



IN PARTNERSHIP WITH:
Université Nantes

Ecole des Mines de Nantes

Activity Report 2013

Project-Team ATLANMOD

Modeling Technologies for Software
Production, Operation, and Evolution

IN COLLABORATION WITH: Laboratoire d'Informatique de Nantes Atlantique (LINA)

RESEARCH CENTER
Rennes - Bretagne-Atlantique

THEME
Distributed Systems and middleware

Table of contents

1. Members	1
2. Overall Objectives	1
2.1. Presentation	1
2.2. Previous Achievements	2
2.3. Highlights of the Year	2
3. Research Program	2
3.1. MDE Foundations	2
3.2. Reverse Engineering	3
3.3. Security Engineering	4
3.4. Software Quality	5
3.5. Collaborative Development	5
3.6. Scalability	6
3.7. Industrialization of open source tools	7
4. Application Domains	7
5. Software and Platforms	8
5.1. The ATL Model Transformation Language	8
5.2. MoDisco (Model Discovery)	8
5.3. Community-driven language development	9
5.4. JSON Discoverer	9
5.5. EMF-REST	10
5.6. EMF Views (Model Views)	10
5.7. EMFtoCSP	10
5.8. EMF Facet	11
5.9. Neo4EMF	12
6. New Results	12
6.1. Reverse Engineering	12
6.2. Security	13
6.3. Collaborative development	14
6.4. MDE Scalability	14
6.5. Model Quality	14
7. Bilateral Contracts and Grants with Industry	15
7.1.1. WebRatio	15
7.1.2. IBM	15
8. Partnerships and Cooperations	15
8.1. Regional Initiatives	15
8.2. National Initiatives	15
8.3. European Initiatives	17
8.3.1. FP7 Projects	17
8.3.1.1. ARTIST	17
8.3.1.2. MONDO	18
8.3.1.3. Automobile	18
8.3.2. Collaborations in European Programs, except FP7	19
8.4. International Initiatives	19
8.5. International Research Visitors	20
8.5.1. Visits of International Scientists	20
8.5.2. Visits to International Teams	20
9. Dissemination	20
9.1. Scientific Animation	20
9.1.1. Organization	20

9.1.2. Editorial Boards	20
9.1.3. Reviewing of International Journals	20
9.1.4. Program Committee members	21
9.1.5. Research Evaluation Committees	21
9.1.6. Steering Committees	21
9.2. Teaching - Supervision - Juries	21
9.2.1. Teaching	21
9.2.2. Supervision	22
9.2.3. Juries	22
9.3. Popularization	22
10. Bibliography	23

Project-Team ATLANMOD

Keywords: Model-driven Engineering, Software Engineering, Reverse Engineering, Formal Methods

Creation of the Team: 2008 July 01, *updated into Project-Team:* 2013 January 01.

1. Members

Faculty Members

Jordi Cabot [Team leader, EMN, Associate Professor, HdR]
Gerson Sunyé [Univ. Nantes, Associate Professor, from Jun 2013]
Massimo Tisi [EMN, Associate Professor]

Engineers

Matthieu Allon [EMN, from Aug 2013]
Hugo Brunelière [EMN]
Javier Canovas Izquierdo [Inria, granted by FP7 ARTIST project]
Hassene Choura [Inria, granted by OSEO Innovation]
Duc-Hanh Dang [Inria, granted by Région des Pays de la Loire, from Mar 2013]
Guillaume Doux [Inria, granted by FP7 ARTIST project, until Oct 2013]
Juan David Villa Calle [Inria, granted by OSEO Innovation]

PhD Students

Amine Benelallam [EMN, granted by FP7 MONDO project from Mar 2013]
Valerio Cosentino [EMN granted by CIFRE]
Carlos Alberto Gonzalez Perez [EMN]
Salvador Martínez Pérez [EMN]

Post-Doctoral Fellows

Fabian Buettner [EMN, until Jun 2013]
Abel Gomez Llana [Inria, granted by Région des Pays de la Loire, from Oct 2013]

Visiting Scientist

Camilo Alvarez Duran [Inria, from Apr 2013 until Aug 2013]

Administrative Assistant

Cecile Derouet [Inria]

2. Overall Objectives

2.1. Presentation

Model Driven Engineering (MDE) is a software engineering paradigm that advocates for the rigorous use of (software) models and model manipulation operations (known as model transformations) as the main artifacts in all software engineering activities. This comes from an industrial need to have a regular and homogeneous organization where different facets of a software system may be easily separated or combined when appropriate. The basic assumption of MDE is that models provide a better abstraction level than the classical programming code to manage the complexity of software development (and, in general, any other software-related task). When needed, executable code can be semi-automatically generated from (low-level) models of the system.

AtlanMod focuses on developing pioneering solutions to solve core research challenges in MDE and to ensure its successful application on relevant industrial problems. In particular, AtlanMod is focusing on three key challenges: evaluating the correctness of models and model transformations, ensuring the scalability of modeling techniques to deal with very large models and developing software comprehension and modernization methods by means of the application of model-driven reverse engineering techniques on running software.

2.2. Previous Achievements

AtlanMod has significantly contributed to the evolution of MDE and to the progressive emergence of a scientific community in this field. The team developed a complete modeling framework [43] [51] providing core MDE components for (meta)model definition and manipulation.

The iterative definition of this conceptual framework has been validated by the construction of an MDE toolbox based on the conclusion that MDE is in fact a branch of language engineering. Models can be formally defined by means of metamodels, considered as the definition of the abstract syntax of a language in the same way grammars are used to define programming languages. Modeling languages are then the combination of a metamodel (abstract syntax), a notation (concrete syntax) plus a definition of the language semantics. In this sense, our toolbox can be regarded as a kind of language workbench offering the building blocks to define and manipulate models and metamodels. All these mutually interrelated tools are available under *Eclipse.org* (projects or components: M2M, ATL, AM3, AMW). They are currently in use in research, teaching, and industry and they have a broad user community.

Beyond the development of core MDE components, AtlanMod has also expressed a strong interest in the application and adaptation of these building blocks for specially relevant and challenging industrial problems. As an example, in this context, AtlanMod has been leading the MoDisco project ¹ to build reverse engineering solutions for legacy systems.

2.3. Highlights of the Year

Two new European projects to support new research directions for the team.

AtlanMod becomes an official Inria team.

3. Research Program

3.1. MDE Foundations

Traditionally, models were often used as initial design sketches mainly aimed for communicating ideas among developers. On the contrary, MDE promotes models as the primary artifacts that drive all software engineering activities (i.e. not only software development but also evolution, reverse engineering, interoperability and so on) and are considered as the unifying concept [43]. Therefore, rigorous techniques for model definition and manipulation are the basis of any MDE framework.

