom Orange Labs (PhD theses of A. Kermarec and M. Shahbaz), and with CRIM in Canada.

Key references: [15][132] [125] [118] [60] [29] [48] [23] [99].

Major results Jan. 2005-Oct. 2009: The RALT tool implements several algorithms for inference of models (with various types of models: DFA, FSM, PFSM, NDFSM). It also implements testing strategies, and test drivers for several applications that have been considered in our experiments (Midlets on mobile phones, UPnP for domotics...). The approach has been shown to work in practice on several applications considered by Orange Labs.

We also developed an approach to track sporadic errors coming from various interleavings in modular systems, again by combining FSM model inference with integration testing strategies and reachability analysis.

Perspectives: The preliminary results in application of combination of machine inference and integration testing are promising, but a number of points need further investigation.

- Abstraction of real interactions (procedure calls, messages) into parameterized state machine events may play a key role in complexity of the inference. This is an application dependent issue, but some systematic guidelines and methods should be considered.
- Inference and integration testing involve a number of various strategies where heuristics could also play a key role in practical complexity. We will be investigating various combinations of heuristics, and their actual efficiency in various contexts.
- Inference derives approximate models of the real systems. We formalized this approximation, and we consider it would be worthwhile relating the degree of approximation on the models with reliability models for the software, so as to link test efforts and test results with reliability estimates. This may also be linked to random testing strategies used in refining the models.

3.2 Test generation

A second set of research themes is dedicated to test generation. Tools such as Tobias or Lutess play a central role in these researches. But models which provide a starting point for test generation, or an oracle for the generated tests, also play a primary role in these researches.

3.2.1 Combinatorial testing

List of participants: Yves Ledru (PR), Lydie du Bousquet (MCF), Olivier Maury (PhD student), Pierre Bontron (PhD student), Frédéric Dadeau (Post-doc), Sébastien Ville (CNAM student), Ulysse Messina (CNAM student)

Scientific issues and positioning of the team: Since 2001, the VASCO team develops Tobias, a combinatorial test generator. The tool unfolds a test pattern, given by the test engineer, into a large number of test inputs. Test patterns are expected to capture the knowledge of the test engineer as abstract sequences of methods calls, associated with sets of candidate values to instantiate the calls. The tool amplifies the work of the test engineer by performing the clerical tasks associated with combinatorial unfolding, and hence significantly improves his/her productivity.

Several experiments have shown that the systematic character of the generated test suites helped to detect more faults than manually produced test suites. The flexibility of the output format of the test cases allows to adapt them to several target languages and technologies (Java/JUnit, C++, B, VDM, IOLTS, . . .).

The tool only generates input data. They must be associated with some oracle technology. In the case of Java programs, we use the Java Modelling Language (JML), to express various executable assertions (invariants, pre- and post-conditions) which are executed at run-time. The combination of Tobias and JML is experimented in the iPOTest project, dedicated to the test of home automation systems based on an OSGi service architecture.

Key references: [135], [138], [34], [38], [22], [1], [66].

Major results Jan. 2005-Oct. 2009: A first version of the tool has been referenced by the Agence de Protection des Programmes in 2005. The associated PhD theses were defended at the same period [135], [138]. This first version of the tool was experimented on various application domains such as interactive systems [66] and banking systems [1].

Based on the lessons learned with the first version of the tool, a new version was developed in 2006 by a CNAM engineering student. The architecture of this new version allows to plug in several kinds of filters in order to address combinatorial explosion. Combinatorial explosion is intrinsic to the tool and must be mastered by the test engineer. The filtering mechanisms allow to select test cases which individually or collectively satisfy some filtering criterion. The tool was demonstrated at the ASE and AFADL conferences, and preliminary experiments with its filtering mechanism were carried out in the context of the POSE ANR project [34]. The tool was also experimented in the context of VLSI descriptions in SystemC [22].

Regarding the use of JML, several experiments were performed in order to compare its use in a testing and in a proof context [38], [1].

Perspectives: Tobias is well adapted to support a scenario-based testing approach. The TASCCC project has been recently accepted by ANR, and will support our collaboration with the LIFC team and the Smartesting company to combine it with their tools, and build on the lessons learned from the POSE ANR project. Further studies will experiment with the filtering mechanisms of the new version of Tobias. In particular, we will address the design of application independent filters, such as selection based on pairwise coverage of the combination parameters. We also aim to continue its experimentation on various application domains such as home automation systems.

Technical improvements to the tool are also under development, e.g. to improve its user interface and to release it as a service on the web.

3.2.2 Test of interactive systems

List of participants: Catherine Oriat (MCF), Lydie du Bousquet (MCF), Ioannis Parissis (PR), Laya Madani (PhD student and Post-doc).

Scientific issues and positioning of the team: In Human-Computer Interaction (HCI), systems are often tested manually, interacting with the system as an end user. In particular, the usability of such systems can be evaluated by experimental methods, which consist in observing end users. Some interactive applications are multi-modal, which means that the exchanged events are from different modalities (keyboard, mouse, voice, gesture) that can be combined, which increases the complexity of the interaction. It is important to verify certain properties of the interface, in particular the CARE multi-modal properties (Complementarity, Assignment, Redundancy, Equivalence), which relate to the combination of events from different modalities. Automatic or semi-automatic generation of test cases allows more intensive testing of these applications.

Key references: [66] [74] [128] [4].

Major results Jan. 2005-Oct. 2009: We developed formal methods for the validation of interactive systems. In particular, we showed that it is possible to model the interaction synchronously, in order to use the Lutess tool (synchronous generator of random tests), by interposing a translator between the application and Lutess. We expressed some properties in Lustre (in particular safety properties, which can be written in Lustre temporal logic). In particular, the CARE properties were expressed in Lustre, and we proposed a technique, based on operational profiles, to generate relevant scenarios [74]. In order to generate tests, the user behaviour must be specified in Lustre. As designers of interactive applications are not very familiar with this synchronous language, we proposed to use task trees, which we enriched with probabilities. We proposed a transformation of a task tree into a finite state machine, which can be used to generate tests [128], [4].

The CARE properties were also expressed using JML (Java Modeling Language) and the fusion engine of multi-modal events was tested with the Tobias combinatorial testing tool [66].

Perspectives: The perspectives of this work focus on the task tree, which is defined very early in the development process of an interactive application. We can use it to specify different types of guidance for generating random tests. We already did it to specify operation profiles for tasks, but it would also be interesting to be able to guide test generation with safety properties. In this case, the generator can favor the production of inputs which lead to a suspect state, which could violate the safety property. Besides, it would be useful to be able to specify multi-modal aspects of an application in the task tree, in order to generate relevant tests cases.

3.2.3 Test methodology for security policies

List of participants: Roland Groz (PR), Marie-Laure Potet (PR), Jean-Luc Richier (CR), Sylvain Boulmé (MCF), Vianney Darmaillacq (PhD Student), Didier Bert (CR), Nicolas Stouls (PhD), Amal Haddad (PhD), Keqin Li (post-doc), Frédéric Dadeau (post-doc), Romain Janvier (post-doc), Thierry Moutet (Engineer), Ulysse Messina (Engineer).

Scientific issues and positioning of the team: We approach the validation of the security of systems through derivation methods from formal models of policies, that is to say the sets of specific requirements for ensuring security properties. We used several techniques from formal methods. First, derivation of security mechanisms, or refinement preserving security properties have been proposed to develop secure implementations. This track has been explored in particular in the POSE project, and on the development of code for smart cards. Second, we derived conformance tests from logic specifications of policy requirements. These tests can be used to check that a system abides by a given policy. This is important at two stages: when a new system has been developed or set up, and later on to check that despite configuration changes associated with the administration of the system, the requirements are preserved.

Key references: [53], [126], [103], [130], [51], [63], [45], [98].

Major results Jan. 2005-Oct. 2009: A method has been defined to generate tests from a restricted modal logic expressing security rules. The method is generic, and only needs a formal rewriting of the policy rules into that logic. It does not require a formal specification on the system, but it assumes that elementary test events called tiles are associated to the predicates appearing in policies. The method has been implemented in a prototype tool, with tiles and test drivers to interface to typical network services (remote connection, e-mail...).

Regarding the modelling of security policies, the Meca tool has been developed during the POSE project. The tool weaves a given access control policy with the functional model, expressed in B, of the system to secure. The resulting B model can be used to generate tests [98], using commercial test generation tools such as LTG.

Perspectives: The work done in the preceding period has been close to traditional methods based on formal methods. It could be applied to various types of requirements expressed by policies, either rule based or expressed by more global requirements. Our research has moved to issues more specific to security, concentrating on the identification of vulnerabilities in software. Two new projects emerged from that activity and have just started: Vulcain (UJF), and a Cifre collaboration with the VUPEN company.

The expertise gained in the modelling of security policies will also contribute to the recently started ANR Selkis project, dedicated to the specification and design of secure medical information systems.

3.3 Test assessment

The third and last set of research themes is dedicated to assessment. Test coverage is a crucial metrics to halt the tests, and software testability evaluates to what extent a design will favour testing activities.

3.3.1 Test coverage for reactive systems

List of participants: Lydie du Bousquet (MCF), Ioannis Parissis (MCF), Farid Ouabdesselam (PR), Abdesselam Lakehal (PhD student), Virginia Papailiopoulou (PhD student), Laya Madani (Post-doc)

Scientific issues and positioning of the team: Lustre is a formal synchronous declarative language widely used for modelling and specifying safety-critical applications in the fields of avionics, transportation or energy production. Testing this kind of applications is an important and demanding task during the development process. It mainly consists in generating test data and measuring the achieved coverage. The challenge here is to provide adequate coverage criteria consistent with the data-flow nature of the language. A hierarchy of structural coverage criteria for Lustre programs

have been defined to assess the thoroughness of a given test set. They are based on the operator network, which is the graphical representation of a Lustre program and depicts the way that input flows are transformed into output flows through their propagation along the program paths.

Key references: [71] [70] [87] [133] [43] [81] [26]

Major results Jan. 2005-Oct. 2009: The hierarchy of structural coverage criteria for Lustre programs is the result of A. Lakehal PhD thesis [133]. A tool has been implemented, called Lustructu [71], [70], [87], [43]. Lustructu tool is currently improved in the context of the Virginia Papailiopolou's PhD [81], [26]. It is one of the tools involved in the Siesta project and an integration of the criteria in the SCADE environment¹ is currently undertaken by Esterel Technologies.