The MDE community distinguishes three levels of models: (terminal) model, metamodel, and metametamodel. A terminal model is a (partial) representation of a system/domain that captures some of its characteristics (different models can provide different knowledge views on the domain and be combined later on to provide a global view). In MDE we are interested in terminal models expressed in precise modeling languages. The abstract syntax of a language, when expressed itself as a model, is called a metamodel. A complete language definition is given by an abstract syntax (a metamodel), one or more concrete syntaxes (the graphical or textual syntaxes that designers use to express models in that language) plus one or more definition of its semantics. The relation between a model expressed in a language and the metamodel of that language is called *conformsTo*. Metamodels are in turn expressed in a modeling language called metamodeling language. Similar to the model/metamodel relationship, the abstract syntax of a metamodeling language is called a metametamodel

¹<http://eclipse.org/MoDisco/>

and metamodels defined using a given metamodeling language must conform to its metamodel. Terminal models, metamodels, and metamodel form a three-level architecture with levels respectively named M1, M2, and M3. A formal definition of these concepts is provided in [50] and [44]. MDE promotes *unification by models*, like object technology proposed in the eighties *unification by objects* [42]. These MDE principles may be implemented in several standards. For example, OMG proposes a standard metamodel called Meta Object Facility (MOF) while the most popular example of metamodel in the context of OMG standards is the UML metamodel.

In our view the main way to automate MDE is by providing model manipulation facilities in the form of model transformation operations that taking one or more models as input generate one or more models as output (where input and output models are not necessarily conforming to the same metamodel). More specifically, a model transformation Mt defines the production of a model Mb from a model Ma . When the source and target metamodels (MMs) are identical ($MMa = MMb$), we say that the transformation is endogenous. When this is not the case ($MMa \neq MMb$) we say the transformation is exogenous. An example of an endogenous transformation is a UML refactoring that transforms public class attributes into private attributes while adding accessor methods for each transformed attribute. Many other operations may be considered as transformations as well. For example verifications or measurements on a model can be expressed as transformations [46]. One can see then why large libraries of reusable modeling artifacts (mainly metamodels and transformations) will be needed.

Another important idea is the fact that a model transformation is itself a model [4]. This means that the transformation program Mt can be expressed as a model and as such conforms to a metamodel MMt . This allows an homogeneous treatment of all kinds of terminal models, including transformations. Mt can be manipulated using the same existing MDE techniques already developed for other kinds of models. For instance, it is possible to apply a model transformation Mt' to manipulate Mt models. In that case, we say that Mt' is a higher order transformation (HOT), i.e. a transformation taking other transformations (expressed as transformation models) as input or/and producing other transformations as output.

As MDE developed, it became apparent that this was a branch of language engineering [45]. In particular, MDE offers an improved way to develop DSLs (Domain-Specific Languages). DSLs are programming or modeling languages that are tailored to solve specific kinds of problems in contrast with General Purpose Languages (GPLs) that aim to handle any kind of problem. Java is an example of a programming GPL and UML an example of a modeling GPL. DSLs are already widely used for certain kinds of programming; probably the best-known example is SQL, a language specifically designed for the manipulation of relational data in databases. The main benefit of DSLs is that they allow everybody to write programs/models using the concepts that actually make sense to their domain or to the problem they are trying to solve (for instance Matlab has matrices and lets the user express operations on them, Excel has cells, relations between cells, and formulas and allows the expression of simple computations in a visual declarative style, etc.). As well as making domain code programmers more productive, DSLs also tend to offer greater optimization opportunities. Programs written with these DSLs may be independent of the specific hardware they will eventually run on. Similar benefits are obtained when using modeling DSLs. In MDE, new DSLs can be easily specified by using the metamodel concept to define their abstract syntax. Models specified with those DSLs can then be manipulated by means of model transformations (with ATL for example [8]).

When following the previously described principles, one may take advantage of the uniformity of the MDE organization. As an example, considering similarly models of the static architecture and models of the dynamic behavior of a system allows at the same time economy of concepts and economy of implementation.

The following sections describe the main MDE research challenges the team is addressing. They go beyond the development of core MDE techniques (topic on which the team, as mentioned above, has largely contributed in the past, and that we believe is quite well-covered already) and focus on new aspects that are critical for the successful application of MDE in industrial contexts.

3.2. Reverse Engineering

One important domain that is being investigated by the AtlanMod team is the reverse engineering of existing IT systems. We do believe that efficiently dealing with such legacy systems is one of the main challenges in Software Engineering and related industry today. Having a better understanding of these systems in order to document, maintain, improve or migrate them is thus a key requirement for both academic and industrial actors in this area. However, it is not an easy task and it still raises interesting challenging issues to be explored [48].

We have shown how reverse engineering practices may be advantageously revisited with the help of the MDE approach and techniques, applying (as base principle) the systematic representation as models of the required information discovered from the legacy software artifacts (e.g. source code, configuration files, documentation, metadata, etc). The rise in abstraction allowed by MDE can bring new hopes that reverse engineering is now able to move beyond more traditional ad-hoc practices. For instance, a industrial PhD in partnership with IBM France aims to investigate the possibilities of conceptualizing a generic framework enabling the extraction of business rules from a legacy application, as much as possible, independently of the language used to code it. Moreover, different pragmatic solutions for improving the overall scalability when dealing with large-scale legacy systems (handling huge data volumes) are intensively studied by the team.

In this context, AtlanMod has set up within the past years and is still developing the open source Eclipse MoDisco project (see 5.2). MoDisco is notably being referenced by the OMG ADM (Architecture Driven Modernization) normalization task force as the reference implementation for several of its standard metamodels. It is also used practically and improved in various collaborative projects the team is currently involved in (e.g. FP7 ARTIST).

We have also opened a novel research line focused on integration of APIs into MDE. In the application of reverse engineering processes while modernizing software system it is very common to face the need of integrating Application Programming Interfaces (APIs). Indeed, building any application usually involves managing a plethora of APIs to access different software assets such as: basic infrastructures (e.g. operating system, databases, or middleware), general-purpose or domain specific libraries, frameworks, software components, web services, and even other applications. Thus, to promote the interoperability between the API and model technical spaces, we have developed API2MoL, which is an approach aimed at automating the implementation of API-MDE bridges. This new language allows defining mappings between the artefacts of a given API (e.g. API classes in object-oriented APIs) and the elements of a metamodel that represents this API in the MDE technical space. A mapping definition provides the information which is necessary to build a bridge for a concrete API specification and metamodel. Thanks to the API-MDE bridges automatically created, developers are liberated from having to manually implement the tasks of obtaining models from API objects and generating such objects from models. Therefore, API2MoL may improve the productivity and quality of the part of the MDE application that deals with the APIs.

Reverse engineering techniques have also been used in the context of the Web. In the last years the development of Web APIs has become a discipline that companies have to master to succeed in the Web. The so-called API economy requires, on the one hand, companies to provide access to their data by means of Web APIs and, on the other hand, web developers to study and integrate such APIs into their applications. The exchange of data with these APIs is usually performed by using JSON, a schemaless data format easy for computers to parse and use. While JSON data is easy to read, its structure is implicit, thus entailing serious problems when integrating APIs coming from different vendors. Web developers have therefore to understand the domain behind each API and study how they can be composed. We tackle this problem by developing a MDE-based process able to reverse engineer the domain of Web APIs and to identify composition links among them. The approach therefore allows developers to easily visualize what is behind the API and the connections points that may be used in their applications.

3.3. Security Engineering

Several components are required to build up a system security architecture, such as firewalls, database user access control, intrusion detection systems, and VPN (Virtual Private Network) routers. These components must be properly configured to provide an appropriate degree of security to the system. The configuration

process is highly complex and error-prone. In most organizations, security components are either manually configured based on security administrators expertise and flair; or simply recycled from existing configurations already deployed in other systems (even if they may not be appropriated for the current one). These practices put at risk the security of the whole organization.

We have started a Phd thesis in this domain intended to investigate the construction of a model-driven automatic reverse engineering mechanism (implemented as an extension of the MoDisco project) capable of analyzing deployed security aspects of components (e.g. concrete firewall configurations) to derive the abstract model (e.g. network security global policy) that is actually enforced over the system. Once the model is obtained, it can be reconciled with the expected security directives, to check its compliance, can be queried to test consistency or used in a process of forward engineering to generate validated security configurations.

As a first step we intend to apply model-driven techniques for the extraction of high level model representations of security policies enforced by firewalls. Firewalls, core components in network security systems, are generally configured by using very low level vendor specific rule-based languages, difficult to understand and to maintain. As a consequence, as the configuration files grow, understanding which security policy is being actually enforced or checking if inconsistencies has been introduced becomes a very complex and time consuming task. We propose to raise the level of abstraction so that the user can deal directly with the high level policies. Once a model representation of the enforced policy is available, model-driven techniques will ease some of the tasks we need to perform, like consistency checking, validation, querying and visualization. Easy migration between different firewall vendors will be also enabled.

3.4. Software Quality

As with any type of production, an essential part of software production is determining the quality of the software. The level of quality associated to a software product is inevitably tied to properties such as how well it was developed and how useful it is to its users. AtlanMod team focus on researching techniques for the formal verification and testing of software models and model transformations.

These techniques must be applied at the model level (to evaluate the quality of specific software designs) and at the metamodel level (to evaluate the quality of modeling languages). In both cases, the Object Constraint Language (OCL) of the OMG is widely accepted as a standard textual language to complement (meta)model specifications with all those rules/constraints that cannot be easily defined using graphical modeling constructs.

Among all possible properties to verify, we take as the basic property the *satisfiability* property, from which many others may be derived (as liveness, redundancy, subsumption,...). Satisfiability checks whether it is possible to create a valid instantiation (i.e. one that respects all modeling constraints) of a give (meta)model. Satisfiability is an undecidable problem when general OCL constraints are used as part of the model definition.

To deal with this problem, the team maintains the tool EMFtoCSP which translates the model verification challenge into the domain of constraint logic programming (CLP) for which sophisticated decision procedures exist. The tool integrates the described functionality in the Eclipse Modeling Framework (EMF) and the Eclipse Modeling Tools (MDT), making the functionality available for MDE in practice.

To complement these formal verification techniques we are also working on testing techniques, specially to optimize the testing of model transformations. White-box testing for model transformations is a technique that involves the extraction of knowledge embedded in the transformation code to generate test models. In our work, we apply static analysis techniques to model transformation specifications and represent the extracted knowledge as partial models that can drive the generation of highly effective test models (specially in terms of coverage).

3.5. Collaborative Development

Software development processes are collaborative in nature. The active participation of end-users in the early phases of the software development life-cycle is key when developing software. Among other benefits, the collaboration promotes a continual validation of the software to be build, thus guaranteeing that the final

software will satisfy the users' needs. In this context, we have opened two novel research lines focused on the collaborative development *in* MDE and the collaborative development *with* MDE. The former is aimed at promoting the collaboration in the context of MDE while the latter uses MDE techniques to promote the participation in software development processes.

Collaboration is important in the context of MDE, in particular, when creating Domain-Specific Modeling Languages (DSMLs) which are (modeling) languages specifically designed to carry out the tasks of a particular domain. While end-users are actually the experts of the domain for which a DSML is developed, their participation in the DSML specification process is still rather limited nowadays (they are normally only involved in providing domain knowledge or testing the resulting language). This means that the MDE technical experts and not end-users are the ones in control of the DSML construction and evolution. This is a problem because errors in understanding the domain may hamper the development process and the quality of the resulting DSML. Thus, it would be beneficial to promote a more active participation of end-users in the DSML development process.

We have been working on the required support to make effective this participation, in particular, we have developed Collaboro, an approach which enables the involvement of the community (i.e., end-users and developers) in the DSML creation process. Collaboro allows modeling the collaborations between community members taking place during the definition of a new DSML and supports both the collaborative definition of the abstract (i.e., metamodel) and concrete (i.e., notation) syntaxes for DSMLs by providing specific constructs to enable the discussion. Thus, each community member will have the chance to request changes, propose solutions and give an opinion (and vote) about those from others. We believe this discussion will enrich the language definition significantly and ensure that the end result satisfies as much as possible the expectations of the end-users. Collaboro has also been extended to support the example-driven development of DSMLs, thus promoting the engagement of end-users in the process.

The lessons learnt from this MDE-focused collaboration research are now being applied to the more general context of software development. In particular, our interest is to study how software development processes are governed (i.e. how the collaboration among developers and user takes place). Any software development project has to cope with a huge number of tasks consisting of either implementing new issues or fixing bugs. Thus, effective and precise prioritization of these tasks is key for the success of the project. Governance rules enable the coordination of developers in order to advance the project. Despite their importance, in practice governance rules are hardly ever explicitly defined, specially in the context of Open Source Systems (OSS), where it is hard to find a explicit system-level design, a project plan, schedule or list of deliverables. To alleviate this situation, mechanisms to facilitate the communication and the assignment of work are considered crucial for the success of the development. Tracking and issue-tracking systems, mailing lists and forums are broadly used to manage the tasks to be performed. While these tools provide a convenient compartmentalization of work and effective means of communication, they fall short in providing adequate support for specifying and enforcing governance rules (e.g. supporting the voting of tasks, easy tracking of decisions made in the project, etc.).

Thus, we believe the explicit definition of governance rules along with the corresponding infrastructure to help developers follow them would have several benefits, including improvements in the transparency of the decision-making process, traceability (being able to track why a decision was made and who decided it) and the automation of the governance process (e.g. liberating developers from having to be aware and follow the rules manually, minimizing the risk of inconsistent behaviour in the evolution of the project). We resort on MDE techniques to tackle this problem and provide a DSL specially adapted to the domain of governance in software projects to let project managers easily define the governance rules of their projects.