Perspectives: SCADE is a graphical version of Lustre. At this point, the hierarchy of structural coverage criteria for Lustre programs is compliant with SCADE V. SCADE VI deals with new constructions such as automaton. The coverage criteria are thus being extended to be compliant with SCADE VI (part of the Virginia Papailiopolou's PhD). Moreover, the Siesta project will provide feedback on the relevance coverage criteria.

3.3.2 Software testability

List of participants: Lydie du Bousquet (MCF), Farid Ouabdesselam (PR), Michel Delaunay (IR), Muhammad Rabee Shaheen (PhD student)

Scientific issues and positioning of the team: The aim of testing is to find some defects. It is an expensive phase in the development. Researchers and practitioners aim at finding solutions to predict the cost of testing. Lots of metrics have thus been proposed but very few of them have been proved to be predictive indicators. In this context, one challenge is to provide methodologies to assess the predictive power of metrics. This work is currently carried out with respect to two types of languages: object-oriented (Java) and synchronous (Lustre) ones. For Java, the cost of testing is studied with respect to the inheritance tree. For Lustre programs, controllability and observability metrics proposed by ValSys team in LCIS labs at Valence are analysed.

Key references: [20] [37] [36]

Major results Jan. 2005-Oct. 2009: For the testability analysis of Lustre program, a mutation tool called Alien-V was built in collaboration with ValSys team [37], [36]. Mutation testing consists in introducing small syntactical defects in the source code of a program. Alien-V is currently used in order to evaluate how difficult it is to detect an error in the program with respect to the testability metrics proposed by ValSys team. It is part of the Siesta ANR project.

For the testability analysis of Java programs, Muhammad Rabee Shaheen is about to defend his PhD. Several results have been established about the influence of inheritance on the testing cost [20].

Perspectives: Validation of Lustre testability metrics will be proceeded in the context of SIESTA project. Depending of the results, metric definitions will either be adjusted or modified. For the testability analysis of Java programs, a new collaboration with Lionel Briand (Simula Labs) has been started in 2009 (PHC Aurora 2009-10). New results in terms of cost of testing methods are expected.

4 Application domains and social, economic or interdisciplinary impact

Although validation, and especially testing, makes sense for all kinds of applications, formal methods, which are the foundation of most of our research, traditionally applies to "critical systems". Nevertheless, the term "critical system" tends to broaden its scope. It was originally focused on human-critical systems, i.e. systems whose failure may kill or cause serious injuries to human beings. Now, the term "critical" also applies to economical or societal concerns, i.e. systems whose failure may cause the loss of unacceptable amounts of money, or may impact fundamental social links such as trust or privacy.

The application domains of VASCO have followed this trend. The team is active in the field of human-critical systems, as shown by our cooperations with significant actors in the field of avionics (ANR Siesta project with Airbus and ONERA). Our researches in the field of security, and especially security testing, correspond to the fields of economical and societal systems. Actually, VASCO is one of the rare teams which addresses security testing in a wide variety of domains: from smart cards (ANR projects POSE and TASCOC with Gemalto), to distributed information systems and web applications (ANR project PoliteSS with Orange Labs and SAP research, Vulcan project with VUPEN). The team has also significant activities in the field

¹<http://www.esterel-technologies.com/products/scade-suite/>

of security modeling with projects such as ANR Selkis (medical information systems), and ACI EDEMOI (airport security modeling). Finally, a field such as home automation, addressed in the iPOTest project, belongs to several of these categories with security and safety problems.

5 Contracts and grants

5.1 External contracts and grants (Industry, European, National)

Most of our contracts are national projects, they are grouped following the research themes of section 3, then in chronological order.

5.1.1 Models for test oracles

Acronym: EDEMOI

Project name: Elaboration d'une démarche et d'outils pour la modélisation informatique, la validation et la restructuration de réglementations de sûreté, et de la détection des biais dans les aéroports

Dates: 2003-2007

Funded by: national funding: FNS

Partners: Cedric/CNAM, GET-ENST, LACL, LIG, LIFC, ONERA

Scientific leader: Yves Ledru

Short description: The EDEMOI project proposed an approach to model airport security regulations, using modelling languages from the computer science community. The VASCO team was in charge of the overall coordination of the project, and made contributions in requirements analysis, formal modelling, reverse engineering of formal models into graphical ones, and model-based test generation. These contributions addressed realistic size models based on international civil aviation standards.

Project name: CIFRE thesis of M. M. Shahbaz

Dates : 2005-2008

Funded by: industrial contract with France Télécom R& D (now Orange Labs)

Scientific leader : Roland Groz

Short description: The PhD work of M. Muzammil Shahbaz was developed under a Cifre contract with Orange Labs. Since the contract was with Orange Labs in Lannion, in practice most of the research work was done under LIG supervision in Grenoble.

Acronym: SELKIS

Project name: Une méthode de développement de systèmes d'information médicaux sécurisés: de l'analyse des besoins à l'implémentation

Dates: 2008-2011

Funded by: national funding: ANR/ARPEGE : systèmes embarqués et grandes infrastructures

Partners: MEDECOM, SWID, CHU Brest, IFREMMONT, CEDRIC/CNAM, LACL, LIG, Télécom Bretagne

Scientific leader: Régine Laleau (LACL)

Scientific leader for LIG: Yves Ledru

Short description: The SELKIS project aims at developing a Model-Driven Engineering approach for the analysis and design of Secure Information Systems, with case studies in the field of medical information systems. The role of the VASCO team in this project is to take advantage of the integration of graphical and formal languages to validate the information system at the PIM (Platform Independent Model) level.

5.1.2 Test generation

Acronym: VERBATIM

Project name: Vérification Biformelle et Automatisation du Test d'Interfaces Multimodales

Dates: 2003-2007

Funded by: national funding: ANR RNRT

Partners: AQL, Clearsy, France Telecom, ENSMA, LIG, ONERA

Scientific leader: Joëlle Blanquet (FT R&D)

Scientific leader for LIG: Ioannis Parissis

Short description: The Verbatim RNTL project brought together the VASCO and IIHM teams of the LIG, with France Télécom, ENSMA/LISI, ONERA/CERT, Clearsy and AQL. It aimed at providing a formal validation method for interactive multi-modal applications, which can easily be used by developers of such applications. The role of the VASCO team was to develop a synchronous approach to generate tests for interactive multi-modal applications.

Acronym: DANOCOPS

Project name: Détection Automatique de NON-CONformités d'un Programme vis-à-vis de ses Spécifications

Dates: 2004-2006

Funded by: national funding: RNTL

Partners: AXLOG S.A, Thalès, LIG, I3S, LIFC

Scientific leader: Bernard Botella (Thalès)

Scientific leader for LIG: Ioannis Parissis

Short description: The project aim was to define model-based testing tools able to identify discrepancies between a program and its, partially formal, specification. As a common technology, the approaches developed in DANOCOPS, used Constrain Logic Programming. The LIG contribution was an extension of the LUTESS testing environment. The new version of the tool, LUTESS V2, deals with specifications handling numeric inputs and outputs, supports more powerful conditional probabilities and introduces hypotheses based testing.

Acronym: ACI POTESTAT

Project name: Politiques de sécurité: test et analyse par le test de systèmes en réseau ouvert

Dates: 2004-2007

Funded by: national funding: FNS

Partners: IRISA, LIG, Verimag

Scientific leader: Roland Groz

Short description: This project addressed the test of policy securities for open networked systems. It investigated three main directions: analysis of information flows, passive testing techniques (relating security monitoring to diagnosis theory), and generation of active tests from formal models of the policies. LIG was active in this last direction, collaborating with Verimag on a test generation method based on a logic formalization of security rules, and a combination of elementary tests called tiles for predicates.

Acronym: POSE

Project name: Automatiser la génération et l'exécution de tests permettant la validation de conformité d'un système aux politiques de sécurité

Dates: 2005-2007

Funded by: national funding : ANR/Technologies Logicielles (RNTL)

Partners: Gemalto, Leirios, Silicomp SA, LIFC, LIG, LORIA

Scientific leader: Bruno Legeard (Leirios)

Scientific leader for LIG: Marie-Laure Potet

Short description: The POSE project aimed at validating the conformance of a system with respect to a security policy. It built on a formal model of the secure system, with traceability to the initial security requirements. This model was expressed in the B language and supported validation activities such as refinement proofs and test generation. The role of LIG was to contribute to the formal activities of the project (modeling, proof and test generation).

Acronym: POLITESS

Project name: Politique de sécurité pour des systèmes d'information en réseau : modélisation, déploiement et test

Dates: 2005-2008

Funded by: national funding : ANR/Réseau National de Recherche en Télécommunications (RNRT)

Partners: France Télécom R& D, Leirios, SAP Research, Silicomp/AQL, GET, IRISA, LIG,

Scientific leader: Roland Groz

Short description: The POLITESS project investigated methods to ensure a correct implementation of security policies for distributed information systems. It addresses such systems as those built over web services. Several directions were developed and solutions were proposed for a variety of policy-related validation issues. All approaches have been based on policy modelling with formal notations. Starting from a formal policy, POLITESS investigated deployment techniques, monitoring and active conformance testing. LIG and Verimag were associated in this project, as in POTESTAT, to propose methods for test generation from logic and EBE (extended behavioural expressions) of security rules. We also proposed an approach to generate test purposes from OrBAC models of security policies.

Project name: Contract with FrSIRT

Dates: 2008

Funded by: industrial contract with FrSIRT

Partners: FrSIRT, LIG, Vérimag

Scientific leader: Jean-Luc Richier

Short description: The LIG (Mescal and VASCO teams) and Verimag laboratories are working with the FrSIRT company (Montpellier), now renamed VUPEN, in the domain of security testing. A bibliographic report has been written. A CIFRE thesis will start mid 2009.

5.1.3 Test assessment

Acronym: SIESTA

Project name: Automatisation du test des systèmes embarqués réalisés en SCADE et SIMULINK

Dates: 2008-2011

Funded by: national funding : ANR/Technologies Logicielles (RNTL)

Partners: Airbus France, Astrium Space Transportation, Hispano-Suiza, Turbomeca, Esterel Technologies, CEA-LIST, LCIS, LIG, LRI, ONERA

Scientific leader: Ioannis PARISSIS

Short description: Thanks to the automatic generation of executable code from graphical languages (SCADE or SIMULINK), the development cycle of embedded systems has been considerably reduced in recent years. SIESTA studies the improvement of the testing process with the aim to automate the generation of tests and the evaluation of their quality. VASCO works on the definition of coverage criteria and testability metrics validation.