3.6. Scalability

As MDE is increasingly applied to larger and more complex industrial applications, the current generation of modelling and model management technologies are being stressed to their limits in terms of their capacity to accommodate collaborative development, efficient management and persistence of models larger than a few hundreds of megabytes in size. Additional research and development is imperative in order to enable

MDE to remain relevant with industrial practice and to continue delivering its widely recognised productivity, quality, and maintainability benefits. Achieving scalability in modelling and MDE involves being able to construct large models and domain-specific languages in a systematic manner, enabling teams of modellers to construct and refine large models in a collaborative manner, advancing the state-of-the-art in model querying and transformations tools so that they can cope with large models (of the scale of millions of model elements), and providing an infrastructure for efficient storage, indexing and retrieval of large models. AtlanMod wants to provide a solution for these aspects of scalability in MDE by extending the Eclipse modeling framework, to create an open-source solution to scalable modeling in industry.

3.7. Industrialization of open source tools

Research labs, as a source of innovation, are potential key actors of the Software Engineering market. However, an important collaborative effort with the other players in the software industry is still needed in order to actually transfer the corresponding techniques or technologies from the research lab to a company. Based on the AtlanMod concrete experience with the previously mentioned open source tools/projects, we have extracted a pragmatic approach [3] for transforming the results of scientific experimentation into practical industrial solutions.

While dealing with innovation, this approach is also innovation-driven itself, as the action is actually conducted by the research lab via a technology transfer. Three different partners are directly involved in this process, using open source as the medium for maintaining a constant interaction between all of them:

- **Use Case Provider.** Usually a company big enough to have to face real complex industrial scenarios which need to be solved (at least partially) by applying new innovative principles and techniques;
- **Research Lab.** Usually a group from a research institute (public or private) or university evaluating the scientific relevance of the problems, identifying the research challenges and prototyping possible solutions;
- **Technology Provider.** Usually a small or medium company, with a particular technical expertise on the given domain or Software Engineering field, building and delivering the industrial version of the designed solutions;

From our past and current experience, three main characteristics of this industrialization *business model* can be highlighted:

- **Win-win situation.** Each partner can actually focus on its core activity while also directly benefiting from the results obtained by the others (notably the research lab can continue to do research);
- **Application-driven context.** The end-user need is at the origin of the process, which finally makes the developed solution actually relevant;
- **Iterative process.** The fact of having three distinct partners requires different regular and consecutive exchanges between all of them.

4. Application Domains

4.1. Application domains

By definition, MDE can be applied to any software domain. Core MDE techniques developed by the team have been successfully applied to a large variety of industrial domains from information systems to embedded systems. MDE is not even restricted to software engineering, but also applies to data engineering [49] and to system engineering [41]. There are a lot of problems in these application domains that may be addressed by means of modeling and model transformation techniques.

As a result, AtlanMod has collaborated with a great variety of different companies ranging from the Automotive to the Insurances domains and from SMEs to large enterprises through the projects described later on in this same report. AtlanMod hopes to continue this trend in the future.

5. Software and Platforms

5.1. The ATL Model Transformation Language

URL: <http://www.eclipse.org/atl/>

With an eye on the normative work of the OMG (MOF, OCL, QVT, etc.), a new conceptual framework has been developed based on a second generation model transformation language called ATL. Although ATL influenced the OMG standard, the approach is more general as discussed in [8]. In 2004 IBM gave an Eclipse innovation award to the ATL project. In 2007 Eclipse recognized ATL as one central solution for model transformation and promoted it to the M2M project (see *Eclipse.org/m2m*). There are more than 200 industrial and academic sites using ATL today, and several Ph.D. thesis in the world are based on this work.

In 2011 we started a new evolution phase for ATL. Our mid-term plan is making of ATL the leading solution for building autonomous reactive transformation systems, i.e. transformation networks that can autonomously manage a set of dataflows among the application models.

Following this line, we first implemented a new refinement mode for ATL, to support in-place transformations. This extension allows the dynamic manipulation of models while keeping them connected to runtime applications. Next, we presented a lazy execution algorithm for ATL. With it, the elements of the target model are generated only when and if they are accessed. This extension allows to build reactive transformation systems that react to requests of model elements, by triggering the necessary computation. Our lazy version of ATL enables also transformations that generate infinite target models, extending the application space of the model-transformation paradigm.

The latest (still ongoing) work in this direction is the development of a full reactive ATL engine, able to activate the minimal computation for responding to updates or request on the involved models. This engine is studied to scale up with large ATL networks. In this line we also introduced an algorithm for simplifying ATL transformation chains.

Performing just the required work on model transformation improves scalability, an open issue the previous described works contribute to solve. An efficient execution, as in the the lazy and reactive scenarios, may help with scalability problems by focusing the tasks in the required part of a very large transformation. However, this is not always the case and we might have to perform operations in the whole model. In this scenario, a solution for the scalability problem would be to take advantage of multi-core architectures that are very popular today, to improve computation times in the transformation of very large models. In this sense, a first step explores the strong parallelization properties rule-based languages like ATL have. A new prototype implementation of a parallel ATL engine have been developed showing how transformations can be developed without taking into account concurrency concerns, and that a transformation engine can automatically parallelize operations improving execution times.

5.2. MoDisco (Model Discovery)

URL: <http://www.eclipse.org/MoDisco/>

MoDisco is an open source Eclipse project that provides a generic and extensible framework dedicated to the elaboration of Model Driven Reverse Engineering (MDRE) solutions. Gathering contributions from both academics and industrials, the goal of the project is to federate common efforts in the model-based transformation of legacy software systems implemented using different technologies (e.g. Java, COBOL, C). The first principle is to discover models out of legacy artifacts, representing appropriately all the relevant information, to be then used as part of reverse engineering processes for software understanding, evolution or modernization. Targeted scenarios include software (technical or architectural) migration of large legacy systems, but also retro-documentation, refactoring, quality assurance, etc. Within this context, MoDisco has collaborations with the OMG Architecture Driven Modernization (ADM) Task Force, for which the project provides several reference implementations of its standards: Knowledge Discovery Metamodel (KDM), Software Measurement Metamodel (SMM) and Abstract Syntax Tree Metamodel (ASTM).

The MoDisco framework is composed of a set of Eclipse plugins, and relies on the de-facto standard Eclipse Modeling Framework (EMF) for model handling. Thanks to its modular architecture, it allows completely covering the three steps of a standard MDRE approach: 1) Discovery (i.e. extracting a complete model of the source code), 2) Understanding (i.e. browsing and providing views on this model for a given purpose) and 3) Transformation (evolving the model towards a new technology, architecture, etc). More specifically, as part of its *Infrastructure* layer, MoDisco offers the set of generic (i.e.; legacy technology-independent) reusable components really useful to build the core of MDRE solutions: Discovery Manager and Workflow for MDRE task orchestration, Model Browser for advanced navigation in complex models, model extension and customization capabilities for understanding (e.g. views definition), etc. As part of its *Technologies* layer, it provides an advanced support for the Java, JEE and XML technologies, including complete metamodels, corresponding model discoverers, transformations, code generators, customizations, query libraries, etc.

MoDisco (or some of its components) is being used by different partners including other academics, industrials (e.g. Sodifrance on several of their real modernization projects for their customers) or Eclipse projects (e.g. Eclipse-MDT Papyrus as developed by CEA). Moreover, the Eclipse-EMFT EMF Facet project has been initiated as a MoDisco spin-off, in order to externalize some features which are not actually specific to reverse engineering problems and thus may be reused in many different contexts (cf. corresponding EMF Facet section).

The initiative continues to be developed within the context of the European FP7-ICT project named ARTIST², and also to a lower extent within the context of the French FUI 13 project named TEAP.

5.3. Community-driven language development

URL: <http://code.google.com/a/eclipselabs.org/p/collaboro/>

Software development processes are collaborative in nature. Neglecting the key role of end-users leads to software that does not satisfy their needs. This collaboration becomes specially important when creating Domain-Specific Languages (DSLs), which are (modeling) languages specifically designed to carry out the tasks of a particular domain. While end-users are actually the experts of the domain for which a DSL is developed, their participation in the DSL specification process is still rather limited nowadays.

Thus, Collaboro is an approach to make language development processes more participative, meaning that both developers and users of the language can collaborate together to design it and make it evolve. The tool has been developed as an Eclipse plugin, with currently the following features implemented:

- Version view to navigate through the Proposals of a version of a language. For each Proposal, the solutions and comments are shown.
- Collaboration view to show the data related to a Collaboration selected in the version view. This view also shows the changes to apply if the selected element is a Solution.
- The user can login to the Collaboro system and create proposals, solutions and comments by right-clicking in the version view. The user can also vote for/against the collaborations.
- Decision engine based on a total agreement (i.e., all the community users must vote for the collaboration). The decision engine can be launch by using the menu bar.
- Notation engine and Notation view to render SVG snapshots of the DSL concrete syntax.
- Support for example-driven development of DSMLs, thus incorporating a graphical editor which allows end-users to draw examples of the DSML they are developing.

5.4. JSON Discoverer

URL: <http://atlanmod.github.io/json-discoverer/>

²<http://www.artist-project.eu/>

Given a set of JSON documents, the tool (distributed as an open source Eclipse plugin contributed to MoDisco) returns a model describing their implicit schema. We follow an iterative process where new JSON documents (from the same or different services within the API) contribute to enrich the generated model. The model helps to both understand single services and to infer possible relationships between them, thus suggesting possible compositions and providing an overall view of the application domain. The tool has also been released as a web site, thus allowing any web developer to use our approach without the need of installing Eclipse.

5.5. EMF-REST

URL: <http://emf-rest.com/>

EMF is *the modeling framework* of the Eclipse community. While EMF is able to automatically generate Java APIs from Ecore models, it is still missing support to deal with Web APIs such as RESTful ones that could boost the use of modeling techniques in the Web. However, the creation of RESTful APIs requires from developers not only an investment in implementation but also a good understanding of the REST Principles to apply them correctly. We therefore created EMF-REST, a tool that empowers EMF to get Truly RESTful APIs from Ecore models, thus allowing web developers to generate JSON-based Web APIs for their applications. It generates both a JavaScript API to work with models as Javascript Objects in the client-side (without any EMF dependency) and REST services in the server-side based on the Java JAX-RS specification.

5.6. EMF Views (Model Views)

URL: <http://emfviews.jdvillacalle.com/>

The Eclipse Modeling Framework (EMF) is widely used in the Eclipse community: defining domain models and generating corresponding source code, modeling software architectures, specifying DSL concepts or simply representing software/user data in different contexts. This implies that any software project involves a large number of heterogeneous but interrelated EMF models.

To make matters worse, not all participants in the project should have the same kind of access/views on the models. Some users only need to see some parts of one model, others have to get the full model extended with data from another model, or simply access to a combination of information coming from different interconnected models. Up to now, creating such perspectives transparently in EMF was almost impossible.

Based on the unquestionable success/usefulness of database views to solve similar problems in databases, EMF Views aims to bring the same concept to the modeling world. Thanks to the three main constructs (inspired from SQL) offered by the tool, designers can create new model views: **SELECT**ing a subset of elements from a model, **PROJECT**ing only some of the properties of those elements and/or **JOIN**ing them with elements from other models. A model view is a special type of model whose instances are directly computed at runtime based on the model view definition and concerned actual model(s).

EMF Views is currently being developed in the context of the TEAP industrial project <http://www.teap-project.org/>, by showing different possible applications of model views including:

- Software architect/developer views relating UML design models and Java code models (cf. Eclipse MoDisco);
- Enterprise architect views linking (BPMN) business process models, (ReqIF) requirements models and (TOGAF) architecture models;
- View querying using dedicated technologies (e.g. Eclipse IncQuery);
- View transformation using dedicated technologies (e.g. Eclipse ATL).

5.7. EMFtoCSP

URL: <http://code.google.com/a/eclipselabs.org/p/emftocsp/>

EMFtoCSP is a tool for the verification of precisely defined conceptual models and metamodels. For these models, the definition of the general model structure (using UML or EMF) is supplemented by OCL constraints. The Eclipse Modeling Development Tools (MDT ³) provides mature tool support for such OCL-annotated models with respect to model definition, transformation, and validation.

However, an additional important task that is not supported by Eclipse MDT is the assurance of model quality. A systematical assessment of the correctness of such models is a key issue to ensure the quality of the final application. EMFtoCSP fills this gap by provided support for automated model verification in Eclipse.

Essentially, the EMFtoCSP is a sophisticated bounded model finder that yields instances of the model that conform not only to the structural definition of the model (e.g. the multiplicity constraints), but also to the OCL constraints. Based on this core, several correctness properties can be verified:

1. Satisfiability – is the model able to express our domain? For this check, the minimal number of instances and links can be specified to ensure non-trivial instances.
2. Unsatisfiability – is the model unable to express undesirable states? To verify this, we add further constraints to the model that state undesired conditions. Then we can check if it is impossible to instantiate the amended model.
3. Constraint subsumption – is one constraint already implied by others (and could therefore be removed)?
4. Constraint redundancy – do different constraints express the same fact (and could therefore be removed)?

To solve these search problems, EMFtoCSP translates the EMF/OCL (resp. UML/OCL) model into a constraint satisfaction problem and employs the Eclipse CLP solver ⁴to solve it. This way, constraint propagation is exploited to tackle the (generally NP-hard) search.