5.1.4 Other

Acronym: IPV6

Project name: Autoconfiguration et adressage dans les réseaux domotiques IPv6

Dates: 2005-2006

Funded by: industrial funding : France Télécom

Partners: IRISA, LIG

Scientific leader: Jean Luc RICHIER

Short description: This work (2005 - 2006) is a collaboration between France-Télécom, Irisa and LIG on the transition of Internet to IPv6. It allowed to validate the DSTM protocol (Dual Stack Transition Mechanism), proposed jointly by LIG and Enst-Bretagne. This work has taken place within the collaboration of LIG teams VASCO and Drakkar.

5.2 Research Networks (European, National, Regional, Local)

5.2.1 TAROT

Acronym: TAROT

Project name: Training And Research On Testing

Dates: 2005-2008

Funded by: European funding: Marie Curie Research and Training Network/FP6

Partners: Brunel University, CNR, Fraunhofer FOKUS, GET/INT, Radboud Universiteit Nijmegen, Tomsk State University, Univ. Bordeaux I, Univ. Complutense of Madrid, Univ. Evry, Univ. Göttingen, Univ. Joseph Fourier (LIG)

Scientific leader: Ana Cavalli (GET/INT)

Scientific leader for LIG: Farid Ouabdesselam

Short description: The TAROT Marie-Curie Network aimed at encouraging common research between European teams working on different aspects of software testing as well as researchers mobility. The LIG organized one of the four summer school editions of the network (2007, Grenoble, over 40 participants). Ioannis Parissis visited ISTI-CNR, during the academic period 2006-2007 (sabbatical) and started a common research activity with the the Software Engineering Lab (Antonia Bertolino, TAROT partner) on Web Services Testing. Finally, a new PhD student, Virginia Papailiopolou, was recruited.

5.2.2 Cluster ISLE

Acronym: ISLE

Project name: Informatique, Signal, Logiciel Embarqué

Dates: 2007-2010

Funded by: Rhône-Alpes Region

Partners: 50 laboratories in Rhône-Alpes

Scientific leader: Yves Ledru

Short description: ISLE is a regional cluster dedicated to Informatics, Signal processing, and Embedded software. It groups about 570 permanent researchers or professors from 50 labs of the Rhône-Alpes region. It is structured into 8 working groups which address a wide variety of research subjects (Embedded software, High performance computing, Web Intelligence, e-learning, Bio-informatics, Imaging, Signal processing for safety, Computer science for health). It receives 8 research grants and 365kEUR every year from the Rhône-Alpes Region. The VASCO team participates to this cluster, through the Embedded software working group, and Yves Ledru is heading the whole cluster and in charge of its overall scientific animation.

5.3 Internal Funding

Project name: IPOTEST

Dates: 2008-2009

Funded by: Université Joseph Fourier/pôle MSTIC

Partners: ADELE and VASCO teams of LIG

Scientific leader: Jacky Estublier and Yves Ledru

Short description: iPOTest is a joint project of the ADELE and VASCO teams, supported by the Université Joseph Fourier. It addresses the test of home automation systems based on a service oriented architecture. The ADELE team has developed iPOJO, a technology which embeds java classes into OSGi services, and applied this technology to the field of home automation. The iPOTest project aims at automating test generation for iPOJO services, and to adapt oracle technologies based on JML to this technology.

Acronym: Vulcain

Project name: Vulnérabilités : caractérisation et inférences

Dates: 2009-2010

Funded by: Université Joseph Fourier/pôle MSTIC

Partners: LIG, Vérimag

Scientific leader: Jean-Luc Richier

Short description: The project objective is to provide automated techniques to aid the detection of security vulnerabilities in a “classical” environment. The project aims to find vulnerabilities in an application and characterizes their activation. Different approaches are used, according to the information available (black-box approach with learning, white-box approach with analysis of code, ...). The project is supported by the MSTIC programme of University Joseph Fourier (2009–2010).

6 Principal International collaborations

6.1 PHC SAKURA (2007-2008), with Kobe University (M. Nakamura, Japan)

Project name: Assessing Safety and Security for Ubiquitous / Pervasive Services

Dates: 01/2007 -12/2008

Funded by: Egide

Partners: Nara and Kobe Universities

Scientific leader: L. du Bousquet

Short description: The goal of the project is to establish a formal framework to verify and validate safety and security of ubiquitous/pervasive services. For every service given, the framework automatically proves if the service is surely safe and secure based on mathematical and logical foundations. This framework is based on the usage of the Java Modelling Language (JML), that is used to insert executable assertions in the Java code of the home services. Those assertions can then be used for off-line or on-line testing, verification by proof or on-line monitoring. Besides the validation framework, a method has been proposed to capture risks (potential accident) and their associated cause-effect chain. It is expected to help the derivation of safety analysis. It is planned to develop and experiment this method in the next three years (proposition of a CNRS PICS project in submission).

6.2 PHC AURORA (2009-2010), with Simula (L. Briand, Norway)

Acronym: COST

Project name: Cost-effectiveness of Software Testing

Dates: 01/2009 -12/2010

Funded by: Egide

Partners: Simula Labs

Scientific leader: L. du Bousquet

Short description: In the foreseeable future, software testing will remain one of the best tools we have at our disposal to ensure software dependability. However, testing is generally expensive and often consumes around half of software development resources. It is therefore necessary to provide methods and tools to predict the cost of testing as early as possible in the development process, so that resources can be planned and used efficiently. Empirical studies are crucial to software testing research in order to compare and improve software testing techniques and practices. One objective of the project is to propose an operational, experimental framework to guide the evaluation of the cost-effectiveness of the testing methods. The main idea is to carry several empirical studies, under different conditions, with different testing strategies, and determine for each its cost-effectiveness and costs (there are several way to evaluate the cost of a testing technique). The effective testing costs will then be compared to several existing predictive measures, in order to determine the most adequate ones with respect to the testing strategies.

6.3 Collaboration with CRIM (Montreal)

Funded by: CRIM, UJF and GINP (salary for invited professors/researchers)

Partners: Centre de Recherches Informatiques de Montréal

Short description: Our team has collaborated with Alexandre Petrenko from CRIM throughout the period. A. Petrenko was associated to the method defined in A. Kermarrec's PhD work. We later worked on a method to identify sporadic errors in systems based on asynchronous communication of components. This uses a combination of model inference (on LTS models), testing and reachability analysis. Alexandre Petrenko spent a total of 4 months in Grenoble in 2006 and 2007 as invited professor. Another collaboration with Alexandre Petrenko addresses the prioritisation of test suites on the basis of string distances. Yves Ledru spent one month at CRIM in Montreal (june 2006) to work on this research topic.

7 Visibility, Scientific and Public Prominence

This section only refers to the members of VASCO on January 1st 2009. In particular, we omit to list responsibilities related to Didier Bert, Marie-Laure Potet and Ioannis Parissis.

7.1 Contribution to the Scientific Community

Management of Scientific Organisations

- Yves Ledru is director of the *CNRS GDR Génie de la Programmation et du Logiciel* (national research group on programming languages and software engineering), since 2008.
- Yves Ledru is head of the regional *ISLE cluster*, which groups 570 permanent researchers and professors from 50 laboratories, on the topics of Informatics, Signal processing, and Embedded Software.
- Farid Ouabdesselam was director of the LSR Laboratory (UMR 5526), 2005-2006, and adjoint-director of LIG, 2007.

Editorial Boards

- *Technique et Science Informatiques*, Yves Ledru, member of the comité de rédaction, 2008-09.
- *Annals of Telecommunications*, Roland Groz, member of the scientific board, 2005-2009.

Organisation of Conferences and Workshops

- *Colloque Francophone sur l'Ingénierie des Protocoles (CFIP 2008)*, Roland Groz, programme co-chair, Jean-Luc Richier, member of the organizing committee, 2008.
- *International Conference on Feature Interactions in Software and Communication Systems (ICFI)*, Jean-Luc Richier (member of the organizing committee and co-publisher of the proceedings), Lydie du Bousquet (member of the organizing committee, co-chair and co-publisher of the proceedings) and Farid Ouabdesselam (member of the organizing committee and co-chair).

- *Premières journées nationales du GDR Génie de la Programmation et du Logiciel*, Yves Ledru, programme committee chair, Toulouse, 2009.
- *IEEE/ACM International Conferences on Automated Software Engineering (ASE)*, Yves Ledru, steering committee chair 2001-2007, steering committee member 2008-2009.
- *Third International Workshop on Software Quality Assurance (SOQUA2006)*, Yves Ledru, programme committee co-chair, Portland (OR, USA), 2006, steering committee member 2005-2007.
- *TestCom - International Conference on Testing of Communicating Systems*, Roland Groz, Steering Committee member 2005-2009.
- *International Workshop on Software Quality Assurance (SOQUA)*, Yves Ledru, Programme co-Chair 2006.

Program committee members

International programme committees

- *International Conference on Feature Interactions in Software and Communication Systems (ICFI)*, Jean-Luc Richier, 2007, 2009.
- *International Conference on Feature Interactions in Software and Communication Systems (ICFI)*, Lydie du Bousquet, 2007, 2009.
- *International Conference on Feature Interactions in Software and Communication Systems (ICFI)*, Farid Ouabdesselam, 2007.
- *International Conference on Software Engineering Advances (ICSEA)*, Lydie du Bousquet, 2007, 2008, 2009.
- *International Conference on software and Data Technologies (ICSOFT)*, Lydie du Bousquet, 2008, 2009.
- *International Conference on Software Testing Verification and Validation (ICST)*, Lydie du Bousquet, 2009.
- *International Conference on Advances in System Testing and Validation Lifecycle (VALID)*, Lydie du Bousquet, 2009.
- *IEEE/ACM International Conferences on Automated Software Engineering (ASE)*, Yves Ledru, programme committee member 2005 and 2009, expert review pannel member, 2006, 2007, 2008.
- *16th International Symposium on Formal Methods (FM2009)*, Yves Ledru, 2009.
- *Z conferences (ZB 2005, ZUM 2006 and 2007, ABZ 2008)*, Yves Ledru.
- *Workshop On Leveraging Applications of Formal Methods, Verification and Validation (ISOLA)*, Yves Ledru, 2007.
- *International Conference on Formal Engineering Methods*, Yves Ledru, 2005.
- *European Congress Embedded Real-Time Software (ERTS)* Yves Ledru, 2008.
- *International Workshop on Software Quality Assurance (SOQUA)*, 2005 and 2007.
- *Australian Software Engineering Conference (ASWEC)*, Yves Ledru, 2009.
- *Interdisciplinary Workshop Regulations Modelling and Deployment (REMOD)*, Yves Ledru, 2008.
- *International Workshop on Regulations Modelling and their Validation & Verification (REMO2V)*, Yves Ledru, 2006.
- *A-MOST - Workshop on Advances in Model baSed Testing*, Roland Groz, 2007, 2008, 2009.
- *ICNP06 - International Conference on Network Protocols*, Roland Groz, 2006.
- *ICST08 - International Conference on Software Testing*, Roland Groz, 2008.
- *SecTest08 - Workshop on Security Testing*, Roland Groz, 2008.
- *TestCom - International Conference on Testing of Communicating Systems*, Roland Groz, 2005-2009.
- *MoDeVVa 2009 Workshop on Model-Driven-Engineering, Verification and Validation*, German Vega, 2009.

National programme committees

- *Conférence sur la Sécurité des Architectures Réseaux et des Systèmes d'Information (SAR SSI)*, Jean-Luc Richier, member of the program committee, 2009; Roland Groz 2008, 2009.
- *Approches Formelles dans l'Assistance au Développement de Logiciels (AFADL)*, Yves Ledru, programme committee member 2006, 2007, 2009; Roland Groz 2009.
- *Conférence Francophone sur les Architectures Logicielles (CAL)*, Yves Ledru, programme committee member, 2006, 2008, 2009.
- *Conférence Francophone sur les Langages et Modèles à Objets (LMO)*, Yves Ledru, 2009.
- *INFormatique des ORganisations et Systèmes d'Information et de Décision (INFORSID)*, Yves Ledru, 2007.
- *Colloque Francophone sur l'Ingénierie des Protocoles*, Roland Groz, 2005, 2006, 2008, 2009.

International expertise

- *FP6, IST, Research Networking Testbeds*, Jean-Luc Richier, expert for Call 5 (October 2006).
- *FP6, IST*, Jean-Luc Richier, expert for project review (june 2005, september 2006).
- *Natural Sciences and Engineering Research Council of Canada (NSERC)*, Yves Ledru, expert, 2007.
- Yves Ledru : reviewer for the following journals ACM Transactions on Software Engineering Methodology (ACM), Journal of Automated Software Engineering (Kluwer/Springer), Information and Software Technology (Elsevier), Empirical Software Engineering (Springer).

National expertise

- Designated member of the Conseil National des Universités (CNU), section 27, Lydie du Bousquet, 2009-.
- *AERES*, Yves Ledru, member of the visiting committee of VALORIA (2007), LORIA (2008), LRI (2009).
- *Imaginove competitiveness cluster*, Yves Ledru, member of the scientific board.
- *Réseau National des Technologies Logicielles (RNTL)*, Evaluation committee, Roland Groz, 2005.
- *Jury for the Prime d'Encadrement Doctoral et de Recherche*, Roland Groz, member 2006; Yves Ledru, member 2007.
- Expert for the Mission Scientifique Technique Pédagogique - DSPT 9 - Stic of the Ministère Délégué à la Recherche et aux Nouvelles Technologies, Yves Ledru, 2003-2007.
- Member of the Selection Committee of Univ. Paris 12 for 2 professor positions, Yves Ledru, 2009.
- Member of the Commission de Spécialistes of Univ. Paris Sud (Orsay), Yves Ledru, 2007.
- Member of the Commission de Spécialistes of Univ. of Franche-Comté, Catherine Oriat, 2005-2008.

Local expertise

- Jean-Luc Richier has been member of a selection committee for Grenoble INP (2009).
- Roland Groz has been member of a selection committee for Grenoble INP (2009).
- *Commission de spécialistes 27 INP Grenoble*, Catherine Oriat, 2005-2008.
- *Commission de spécialistes 27 UJF*, Yves Ledru (substitute member), 2005-2008.

7.2 Prizes and Awards

Personal Awards

- Yves Ledru: “ASE Fellow for outstanding scientific and service contributions to the Automated Software Engineering Community”, by the steering committee of the IEEE/ACM International Conferences on Automated Software Engineering, 2008.

7.3 Public Dissemination

- Jean-Luc Richier has been member of the administration board of the association G6 for promoting IPv6 until june 2006.
- Interview of Roland Groz to present LIG in the special issue of Le Journal des Entreprises, Isère avril 2007 on embedded systems.

8 Software and Research Infrastructure

Software Publication

TOBIAS, software, combinatorial test input generator based on the unfolding of a test pattern, proprietary software (UJF), licensed for research and teaching purposes to Engineering College of Aarhus (Denmark), Sanaga Labs Softwareentwicklung GmbH (Austria), Université de Franche-Comté

Referenced by APP : P. Bontron, L. du Bousquet, Y. Ledru, and O. Maury. TOBIAS. Référencement par l'Agence de Protection des Programmes sous le No IDDN.FR.001.230021.000.R.P.2005.000.10600, déposé par l'Université Joseph Fourier, 2005

RoZ, scripts for Rational Rose, translation of UML specifications into Z, distributed for research and teaching purposes to 21 researchers around the world. It is also used for teaching purposes at Master's level.

Lutess, Lutess is a testing environment for synchronous reactive software. It produces automatically and dynamically test data with respect to some environment constraints of the program under test. It offers several specification-based testing methods, which aim at simulating more realistic environment behaviors. Lutess is distributed with the SIESTA project consortium.

Jartege Jartege (Java Random Test Generator) is a tool which allows random generation of unit tests for Java classes specified in JML [75]. Jartege can be downloaded freely, and has been used in several places such as Technische Univ. Graz (Austria), Technische Univ. Dresden (Germany), and Univ. of Western Ontario (Canada).

RALT, Rich Automata Learning and Testing, was developed by Muzammil Shahbaz in our collaboration with Orange Labs. Both partners intend to distribute it as Open Source, as extensions might be developed by other parties.

9 Educational Activities

Supervision of Educational Programs

(by members of the team)

- Paul Jacquet: President, 2003-2007, then “Administrateur General”, 2008-2009, of Grenoble INP
- Farid Ouabdesselam: President of Université Joseph Fourier, 2007-2009
- Yves Ledru: Chair of the Commission HDR Informatics and Applied Mathematics, UJF, 2008-09
- Roland Groz: in charge of the ARR (Applications Réparties et Réseaux) option of the Telecom school 2005-2008
- Roland Groz: co-leader of the Telecom “filrière” (M1+M2) for Ensimag and Phelma 2008-2009
- Lydie du Bousquet: in charge of the apprentice section of the Professional Master “Génie Informatique”, UJF, 2007-2009.

Teaching

Name	Position	Year	Number of hours to teach	Academic Program	University
Lydie du Bousquet	MCF	2005-2009	210/year	L1-L2, M1, M2, Polytech'Grenoble 2 and 3	UJF
Roland Groz	PR INP	2005-09	220/year	L3, M1, M2 (1A-3A) Ensimag, 1A Phelma	Grenoble INP
Akram Idani	MCF INP	2008-2009	192/year	(2A, 3A) ENSIMAG	Grenoble INP
Yves Ledru	PR UJF	2005-09	230/year	M1Miage, M2P, M2R, Polytech'Grenoble 2 and 3	UJF
Catherine Oriat	MCF	2005-2009	230/year	ENSIMAG	Grenoble INP
Farid Ouabdesselam	PR	2005-2007	96/year	L1, M2P, Polytech'Grenoble 3	UJF
Jean-Luc Richier	CR CNRS	2005-2009	40/year	M2P, Polytech'Grenoble 3	UJF
German Vega	IR CNRS	2006-2008	30/year	M2MIAGE, M2P, M2R	UJF

10 Industrialization, patents and technology transfer

Patents (French, European and WorldWide)

Consulting Activities

- Roland Groz, Jean-Luc Richier: FrSirt. A contract for writing a report on research in this domain was executed in november-december 2008.

- Roland Groz, Lydie du Bousquet: Planck satellite [http://fr.wikipedia.org/wiki/Planck_\(satellite\)](http://fr.wikipedia.org/wiki/Planck_(satellite)), <http://smc.cnes.fr/PLANCK/Fr/> For the first half of 2005, Roland Groz and Lydie du Bousquet advised the LPSC Lab (Laboratoire de Physique Subatomique et de Cosmologie) for the software tests to be done on the control of the cryogenic part of the Planck satellite.

11 Self-Assessment

VASCO is going through a significant transition period. Due to various reasons (retirements, promotions, change of laboratory), its number of active researchers was nearly divided by two, and the research activities of the team were refocused on two main topics : modelling and test. Despite this transition, our scientific production has increased compared to the previous 4-year period, e.g. between 2005 and 2008, we published 5 papers in international journals and 8 in national ones compared to 3 international and 6 national ones between 2001 and 2004. Moreover, the smaller size of the team favours the participation of most members to several projects with both modelling and testing dimensions (e.g. iPOTest and Selkis), which increases the cohesion of the team.

One of the strong points of VASCO is its involvement in national ANR projects, which reflect the national significance of the team in the areas of testing and integration of formal and graphical specifications. VASCO plays a leading national role in software engineering with a strong involvement in the GDR GPL.

The team has also international visibility through recurrent participation in steering and programme committees of international conferences, and participation in a european working group on testing. This visibility has contributed to attract international post-docs from the USA and China.

A large majority of the funding of VASCO (PhD grants, post-docs, travel budgets) comes from our projects. This requires to submit projects on a regular basis, but also to dedicate most of our research efforts to these projects. As a result, we are not always masters of our future: some of our long term research goals may be discontinued, depending on the results of the submissions, and new research topics may appear due to external solicitations.

Although several VASCO members have international visibility, this can be significantly improved. A reasonable objective is to increase our publications in top international conferences and journals, and to participate to more international projects. At longer term, our ambition should be to increase the international visibility of VASCO as a team, and not only as the result of the visibility of its individuals.

Finally, although VASCO has developed significant software tools, which are at the heart of our research projects and have already been used outside our team, further effort is needed to get more value and impact from these research efforts, and care should be taken to bring these tools to a wider research community. This progress may only result from planned and dedicated efforts.

12 Perspectives for the research team

Modelling and test will remain the major axes of the team and we hope that the team will keep the balance between these axes, and will grow by hiring new permanent researchers and professors for both. Our researches contribute to the development of higher quality software, especially regarding safety and security, and therefore contribute to the “Sustainable ambient computing” project of the LIG.

We foresee several major research directions for the coming years: modelling based on integrated formalisms, reverse engineering of specifications based on testing techniques, and test and feature interaction detection in home automation systems.