The tool is a continuation of the UMLtoCSP approach [47] developed previously by Jordi Cabot, Robert Clarisó and Daniel Riera. It provides a generic plugin framework for Eclipse to solve OCL-annotated models using constraint logic programming. Apart from already supported Ecore and UML metamodels, further metamodels can be added easily in the future. Similarly, other constraint solving back-ends can be integrated. It is provided under the Eclipse Public License.

5.8. EMF Facet

URL: <http://www.eclipse.org/modeling/emft/facet/>

EMF Facet is an open source Eclipse project, under the Eclipse Public License (EPL), that provides a generic and extensible framework dedicated to the dynamic and non-intrusive extension of models. It can be used to extend already existing metamodels with additional concepts and properties, the corresponding models being then transparently augmented, reduced or modified accordingly at runtime. Such a metamodel extension is called a facet, and can be specified on top of any metamodel in EMF Ecore. The underlying mechanism is based on the runtime execution of queries on the models corresponding to the *faceted* metamodels. Facets are notably particularly relevant for obtaining different views on existing models without having to actually alter them with any extra data.

The EMF Facet framework is composed of several Eclipse plugins, and relies on the de-facto standard Eclipse Modeling Framework (EMF) for model handling. The facet definitions are stored as facet models, allowing them to be exchanged and reused in various contexts. The queries can be implemented using any suitable query language (e.g. ATL, OCL, Java, XPath), as far as the corresponding adapters exist and are correctly registered within the framework. The proposed tooling includes dedicated editors for creating, editing and saving both facet and query definitions, the implemented support for Java, OCL and ATL queries, a Table Editor for visualizing query results. An advanced support for the model display customization (e.g. icons, colors, fonts) is also provided as part of the framework.

³<http://www.eclipse.org/modeling/mdt/?project=ocl>

⁴<http://eclipseclp.org/>

EMF Facet is currently intensively used in MoDisco for extracting and displaying different specific views from large models of legacy systems. Its extension and customization capabilities are actually integrated into several MoDisco components, such as notably the MoDisco Model Browser. However, different other integration possibilities will be also explored in the future.

The initiative continues to be developed within the context of the European FP7-ICT project ARTIST.

5.9. Neo4EMF

URL: <http://www.neo4emf.com>

Neo4EMF is an open source software distributed under the terms of the Eclipse Public License, that provides a persistence backend for big, complex and highly interconnected EMF models.

Neo4EMF is a model repository and persistence framework allowing on-demand loading, storage, and unloading of large-scale EMF models. Neo4EMF uses a sophisticated unloading approach apart from simple Soft/Weak references. Moreover, Neo4EMF provides a No-SQL database persistence framework based on Neo4j ⁵, which is a transactional property-graph database that proved a remarkable running speed for connected data operations compared to relational databases.

In terms of performance, Neo4EMF eases data access and storage not only in a manner to reduce time and memory usage but also to allow big models to fit into small memory. This is established through an on-demand loading mechanism that offers :

- Lightweight first time loading of model elements : we separated EMF objects and their data fields, thus, data objects are only instantiated if an access request to one of their fields is established
- Dynamic partitioning of model elements : a partition represents a group of model elements to be unloaded all together. Hence, after each EMF operation call, first time loading objects are organized in their suitable partition
- Unloading of model partitions : when memory reaches a given threshold, we use a selection strategy to choose one or more partitions to be removed from the memory

A session about Neo4EMF took place at eclipseCon Europe 2013 ⁶, held in Ludwigsburgh Germany.

However, works are still going over Neo4EMF (within the context of the project ITM Factory -FUI14), to provide more utilities such as concurrent access, model distribution, and other Ecore utilities.

6. New Results

6.1. Reverse Engineering

Model Driven Reverse Engineering (MDRE), and its applications such as software modernization, is a discipline in which model-driven development (MDD) techniques are used to treat legacy systems. During this year, Atlanmod has continued working actively on this research area. The main contributions are the following:

- In the context of the ARTIST FP7 project, the work has started on reusing (and extending accordingly) MoDisco and several of its components to provide the Reverse Engineering support required within the project. More particularly, the MoDisco Model Discovery + Model Understanding two-step approach is being promoted as an important part of the ARTIST migration methodology and process [35] [19]. Work has also been performed, in the context of the TEAP FUI project dealing with Enterprise Architecture, on how to design and implement a model driven federation approach from heterogeneous data sources (e.g. Excel files, databases, etc.) directly inspiring from these same MoDisco principles [20].

⁵<http://www.neo4j.org>

⁶<https://www.eclipsecon.org/europe2013/neo4emf-big-models-made-possible>

- In order to react to the ever-changing market, every organization needs to periodically reevaluate and evolve its company policies. These policies must be enforced by its Information System (IS) by means of a set of so-called business rules that drive the system behavior and data. Clearly, policies and rules must be aligned at all times but unfortunately this is a challenging task. In most ISs, the implementation of business rules is scattered among the different components of the system, therefore appropriate techniques must be provided for the discovery and evolution of changing business rules. In [39], [25], [26], we describe a MDRE framework and tool aiming at extracting business rules out of COBOL source code. In [27], we describe a Model-based process and tool to extract business rules, expressed as OCL integrity constraints, from relational databases. In these works, the use of modeling techniques facilitate the representation of the rules at a higher-abstraction level which enables stakeholders to understand and manipulate them more easily. A thesis financed by IBM to advance the research on this topic has been completed this year
- In a web context, JSON has become a very popular lightweight format for data exchange. JSON is human readable and easy for computers to parse and use. However, JSON is schemaless. Though this brings some benefits (e.g. flexibility in the representation of the data) it can become a problem when consuming and integrating data from different JSON services since developers need to be aware of the structure of the schemaless data. We believe that a mechanism to discover (and visualize) the implicit schema of the JSON data would largely facilitate the creation and usage of JSON services. For instance, this would help developers to understand the links between a set of services belonging to the same domain or API. In this sense, we have proposed a model-based approach to generate the underlying schema of a set of JSON documents [22].

6.2. Security

Most companies information systems are composed by heterogeneous components responsible of hosting, creating or manipulating critical information for the day-to-day operation of the company. Securing this information is therefore one of their main concerns, more particularly specifying Access Control (AC) policies. However, the task of implementing an AC security policy (sometimes relying on several mechanisms) remains complex and error prone as it requires knowing low level and vendor-specific facilities. In this context, discovering and understanding which security policies are actually being enforced by the Information System (IS) becomes critical. Thus, the main challenge consists in bridging the gap between the vendor-dependent security features and a higher-level representation. This representation has to express the policies by abstracting from the specificities of the system components, allowing security experts to better understand the policy and to implement all related evolution, refactoring and manipulation operations in a reusable way.

In 2013, we have tackled the aforementioned problems with respect to three key information system components: networks of firewalls, relational database systems and content management systems.