Modelling based on integrated formalisms builds on the successes and experience of our RoZ and B2UML tools. Our project is to take into account recent evolutions and needs related to this research. In particular, there is a significant need for more flexible transformation frameworks. Such frameworks should allow user-defined rules, or rules adapted to specific kinds of analyses, and the opportunity to tailor the choice of translation rules to each model, e.g. to take into account the size of the model and choose adequate structuration. Also, VASCO’s research privileges the use of animation techniques to validate such models, with the challenge of being able to animate realistic size models. This research will build on the advances of Model-Driven Engineering, which is now able to provide industrial software tools for model transformations. These researches have already begun in 2009, with two PhD theses and the start of the ANR Selkis project. It is part of the “Security, Safety, Reliability” challenge of the LIG scientific project.

Reverse engineering of specifications based on testing techniques This research has already started in 2009 with one PhD thesis, that will extend, assess and confort the work already done around the RALT tool. It is part of the “Security, Safety, Reliability” challenge of the LIG scientific project, but also contributes to the “Embedded Systems” challenge. Two major directions for extension and application of the technique have already been identified:

- Security: retrieval of models of software to target specific states for vulnerability analysis.

- Integration testing of black box components. As integration is becoming a major orientation for the (software) industry in France, we aim at providing methodological elements on top of a tool to support the validation of integrated systems.

Test and feature interaction detection in home automation systems It is part of the “Intelligent Building”, “Security, Safety, Reliability”, and “Embedded Systems” challenges of the LIG scientific project. A new PhD thesis has just begun on this topic, to investigate, in collaboration with the LCIS laboratory (ESISAR/Valence), the validation of domotic services. In contrast to the approach followed in iPOTest where we instrument the services to validate, we shall investigate a complementary approach focusing on the environment of the services to be validated. To address the complexity of dynamic services and configurations, simulation of the (software) environment will be a major element of the validation approach. We shall also investigate methodologies for validation in that context, combining various techniques (model based testing, model-checking, stochastic analysis, model transformations etc), as well as linking to risk-based analysis of systems and their safety and security properties. This latter aspect will also be studied within the current PHC Aurora project with Simula and NTNU Labs in Norway.

Test of security policies and Combinatorial testing are both part of the “Security, Safety, Reliability” challenges of the LIG scientific project. Several current projects are concerned with these topics: Vulcain/FrSirt dedicated to the identification of vulnerabilities in software, Selkis dedicated to the modelling and validation of security policies, and the recently accepted TASCOC project dedicated to the test of smartcards. These projects have two major objectives: to improve testing techniques which are helpful in the context of security testing, and to develop new testing techniques specific to the field of security.

Other research themes, such as testability, test of reactive or interactive systems, remain of interest for VASCO and perspectives for each of them have been discussed in Section 3. But they require to attract new PhD students or success in the submission of new projects.

Finally, a dedicated effort will be undertaken in order to get more impact out of our tools. The mature tools will be available through the team’s website, under various usage or licensing schemes.

13 Publications

International peer reviewed journal [ACL]

2009

- [1] L. du Bousquet, Y. Ledru, O. Maury, C. Oriat, and J.-L. Lanet. Reusing a JML specification dedicated to verification for testing, and vice-versa: case studies. *Journal of Automatic Reasoning, Springer, To appear, 2009.*
- [2] L. du Bousquet, M. Nakamura, B. Yan, and H. Igaki. Using formal methods to increase confidence in a home network system implementation: a case study. *Innovations in Systems and Software Engineering, 5(3), Sept. 2009.*
- [3] A. Idani, J.-L. Boulanger, and L. Philippe. Linking paradigms in safety critical systems. *International Journal of Computers and their Applications (IJCA), Special Issue on the Application of Computer Technology to Public Safety and Law Enforcement, 16(2):111–120, June 2009.*
- [4] I. Parissis and L. Madani. Automatically testing interactive applications using extended task trees. *Journal of Logic and Algebraic Programming, To appear, 2009.*

2008

- [5] A. Lakehal and I. Parissis. Structural coverage criteria for LUSTRE/SCADE programs. *Software Testing, Verification and Reliability, Wiley Interscience, June 2008.*
- [6] B. Yan, M. Nakamura, L. du Bousquet, and K.-i. Matsumoto. Validating Safety for Integrated Services of Home Network System Using JML. *Journal of Information Processing (IPSJ), 16:38–49, 2008.*

2007

- [7] A. Idani and Y. Ledru. Object Oriented Concepts Identification from Formal B Specifications. *International Journal of Formal Methods in System Design, Springer, 30(3):217–232, juin 2007.*

2006

- [8] A. Idani and Y. Ledru. Dynamic Graphical UML Views from Formal B Specifications. *Int. Journal of Information and Software Technology*, 48(3):154–169, Mar. 2006.
- [9] R. Laleau, S. Vignes, Y. Ledru, M. Lemoine, D. Bert, V. Donzeau-Gouge, C. Dubois, and F. Peureux. Adopting a situational requirements engineering approach for the analysis of civil aviation security standards. *Software Process: Improvement and Practice (SPIP)*, 11(5):487–503, 2006.

International peer-reviewed conference proceedings [ACT]

2009

- [10] L. du Bousquet, A. Rajan, C. Oriat, J.-L. Richier, and G. Vega. Service specification and validation in the context of the home. In *10th International Conference on Feature Interactions (ICFI 2009)*, pages 207–219, Lisbon, Portugal, June 2009. IOS Press.
- [11] A. Idani. UML models engineering from static and dynamic aspects of formal specifications. In *14th International Conference on Exploring Modeling Methods for Systems Analysis and Design ; co-located with CaiSE'2009, Springer, LNBIP*, volume 29, pages 237–250, Amsterdam, The Netherlands, June 2009.
- [12] Y. Ledru, A. Petrenko, and S. Boroday. Using String Distances for Test Case Prioritisation. In J. Grundy, M. Heimdahl, and G. Taentzer, editors, *24th IEEE/ACM International Conference on Automated Software Engineering (ASE 2009), short paper (5 pages), November 16-20, 2009, Auckland, New Zealand*. IEEE, 2009.
- [13] I. Parissis, V. Papailiopoulou, and B. Seljimi. Revisiting the Steam-Boiler Case Study with Lutess : Modeling for Automatic Test Generation. In *12th European Workshop on Dependable Computing*, Toulouse, France, 2009.
- [14] M. N. Qamar. Analysis and Composition of Multiple Aspects in Aspect Oriented Programs. In *16th IEEE Asia-Pacific Software Engineering Conference*. IEEE Computer Society, Dec. 2009.
- [15] M. Shahbaz and R. Groz. Inferring Mealy Machines. In *Formal Methods 2009*, Eindhoven, Netherland, Nov. 2009.
- [16] M. R. Shaheen and L. du Bousquet. Analysis of the introduction of testability antipatterns during the development process. In *Fourth International Conference on Software Engineering Advances ICSEA*, Porto, Portugal, Sept. 2009. IEEE.
- [17] M. R. Shaheen and L. du Bousquet. Is Depth of Inheritance Tree a Good Cost Prediction For Branch Coverage Testing? In *First International Conference on Advances in System Testing and Validation Lifecycle VALID*, Porto, Portugal, Sept. 2009. IEEE.

2008

- [18] V. Darmaillacq, J.-L. Richier, and R. Groz. Test generation and execution for security rules in temporal logic. In *First International Workshop on Security Testing, a satellite event of ICST 2008, April 9-11, 2008, Lillehammer, Norway*, Apr. 2008.
- [19] L. du Bousquet and M. Delaunay. Towards Mutation Analysis for Lustre Programs. In *Electr. Notes Theor. Comput. Sci.*, volume 203, pages 35–48, 2008.
- [20] L. du Bousquet and M. R. Shaheen. Relation between Depth of Inheritance Tree and Number of Methods to Test. In *First International Conference on Software Testing, Verification, and Validation, ICST 2008*, pages 161–170, Lillehammer, Norway, Apr. 2008. IEEE Computer Society.
- [21] Y. Falcone, L. Mounier, J.-C. Fernandez, and J.-L. Richier. j-POST: a Java Toolchain for Property-Oriented Software Testing. In *Fourth Workshop on Model-Based Testing (MBT'08), a satellite event of ETAPS'08, March 29 - April 6, 2008, Budapest*, volume 220(1) of *Electronic Notes in Theoretical Computer Science*, pages 29–41. Springer, Mar. 2008.
- [22] L. Ferro, L. Pierre, Y. Ledru, and L. du Bousquet. Generation of test programs for the assertion-based verification of TLM models. In *Design and Test Workshop, 2008. IDT 2008. 3rd International*, pages 237–242. IEEE, Dec. 2008.

- [23] R. Groz, K. Li, A. Petrenko, and M. Shahbaz. Modular System Verification by Inference, Testing and Reachability Analysis. In K. Suzuki, T. Higashino, A. Ulrich, and T. Hasegawa, editors, *Testing of Software and Communicating Systems, 20th IFIP TC 6/WG 6.1 International Conference, TestCom 2008, 8th International Workshop, FATES 2008, Tokyo, Japan, June 10-13, 2008*, volume 5047 of *Lecture Notes in Computer Science*, pages 216–233. Springer, 2008.
- [24] A. Idani and B. Coulette. Towards reverse-engineering of UML views from structured formal developments. In *10th International Conference on Enterprise Information Systems (ICEIS'08)*, pages 94–103, Spain, 2008.
- [25] L. Madani and I. Parissis. Automated Test of Interactive Applications Using Task Trees. In *4th Workshop on Advances in Model-based Testing (A-MOST 2008)*, pages 13–22, Lillehammer, Norway, 2008.
- [26] V. Papailiopoulou, L. Madani, L. du Bousquet, and I. Parissis. Extending Structural Test Coverage Criteria for Lustre Programs with Multi-clock Operators. In *13th International Workshop on Formal Methods for Industrial Critical Systems (FMICS 2008)*, L'Aquila, Italy, 2008.
- [27] M. R. Shaheen and L. du Bousquet. Quantitative analysis of testability antipatterns on open source Java applications. In *12th ECOOP Workshop on Quantitative Approaches on Object Oriented Software Engineering*, 2008.

2007

- [28] A. Bertolino, E. Marchetti, and I. Parissis. Perspectives on Data Flow-based Validation of Web Services Compositions. In *3rd Workshop on the Role of Software Architecture for Testing and Analysis (ROSATEA)*, Boston, USA, July 2007.
- [29] S. Boroday, A. Petrenko, and R. Groz. Can a Model-Checker generate Tests for Non-Deterministic Systems. In *Third Workshop on Model-Based Testing (MBT)*, pages 3–19, Braga, Portugal, Mar. 2007.
- [30] J. Bouchet, L. Madani, L. Nigay, C. Oriat, and I. Parissis. Formal Testing of Multimodal Interactive Systems. In *Engineering Interactive Systems (EIS'07)*, pages 36–52, 2007.
- [31] S. Boulmé. Intuitionistic Refinement Calculus. In *Proc. of International Conference on Typed Lambda Calculi and Applications (TLCA 2007)*, LNCS 4583, Paris, juin 2007. Springer-Verlag.
- [32] S. Boulmé and M.-L. Potet. Interpreting invariant composition in the B method using the Spec# ownership relation: a way to explain and relax B restrictions. In *Proc. of Formal Specification and Development in B, 7th International Conference of B Users (B2007) LNCS 4355*, pages 4–18. Springer-Verlag, Jan. 2007.
- [33] J.-F. Couchot and F. Dadeau. Guiding the Correction of Parameterized Specifications. In J. Davies and J. Gibbons, editors, *7th Int. Conf. on Integrated Formal Methods (IFM'2007)*, pages 176–194, Oxford, UK, July 2007. Springer.
- [34] F. Dadeau, Y. Ledru, and L. du Bousquet. Directed random reduction of combinatorial test suites. In *RT'07: Proceedings of the 2nd international workshop on Random testing*, pages 18–25, New York, NY, USA, 2007. ACM.
- [35] F. Dadeau, Y. Ledru, and L. du Bousquet. Measuring a Java Test Suite Coverage using JML Specifications. In *Third Workshop on Model-Based Testing (MBT)*, Braga, Portugal, Mar. 2007.
- [36] L. du Bousquet and M. Delaunay. Towards mutation analysis for LUSTRE programs. In *Proc. of Model-driven High-level Programming of Embedded Systems (SLA++P)*, Braga, Portugal, Mar. 2007.
- [37] L. du Bousquet and M. Delaunay. Using mutation analysis to evaluate test generation strategies in a synchronous context. In *Proceedings of the Second International Conference on Software Engineering Advances (ICSEA 2007)*, pages 40–45, Esterel, France, Aug. 2007. IEEE.
- [38] L. du Bousquet, Y. Ledru, F. Dadeau, and F. Allouti. A Case Study in Matching Test and Proof Coverage. In *Third Workshop on Model-Based Testing (MBT)*, Braga, Portugal, Mar. 2007.
- [39] L. du Bousquet, M. Nakamura, B. Yan, and H. Igaki. Using Formal Methods to Increase Confidence in one Home Network System Implementation. Case Study. In *ISoLA 2007, Workshop on Leveraging Applications of Formal Methods, Verification and Validation*, Poitiers, France, Dec. 2007.
- [40] Y. Falcone, J.-C. Fernandez, L. Mounier, and J.-L. Richier. A Compositional Testing Framework Driven by Partial Specifications. In A. Petrenko, M. Veanes, J. Tretmans, and W. Grieskamp, editors, *Testing of Software and Communicating Systems, 19th IFIP TC6/WG6.1 International Conference, TestCom 2007, 7th International Workshop, FATES 2007, Tallinn, Estonia, June 26-29, 2007*, volume 4581 of *Lecture Notes in Computer Science*, pages 107–122. Springer, 2007.

- [41] A. Idani, J.-L. Boulanger, and L. Philippe. A generic process and its tool support towards combining UML and B for safety critical systems. In *Proceedings of 20th International Conference on Computer Applications in Industry and Engineering (CAINE'2007)*, pages 185–192, USA, Nov. 2007. ISCA.
- [42] A. Idani, D.-D. Okalas Ossami, and J.-L. Boulanger. Commandments of UML for safety. In *2nd IEEE International Conference on Software Engineering Advances (ICSEA'2007)*, France, Aug. 2007. IEEE CS Press.
- [43] A. Lakehal and I. Parissis. Automated Measure of Structural Coverage for Lustre/Scade Programs: a Case Study. In *Workshop on Automated Software Testing (AST 2007) - satellite event of ICSE 2007*, Minnesota, USA, May 2007.
- [44] R. Laleau, S. Vignes, Y. Ledru, M. Lemoine, D. Bert, V. Donzeau-Gouge, C. Dubois, and F. Bouquet. Using Computer Science Modeling Techniques for Airport Security Certification. In *Proc. of the First International Conference on Research Challenges in Information Science*, Ouarzazate, Maroc, Apr. 2007.
- [45] K. Li, L. Mounier, and R. Groz. Test Generation from Security Policies Specified in Or-BAC. In *COMPSAC - IWSSE Workshop (IEEE International Workshop on Security in Software Engineering)*, pages 255–260, Beijing, July 2007.
- [46] B. Seljimi and I. Parissis. Automatic generation of test data generators for synchronous programs: Lutess V2. In *DOSTA'07: Workshop on Domain Specific Approaches to Software Test automation*, pages 8–12, Dubrovnik, Croatia, Sept. 2007.
- [47] M. Shahbaz and R. Groz. Using Invariant Detection Mechanism in Black Box Inference. In Y. Ait Ameer, F. Boniol, and V. Wiels, editors, *ISO/FA 2007, Workshop On Leveraging Applications of Formal Methods, Verification and Validation*, pages 215–222, Poitiers, France, Dec. 2007.
- [48] M. Shahbaz, K. Li, and R. Groz. Learning and Integration of Parameterized Components through Testing. In *TestCom-Fates'07, LNCS 4581*, pages 319–334, Tallinn, June 2007. Springer.
- [49] M. Shahbaz, K. Li, and R. Groz. Learning Parameterized State Machine Model for Integration Testing. In *COMPSAC - TEST Workshop (IEEE International Workshop on Testing Emerging Software Technology)*, pages 755–760, Beijing, July 2007.
- [50] M. Shahbaz, B. Parreaux, and F. Klay. Model inference approach for detecting feature interactions in integrated systems. In *International Conference on Feature Interactions in Software and Communication Systems, ICFI 2007*, pages 161–171, Grenoble, France, Sept. 2007. IOS Press.
- [51] N. Stouls and M.-L. Potet. Security Policy Enforcement Through Refinement Process. In *Proc. of Formal Specification and Development in B, 7th International Conference of B Users (B2007), LNCS 4355*, pages 216–231. Springer-Verlag, Jan. 2007.
- [52] B. Yan, M. Nakamura, L. du Bousquet, and K.-i. Matsumoto. Characterizing Safety of Integrated Services in Home Network System. In *5th International Conference On Smart Homes and Health Telematics (ICOST)*, volume 4541 of *Lecture Notes in Computer Science*, pages 130–140, Nara, Japan, June 2007. Springer.

2006

- [53] V. Darmaillacq, J.-C. Fernandez, R. Groz, L. Mounier, and J.-L. Richier. Test Generation for Network Security Rules. In M. Umit Uyar, A. Y. Duale, and M. A. Fecko, editors, *Testing of Communicating Systems, 18th IFIP TC6/WG6.1 International Conference, TestCom 2006, New York, NY, USA, May 16-18, 2006*, volume 3964 of *Lecture Notes in Computer Science*, pages 341–356. Springer, 2006.
- [54] L. du Bousquet. Evaluating Behavior Correctness of Synchronous Systems through Time to Service Distribution Analysis: Tools Required. In *International Conference on Software Engineering Advances (ICSEA'06)*, Papeete, Tahiti, French Polynesia, Nov. 2006. IEEE Computer Society.
- [55] Y. Falcone, J.-C. Fernandez, L. Mounier, and J.-L. Richier. A Test Calculus Framework Applied to Network Security Policies. In *Formal Approaches to Testing and Runtime Verification (FATES/RV'06), LNCS 4262*, pages 55–69, Seattle, USA, Aug. 2006.
- [56] A. Idani, Y. Ledru, and D. Bert. A Reverse-Engineering Approach to Understanding B Specifications with UML Diagrams. In *30th Annual IEEE/NASA Software Engineering Workshop (SEW-30)*, Loyola College Graduate Center, Columbia MD, USA, Apr. 2006. IEEE Computer Society Press.

- [57] F. Jourde, L. Nigay, and I. Parissis. Formal test of interactive systems: ICARE-Lutess / Test formel de systèmes interactifs multimodaux : couplage ICARE - Lutess. In *Proceedings of ICSSEA 2006, The 19th International Conference on Software & Systems Engineering and their Applications: Service & System globalization (Paris, France, December 5-7 2006)*, 2006. 8 pages.
- [58] Y. Ledru. Using Jaza to animate RoZ specifications of UML class diagrams. In *Proceedings of Int. Z User Meeting (ZUM'06)*, USA, Apr. 2006. IEEE Computer Society Press.
- [59] Y. Ledru, R. Laleau, M. Lemoine, S. Vignes, D. Bert, V. Donzeau-Gouge, C. Dubois, and F. Peureux. An attempt to combine UML and formal methods to model airport security. In N. Boudjlida and N. Guelfi, editors, *CAISE Forum 2006 - Proceedings of the Forum of the 18th International Conference on Advanced Information Systems Engineering*, pages 47–50, Presses universitaires de Namur, Luxembourg, juin 2006.
- [60] K. Li, R. Groz, and M. Shahbaz. Integration testing of components guided by incremental state machine learning. In *Testing Academic & Industrial Conference Practice And Research Techniques (TAIC PART)*, pages 59–70, Windsor, UK, Aug. 2006.
- [61] K. Li, R. Groz, and M. Shahbaz. Integration Testing of Distributed Components based on Learning Parameterized I/O Models. In *FORTE2006 Paris, LNCS 4229*, pages 436–450, Paris, Sept. 2006.
- [62] B. Seljimi and I. Parissis. Using CLP to Automatically Generate Test Sequences for Synchronous Programs with Numeric Inputs and Outputs. In *17th IEEE International Symposium on Software Reliability Engineering (ISSRE 2006)*, Raleigh, NC, USA, Nov. 2006.