- Firewalls are a key element in network security. They are in charge of filtering the traffic of the network in compliance with a number of access-control rules that enforce a given security policy. In [33] we have described a model-driven reverse engineering approach able to extract the security policy implemented by a set of firewalls in a working network, easing the understanding, analysis and evolution of network security policies. In [17] we have extended this method to cope with a more complex and specific scenario, i.e, the management of stateful packet filtering.
- A similar approach have been successfully used to extract AC information from relational database systems. Concretely, in [32] we contribute a security metamodel and a reverse engineering process that combines standard database access-control rules with the fine-grained access control provided by triggers and stored procedures. The extraction of this comprehensive model helps security experts to visualize and manipulate database security policies in a vendor-independent manner.
- Out-of-the-box Web Content Management Systems (WCMSs) are the tool of choice for the development of millions of enterprise web sites. However, little attention has been brought to the analysis of how developers use the content protection mechanisms provided by WCMSs, in particular, Access-control (AC). We have proposed in [34] a metamodel tailored to the representation of WCMS AC policies, easing the analysis and manipulation tasks by abstracting from vendor-specific details.

6.3. Collaborative development

In the field of Domain-Specific Languages (DSLs), we have focused on the improvement of the DSLs definition process. When developing DSMLs, the participation of end-users is normally limited to providing domain knowledge and testing the resulting language prototypes. Language developers, which are perhaps not domain experts, are therefore in control of the language development and evolution. This may cause misinterpretations which hamper the development process and the quality of the DSML. Thus, it would be beneficial to promote a more active participation of end-users in the development process of DSMLs. While current DSML workbenches are mono-user and designed for technical experts, we have presented a process and tool support for the example-driven, collaborative construction of DSMLs based on Collaboro in order to engage end-users in the creation of their own languages [23], [24].

6.4. MDE Scalability

As Model-Driven Engineering (MDE) is increasingly applied to larger and more complex systems, additional research and development is imperative in order to enable MDE to remain relevant with industrial practice. In [31] we attempt to provide a research roadmap for scalability in MDE and outline directions for work in this emerging research area. As a first result in this roadmap, in [37] we show that rule-based languages like ATL have strong parallelization properties. Parallelization is indeed one of the traditional ways of making computation systems scalable. We describe the implementation of a parallel transformation engine for the current version of the ATL language and experimentally evaluate the consequent gain in scalability. Finally in [28] we compare the improved scalability of the ATL transformation engine with other engines in the community by addressing the task of generating and analyzing very large flow graphs.

6.5. Model Quality

Our work aims to enhance the quality of the modeling activity in the context of software engineering and language engineering. This year, this has translated in the following results:

- A benchmark that facilitates the comparison between the plethora of tools that provide some kind of quality assurance for models. Similarly to what it is done in many other domains, a common set of test benchmarks that new tools can rely on to experiment and evaluate themselves could speed up the advance in the field. Our proposal can be found [30]
- Validation of the feasibility to apply this kind of techniques in industrial settings based on two case studies [12] and [36]
- Advanced on the verification of model transformations using SMT solvers (instead of SAT or CSP-based approaches commonly used before), with some encouraging results [21] and, related to this, [13]
- A method to build models using instance-level information in terms of examples and counterexamples (gathering requirements using these instance scenarios is usually better from a stakeholder's point of view than trying to explain us general rules about the business). So far existing approaches have often focused on the generation of static models from such instance-level information but have omitted the inference of OCL business rules that could complement the static models and improve the precision of the software specification. We propose an approach to automating such inference [29]. The basic idea is based on an incorporation of the problem solving mechanism and getting user feedback: Candidates are generated by a problem solving, and irrelevant ones are eliminated using the user feedback on generated counterexamples and examples. Our approach is realized with the support tool InferOCL and has been applied on several user cases, indicating a possibility to apply this solution prototype in practice.

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

7.1.1. *WebRatio*

AtlanMod has helped WebRatio and the University of Trento in the definition (to be provided as an answer to the corresponding OMG RFP) of IFML, a modeling language for designing user interaction flows (not limited to the Web). Such a language should be: Extremely compact (no useless overhead), Effective (allows to model exactly what users want), Efficient (grants high reusability of model fragments), Easy to learn (very low learning curve), Comprehensive (covers most of the user interaction needs), Open and extensible (for covering any ad-hoc logic) and Platform independent (addressing any type of user interface device).

For more information about IFML - Interaction Flow Modeling Language see ⁷.

7.1.2. *IBM*

IBM is funding a PhD Thesis on the topic of reverse engineering of business rules from COBOL systems (see the new results section for more details).

8. Partnerships and Cooperations

8.1. Regional Initiatives

Program: Pole Images et Reseaux - Appel Projets PME 2011

Project title: StreamMaster

Duration: 2012 - 2014

Coordinator: Data Syscom

Other partners: Research and University (University of Nantes, Ecole de Design Nantes Atlantique, ESC Rennes) and Vendors and service providers (IMINFO)

Abstract: The purpose of the StreamMaster project is creating a universal software solution for the smart management of document streams, providing an added value over all the chain. StreamMaster will provide: an hybrid (local and remote) technological platform to allow user access, the possibility of connection to every information system and every input and output stream, the management of all the parameters of the document stream (cost, speed, delay, quality, environmental impact), security and reinforced document authentication mechanisms, non-falsifiable documents by means of invisible document tattooing, an innovative and multimodal HMI.

Program: Pays de la Loire regional funding. Call: Creation of new teams

Project title: AtlanMod New Team Creation

Duration: 2011 - 2014

Coordinator: AtlanMod

Other partners: None

Abstract: AtlanMod has been funded by the Pays de la Loire Regional Council new research teams program. This funding will mainly cover a PhD Student and two years of a postdoc to work on the quality of models research line.

8.2. National Initiatives

8.2.1. *FUI*

⁷<http://www.ifml.org/>

Program: FUI - AAP 15

Project acronym: MoNoGe

Project title: Atelier de Modélisation de Nouvelle Génération

Duration: 2013 - 2016

Coordinator: Softeam

Other partners: Industry (DCNS), Research and University (ARMINES AtlanMod, LIP6) and Vendors and service providers (Softeam, Soft-Maint, Mia-Software)

Abstract: There is currently in companies a wide diversity of models and modeling tools according to the application domains, services or contexts which are concerned. This implies different problems forbidding their plain exploitation: traceability, global coherence, continuity between works, knowledge management, etc. All are largely penalized by this situation that harms the mastering of the complexity of the related systems and software. The MoNoGe project has for objective to bring innovative solutions allowing to ensure the agility of the models and modeling tools. The term agility is here referring to the properties of interoperability, extensibility and evolution of models. The dynamic extension mechanism to be developed in MoNoGe, potentially inspiring from the OMG MEF standard currently under definition, is intended to preserve the original metamodel which can be conserved, partially hidden or extended. Thus, the legacy data and models can stay operational with the extended metamodel. The user does not have to deal with heavy migration or conversion operations, and can this way focus on its modeling activities while continuously exploiting past models.