2005

- [63] D. Bert, M.-L. Potet, and N. Stouls. GeneSyst: A Tool to Reason about Behavioral Aspects of B Event Specifications. Application to Security Properties. In *ZB2005 Conference*, pages 299–318. LNCS 3455, Springer-Verlag, 2005.
- [64] G. J. Doherty, L. du Bousquet, J. Creissac Campos, E. M. El Atifi, G. Falquet, M. Massink, and C. Santoro. Ambience and Mobility. In *Interactive Systems, Design, Specification, and Verification (DSV-IS'05)*, volume 3941 of *Lecture Notes in Computer Science*, pages 264–264, Newcastle upon Tyne, UK, July 2005. Springer.
- [65] L. du Bousquet and O. Gaudoin. Telephony feature validation against eventuality properties and interaction detection based on a statistical analysis of the time to service. In *Int. Conference on Feature Interactions in Telecommunications and Systems Software (FIW VIII)*, pages 78–95, Leicester, UK, June 2005. IOS Press.
- [66] S. Dupuy-Chessa, L. du Bousquet, J. Bouchet, and Y. Ledru. Test of the ICARE platform fusion mechanism. In *LNCS, 2005. 12th International Workshop on Design, Specification and Verification of Interactive Systems*.
- [67] D. Duval and J.-C. Reynaud. Diagrammatic logic and exceptions: an introduction. In *Proc. of the Dagstuhl Seminar 05021, Materials, Mathematics, Algorithms, Proofs*, Jan. 2005. <http://www.dagstuhl.de/05021/>.
- [68] A. Idani, Y. Ledru, and D. Bert. Derivation of UML Class Diagrams as Static Views of Formal B Developments. In *ICFEM'05 - Int. Conf. On Formal Engineering Methods*, pages 37–51, Manchester, Nov. 2005. LNCS 3785, Springer.
- [69] M. Kessiss, Y. Ledru, and G. Vandome. Experiences in Coverage Testing of a Java Middleware. In *Fifth Int. Workshop on Software Engineering and Middleware (SEM 2005)*, pages 39–45, Lisbonne, Sept. 2005. ACM.
- [70] A. Lakehal and I. Parissis. Lustructu: A Tool for the Automatic Coverage Assessment of Lustre Programs. In *16th IEEE International Symposium on Software Reliability Engineering (ISSRE 2005)*, Chicago, USA, Nov. 2005.
- [71] A. Lakehal and I. Parissis. Structural Test Coverage Criteria for Lustre Programs. In *10th International Workshop on Formal Methods for Industrial Critical Systems (FMICS 2005)*, pages 35–43, Lisboa, Portugal, Sept. 2005.
- [72] R. Laleau, S. Vignes, Y. Ledru, M. Lemoine, D. Bert, V. Viguié Donzeau-Gouge, C. Dubois, and F. Peureux. Application of Requirements Analysis Techniques to the analysis of civil aviation security standards. In *First International Workshop on Situational Requirements Engineering Processes (SREP'05)*, organized by *IFIP WG8.1 Method Engineering Task Group*, in conjunction with the *13th IEEE International Requirements Engineering Conference*, Paris, France, Aug. 2005.

- [73] L. Madani, L. Nigay, and I. Parissis. Testing the CARE properties of multimodal applications by means of a synchronous approach. In *Conference Proceedings of SE 2005, IASTED International Conference on Software Engineering*, pages 181–186, 2005.
- [74] L. Madani, C. Oriat, I. Parissis, J. Bouchet, and L. Nigay. Synchronous Testing of Multimodal Systems: an Operational Profile-Based Approach. In *Conference Proceedings of ISSRE 2005, 16th IEEE International Symposium on Software Reliability Engineering, Chicago, Illinois, USA.*, 2005.
- [75] C. Oriat. Jartege: A Tool for Random Generation of Unit Tests for Java Classes. In *2nd International Workshop on Software Quality (SOQUA 2005)*, pages 242–256, Erfurt, Germany, Sept. 2005. LNCS 3712, Springer.
- [76] V. Prevosto and S. Boulmé. Proof Contexts with Late Binding. In *Typed Lambda Calculi and Applications: 7th, TLCA'2005*, pages 324–338. LNCS 3461, Springer, 2005.
- [77] H. Ruíz Barradas and D. Bert. A Fixpoint Semantics of Event Systems with and without Fairness Assumptions. In *IFM 2005 Conference*, pages 327–346. LNCS 3771, Springer-Verlag, Nov. 2005.

Short communications [COM] and posters [AFF] in conferences and workshops

2009

- [78] A. Idani, Y. Ledru, and P.-Y. Schobbens. Approche formelle pour une Ingénierie des Modèles sûre. In *Atelier LMO/SafeModel*, Nancy, 2009.
- [79] M. N. Irfan. Heuristics for Improving Model Learning Based Software Testing. In *Testing: Academic and Industrial Conference - Practice and Research Techniques (TAIC PART 2009)*, Windsor, UK, Sept. 2009.

2008

- [80] V. Darmaillacq. Security policy testing using vulnerability exploit chaining. In *First International Workshop on Security Testing, a satellite event of ICST 2008, April 9-11, 2008, Lillehammer, Norway*, Apr. 2008.
- [81] V. Papailiopolou. Automatic Test Generation for LUSTRE/SCADE Programs. In *23rd IEEE/ACM International Conference on Automated Software Engineering (ASE 2008) - Doctoral Symposium, 15-19 September 2008, L'Aquila, Italy*, pages 517–520, 2008.
- [82] E. R. Lopez Ruiz, Y. Ledru, and M. Lemoine. Extending the use of rigorous methods with aeronautics. In *Workshop on Formal Aspects of Safety-Critical Systems, The Safety-Critical Systems Club*, 2008.

2007

- [83] D. Bert, F. Bouquet, Y. Ledru, and S. Vignes. Validation of Regulation Documents by Automated Analysis of Formal Models. In R. Laleau and M. Lemoine, editors, *Proceedings of the CAISE*06 Workshop on Regulations Modelling and their Validation and Verification ReMo2V '06, Luxemburg, June 5-9, 2006*, volume 241 of *CEUR Workshop Proceedings*. CEUR-WS.org, 2007.
- [84] Y. Ledru. A Formalisation of the Soccer Substitution Rules. In R. Laleau and M. Lemoine, editors, *Proceedings of the CAISE*06 Workshop on Regulations Modelling and their Validation and Verification ReMo2V '06, Luxemburg, June 5-9, 2006*, volume 241 of *CEUR Workshop Proceedings*. CEUR-WS.org, 2007.
- [85] Y. Ledru, F. Dadeau, L. du Bousquet, S. Ville, and E. Rose. Mastering combinatorial explosion with the Tobias-2 test generator. In R. E. Kurt Stirewalt, A. Egyed, and B. Fischer, editors, *22nd IEEE/ACM International Conference on Automated Software Engineering (ASE 2007), November 5-9, 2007, Atlanta, Georgia, USA*, pages 535–536. ACM, 2007. Demonstration.
- [86] M. Lemoine, E. R. Lopez Ruiz, Y. Ledru, D. Bert, R. Laleau, F. Peureux, F. Bouquet, V. Donzeau-Gouge, C. Dubois, J.-F. Etienne, and S. Vignes. EDEMOI : a methodology for security of air transport system. In *2nd European Conference on Aerospace Sciences (EUCASS)*, 2007.

2006

- [87] B. Blanc, G. Durrieu, A. Lakehal, O. Laurent, B. Marre, I. Parissis, C. Seguin, and V. Wiels. Automated functional test case generation from data flow specifications using structural coverage criteria. In *3rd European Congress on Embedded Real Time Software (ERTS2006)*, Toulouse, France, Jan. 2006.
- [88] Y. Ledru and L. du Bousquet. Tobias-Z: An executable formal specification of a test generator. In *21st IEEE/ACM International Conference on Automated Software Engineering (ASE 2006), 18-22 September 2006, Tokyo, Japan*, pages 353–354. IEEE Computer Society, 2006. Demonstration.
- [89] M. Shahbaz. Incremental Inference of Black-Box Components to Support Integration Testing. In *Testing: Academic & Industrial Conference Practice And Research Techniques, (TAIC PART 2006), PhD Programme*, Windsor, UK, Aug. 2006.

2005

- [90] T. Deruyter, J.-C. Fernandez, and M.-L. Potet. Modélisation d'architecture pour le reciblage et la paramétrisation d'une chaîne de compilateur DSP. In *18th International Conference Software & Systems Engineering and their Applications - ICSSEA'2005*, Paris, Nov. 2005.
- [91] M. Kessiss, Y. Ledru, and G. Vandome. Test de couverture des serveurs J2EE : Etude du serveur J2EE JOnAS et de sa suite de tests. In *18th International Conference Software & Systems Engineering and their Applications - ICSSEA'2005*, Paris, Nov. 2005. 8 pages.
- [92] Y. Ledru. Conformance Test Generation with JML, 2005. TAROT Summer School Tutorial.
- [93] N. Stouls and V. Darmaillacq. Formalisation et implantation de politiques de sécurité de réseaux. In *Majestic 2005*, Rennes, Nov. 2005. Poster avec publication d'un papier court.

Scientific books and chapter [OS]

2009

- [94] J.-L. Boulanger, A. Rasse, and A. Idani. *Handbook of Software Engineering Research and Productivity Technologies: Implications of Globalisation, Chapter 19, Information Science Reference, IGI Global, To appear*, chapter Models Oriented Approach for developing railway safety-critical systems with UML. 2009.
- [95] Y. Ledru. *Protecting Airline Passengers in the Age of Terrorism*, chapter Modeling Airport Security Regulations, pages 228–246. Greenwood Publishing Group, Praeger Security International, 2009.

2008

- [96] C. Bartolini, A. Bertolino, E. Marchetti, and I. Parissis. *Architecting Dependable Systems V, LNCS 5135*, chapter Data Flow-based Validation of Web Services Compositions: Perspectives and Examples. 2008.

2007

- [97] A. Idani. *Computer Software Engineering Research, Chapter 6*, chapter B2UML vs UML2B: Bridging the gap between formal and graphical software modelling paradigms, pages 161–177. 2007.

National peer reviewed journal [ACLN]

2009

- [98] F. Dadeau, A. Haddad, and T. Moutet. Test fonctionnel de conformité vis-à-vis d'une politique de contrôle d'accès. *Technique et Science Informatiques, To appear*, 2009.

2008

- [99] R. Groz, M. Shahbaz, and K. Li. Extraction de modèles paramétrés au cours du test de composants logiciels. *Technique et Science Informatiques*, 27(8):977–1006, 2008.
- [100] Y. Ledru, R. Laleau, and S. Vignes. Une tentative d'utilisation conjointe d'UML et d'une méthode formelle pour la modélisation de la sécurité des aéroports. *Ingénierie des Systèmes d'Information, RSTI, série ISI*, 13(4):133–157, 2008.

2007

- [101] D. Bert and H. Ruíz Barradas. Propriétés de vivacité dans les systèmes B . Application à l'algorithme distribué de Ricart-Agrawala. *Technique et Science Informatiques, RSTI, série TSI*, 26:853–882, 2007.
- [102] A. Idani, Y. Ledru, and D. Bert. Approche formelle pour la dérivation de vues structurelles UML à partir de développements B. Formalisation, preuve et extension pour la prise en compte des raffinements B . *Technique et Science Informatiques, RSTI, série TSI*, 26, 2007.

2006

- [103] V. Darmaillacq, J.-C. Fernandez, R. Groz, L. Mounier, and J.-L. Richier. Tester la conformité d'un réseau à une politique de sécurité. *Revue de l'Electricité et de l'Electronique*, 6/7:33–43, Juin-Juillet 2006.
- [104] H. Ruíz Barradas and D. Bert. Propriétés dynamiques avec hypothèses d'équité en B événementiel. *Technique et Science Informatiques, RSTI*, 25(1):73–102, 2006.

2005

- [105] M. Kessiss, Y. Ledru, and G. Vandome. Test de couverture des serveurs J2EE : Etude du serveur JOnAS et de sa suite de tests. *Génie Logiciel*, 74:37–42, 2005.

National peer-reviewed conference proceedings [ACTN]

2009

- [106] A. Idani, Y. Ledru, and M.-A. Labiadh. Ingénierie Dirigée par les Modèles pour une intégration efficace de UML et B . In *INFORSID 2009*, Toulouse, May 2009.
- [107] L. Madani, A. M'hiri, S. Dupuy-Chessa, and I. Parissis. Vers la formalisation de propriétés ergonomiques de systèmes interactifs. In *Approches Formelles dans l'Assistance au Développement de Logiciels (AFADL'2009)*, 2009.

2007

- [108] F. Dadeau, A. Haddad, and T. Moutet. Test fonctionnel de conformité vis-à-vis d'une politique de contrôle d'accès. In *AFADL'07, Approches Formelles dans l'Assistance au Développement de Logiciels*, Namur, Belgique, June 2007.
- [109] R. Groz, M. Shahbaz, and K. Li. Une approche incrémentale de test par extraction de modèles. In *AFADL'07 (Approches Formelles dans l'Assistance au Développement de Logiciels, 10ème anniversaire)*, Namur, juin 2007.
- [110] Y. Ledru, R. Laleau, and S. Vignes. Une tentative d'utilisation conjointe d'UML et d'une méthode formelle pour la modélisation de la sécurité des aéroports. In *Actes du XXVème Congrès INFORSID, Perros-Guirec, France, 22 au 25 mai 2007*, pages 155–170, 2007.
- [111] L. Madani and I. Parissis. Vers la génération automatique de tests à partir d'arbres de tâches. In *AFADL'07 (Approches Formelles dans l'Assistance au Développement de Logiciels, 10ème anniversaire)*, Namur, juin 2007.
- [112] B. Seljimi and I. Parissis. Test de logiciels synchrones : apports de la programmation par contraintes. In *AFADL'07 (Approches Formelles dans l'Assistance au Développement de Logiciels, 10ème anniversaire)*, Namur, juin 2007.

2006

- [113] D. Bert and H. Ruíz Barradas. Développement et preuve de vivacité de l'algorithme distribué de Ricart-Agrawala. In *Actes de la Conférence AFADL'06: Approches Formelles dans l'Assistance au Développement de Logiciels*, pages 161–178, ENST, Paris, Mar. 2006.
- [114] A. Idani. Couplage de spécifications B et de descriptions UML pour l'aide aux développements formels des systèmes d'information : Approche par méta-modélisation. In *Actes du 24ème congrès INFORSID*, Tunisie, juin 2006.
- [115] A. Idani, Y. Ledru, and D. Bert. Analyse formelle de concepts pour la génération de diagrammes de classe UML à partir de spécifications B. In *Actes de la Conférence AFADL'06: Approches Formelles dans l'Assistance au Développement de Logiciels*, pages 9–24, ENST, Paris, Mar. 2006.
- [116] N. Stouls and V. Darmaillacq. Développement formel d'un moniteur détectant les violations de politiques de sécurité de réseaux. In *Actes de la Conférence AFADL'06: Approches Formelles dans l'Assistance au Développement de Logiciels*, pages 179–193, ENST, Paris, Mar. 2006.

2005

- [117] V. Darmaillacq, J.-C. Fernandez, R. Groz, L. Mounier, and J.-L. Richier. Éléments de modélisation pour le test de politiques de sécurité. In *Colloque sur les Risques et la Sécurité d'Internet et des Systèmes, CRiSIS*, Bourges, Oct. 2005.
- [118] A. Kermarrec, R. Groz, B. Parreaux, and A. Petrenko. Machines de mutations pour l'enrichissement de test de protocoles. In *Colloque Francophone sur l'Ingénierie des Protocoles (CFIP 2005)*, pages 33–49, Bordeaux, Mar. 2005. Hermès.

Book or Proceedings editing [DO]

2009

- [119] Y. Ledru and M. Pantel, editors. *Actes des Journées du GDR CNRS Génie de la Programmation et du Logiciel*. IRIT Press, Toulouse, Jan. 2009.

2008

- [120] A. Duda and R. Groz, editors. *Colloque Francophone d'Ingénierie des Protocoles (CFIP'2008)*, Les Arcs, France, Mar. 2008.

2007

- [121] L. du Bousquet and J.-L. Richier, editors. *Feature Interactions in Software and Communication Systems IX, International Conference on Feature Interactions in Software and Communication Systems, ICFI 2007*, Grenoble, France, Sept. 2007. IOS Press.

2006

- [122] N. Gupta, Y. Ledru, and J. Mayer, editors. *Proceedings of the Third International Workshop on Software Quality Assurance (SOQUA 2006)*. ACM Press, Portland (OR), Nov. 2006.

2005

- [123] L. Toutain and J.-L. Richier, editors. *Gisèle Cizault (nom collectif). IPv6, théorie et pratique, 4ème édition*. O'Reilly, Nov. 2005.

Doctoral Dissertations and Habilitations Theses [TH]

2009

- [124] B. Seljimi. *Test de logiciels synchrones avec la PLC*. PhD thesis, Université Joseph Fourier, Grenoble, France, juillet 2009.

2008

- [125] M. Shahbaz. *Reverse Engineering Enhanced State Models of Black Box Software Components to support Integration Testing*. Thèse, Institut Polytechnique de Grenoble, Grenoble, France, Dec. 2008.

2007

- [126] V. Darmaillacq. *Génération de tests pour les systèmes répartis*. Thèse, Université Joseph Fourier, Grenoble, France, Dec. 2007.
- [127] T. Deruyter. *Modélisation d'architectures DSP pour le reciblage de compilateur*. Thèse, Institut Polytechnique de Grenoble, Grenoble, France, juin 2007.
- [128] L. Madani. *Utilisation de la programmation synchrone pour la spécification et la validation de services interactifs*. Thèse, Université Joseph Fourier, Grenoble, France, Oct. 2007.
- [129] I. Parissis. *Méthodes et outils pour le test des logiciels*. Hdr, Université Joseph Fourier, Grenoble, France, Dec. 2007.
- [130] N. Stouls. *Systèmes de transitions symboliques et hiérarchiques pour la conception et la validation de modèles B raffinés*. Thèse, Institut Polytechnique de Grenoble, Grenoble, France, Dec. 2007.

2006

- [131] A. Idani. *B/UML : Mise en relation de spécifications B et de descriptions UML pour l'aide à la validation externe de développements formels en B*. Thèse, Université de Grenoble 1, Nov. 2006.
- [132] A. Kermarrec. *Enrichissement de tests de protocoles modélisés par des EFSM*. Thèse, Institut National Polytechnique de Grenoble, Sept. 2006.
- [133] A. Lakehal. *Critères de couverture structurelle pour les programmes Lustre*. Thèse, Université Joseph Fourier, Grenoble, France, Sept. 2006.
- [134] H. Ruíz Barradas. *Propriétés de vivacité sous condition d'équité et sémantique des systèmes d'événements avec la méthode B*. Thèse, Université Joseph Fourier, Grenoble, France, Dec. 2006.

2005

- [135] P. Bontron. *Les schémas de test : une abstraction pour la génération de tests de conformité et la mesure de couverture*. Thèse, Université Joseph Fourier, Grenoble, France, Mar. 2005.
- [136] K.-C. Griche. *Génération Automatique de bouchons pour le Test Structurel basée sur l'analyse du flot de contrôle*. Thèse, Université Joseph Fourier, Grenoble, France, juillet 2005.
- [137] P. Hadam. *Transports nouvelle génération dans les réseaux à très haut débit*. PhD thesis, INPG, Grenoble, France, June 2005.
- [138] O. Maury. *Outils pour la synthèse de tests et la maîtrise de l'explosion combinatoire*. Thèse, Université Joseph Fourier, Grenoble, France, Dec. 2005.

Other Publications [AP]

2005

- [139] D. Duval and J.-C. Reynaud. Diagrammatic logic and effects: the example of exceptions. Rapport de recherche, LSR, Feb. 2005. <http://hal.ccsd.cnrs.fr/ccsd-00004129>.
- [140] H. Ruíz Barradas and D. Bert. A Fixpoint Semantics of Event Systems with and without Fairness Assumptions. Rapport de recherche, LSR, Dec. 2005. <http://hal.ccsd.cnrs.fr/ccsd-00016136>.
- [141] H. Ruíz Barradas and D. Bert. Proof obligations for specification and refinement of liveness properties under weak fairness. Rapport de recherche, LSR, Feb. 2005. <http://hal.ccsd.cnrs.fr/ccsd-00004181>.

Summary

	2005	2006	2007	2008	2009	Total
International peer reviewed journal [ACL]	0	2	1	2	4	9
International peer-reviewed conference proceedings [ACT]	15	10	25	10	8	68
Short communications [COM] and posters [AFF] in conferences and workshops	4	3	4	3	2	16
Scientific books and chapter [OS]	0	0	1	1	2	4
National peer reviewed journal [ACLN]	1	2	2	2	1	8
National peer-reviewed conference proceedings [ACTN]	2	4	5	0	2	13
Book or Proceedings editing [DO]	1	1	1	1	1	5
Doctoral Dissertations and Habilitations Theses [TH]	4	4	5	1	1	15
Other Publications [AP]	3	0	0	0	0	3
Total	30	26	44	20	21	141