Program: ANR - ARPEGE program

Project acronym: Galaxy

Project title: Galaxy

Duration: 2010 - 2013

Coordinator: Airbus

Other partners: Industry (Airbus), Research and University (Armines -AtlanMod-, IRIT, LIP6) and Vendors and service providers (AKKA, Softeam)

Abstract: GALAXY (<http://galaxy.lip6.fr>) proposes to deal with the model driven collaborative development of complex systems. Galaxy aims at defining an open and flexible architecture particularly designed to be scalable. One of the key points is related to the fragmentation and distributiveness of huge models, their synchronization and relationship with communication means classically used by development teams. The work is being driven by use cases provided by a company (Airbus), which describe scalability issues they face during systems developments. Our work in this project is composed of two main parts: 1) the conception of efficient mechanisms for multiple views of complex (large) models; 2) the definition of a solution for the automation of modeling tasks on large model repositories, like the execution of large amounts of transformations, the orchestration of their execution, and the effective browsing of repositories for finding specific models. In this context we have developed MoScript, a scripting language (and corresponding execution engine) to write batch processing modeling tasks.

Program: FUI - AAP 13

Project acronym: TEAP

Project title: TOGAF Enterprise Architecture Platform

Duration: 2012 - 2014

Coordinator: Obeo

Other partners: Industry (DCNS), Research and University (Inria AtlanMod) and Vendors and service providers (Obeo, Capgemini)

Abstract: The fast evolution of technologies (SOA, Cloud, mobile environments), the systems complexity and the growing need for agility require to be able to represent information systems as a whole. The high-level approach promoted by Enterprise Architecture (EA) is a key element in this context and intends to address all the systems dimensions: software components, associated physical resources, relationships with the companies requirements and business processes, implied actors/roles/structures, etc. The objective of the TEAP project is to specify and implement an EA platform based on the Open Group international standard named TOGAF and on the SmartEA technical solution. In addition to its base modeling capabilities, this platform will allow data federation from different existing sources (e.g. for reverse engineering purposes such as retro-cartography) as well as the definition of possible transformation chains (for governance and modernization). As part of this project, we are notably using in practice (and improving) some of our works such as Virtual EMF, ATL or some MoDisco components.

Program: FUI - AAP 13

Project acronym: ITM Factory

Project title: Information Technology Modernisation Factory

Duration: 04/2012 - 10/2014

Coordinator: Soft-Maint (Groupe SODIFRANCE)

Other partners: Mia-Software (Groupe SODIFRANCE), ACAPNOS, MMA and Inria AtlanMod.

Abstract: Application maintenance represents about 80 per cent of the computer market (at the French and global level). The challenge of software maintenance is to keep running applications with technologies that are no longer required to be maintained and with changing development teams and whose skills are not always validated on ancient languages. The main goal of the ITM Factory is to propose a software modernization framework, based on the ModDisco project and including: (i) an integrated workbench for software modernization engineers and (ii) a set of ready to use modernization cartirdges, i.e., a solution brick that meets a business challenge level, as opposed to a technical bricks that provides technical solutions that are integrated into a business solution.

8.3. European Initiatives

8.3.1. FP7 Projects

8.3.1.1. ARTIST

Type: COOPERATION

Defi: Cloud Computing, Internet of Services and Advanced Software engineering

Instrument: Integrated Project

Duration: October 2012 - September 2015

Coordinator: Clara Pezuela (ATOS Spain)

Partner: ATOS and TECNALIA (Spain), Inria AtlanMod (France), Fraunhofer (Germany), TU Wien and Sparks (Austria), ENGINEERING (Italy), Spikes (Belgium), ATC and ICCS (Greece)

Inria contact: Hugo Bruneliere

Abstract: Nowadays Cloud Computing is considered as the ideal environment for engineering, hosting and provisioning applications. A continuously increasing set of cloud-based solutions is available to application owners and developers to tailor their applications exploiting the advanced features of this paradigm for elasticity, high availability and performance. Even though these offerings provide many benefits to new applications, they often incorporate constrains to the modernization and migration of legacy applications by obliging the use of specific development technologies and explicit architectural design approaches. The modernization and adaptation of legacy applications to cloud environments is a great challenge for all involved stakeholders, not only from the technical perspective, but also in business level with the need to adapt the business

processes and models of the modernized application that will be offered from now on, as a service. The purpose of the ARTIST project is to propose and develop a novel model-driven approach for the migration of legacy applications in modern cloud environments which covers all aspects and phases of the migration process, as well as an integrated framework that supports all migration process.

8.3.1.2. MONDO

Title: Scalable Modelling and Model Management on the Cloud

Type: COOPERATION (ICT)

Defi: Cloud Computing, Internet of Services and Advanced Software engineering

Instrument: Small or medium-scale focused research project (STREP)

Duration: November 2013 - May 2016

Coordinator: The Open Group - X/Open Company

Partners: The Open Group - X/Open Company (United Kingdom), University of York (United Kingdom), Universidad Autonoma de Madrid (Spain), Budapest University of Technology and Economics (Hungary), IKERLAN (Spain), MIA Software (France), Cassidian (Germany)

Inria contact: Massimo Tisi

Abstract: As Model Driven Engineering (MDE) is increasingly applied to larger and more complex systems, the current generation of modelling and model management technologies are being pushed to their limits in terms of capacity and efficiency, and as such, additional research is imperative in order to enable MDE to remain relevant with industrial practice and continue delivering its widely recognised productivity, quality, and maintainability benefits. The aim of MONDO is to tackle the increasingly important challenge of scalability in MDE in a comprehensive manner. Achieving scalability in modelling and MDE involves being able to construct large models and domain specific languages in a systematic manner, enabling teams of modellers to construct and refine large models in a collaborative manner, advancing the state-of-the-art in model querying and transformations tools so that they can cope with large models (of the scale of millions of model elements), and providing an infrastructure for efficient storage, indexing and retrieval of large models. To address these challenges, MONDO brings together partners with a long track record in performing internationally-leading research on software modelling and MDE, and delivering research results in the form of robust, widely-used and sustainable open-source software, with industrial partners active in the fields of reverse engineering and systems integration, and a global consortium including more than 400 organisations from all sectors of IT.

8.3.1.3. Automobile

Title: Automated Mobile App Development

Type: Research For SMEs

Duration: November 2013 - October 2015

Coordinator: WebRatio s.r.l.

Partners: WebRatio, Politecnico di Milano (Italy), AtlanMod-Armines, Moon Submarine (UK), ForwardSoftware (Rumania).

Inria contact: Jordi Cabot

Abstract: The AutoMobile project aims at designing and bringing to the market innovative methodologies, software tools, and vertical applications for the cost-effective implementation of cross-platform, multi-device mobile applications, i.e. business applications that can be accessed by users on a variety of devices and operating systems, including PC, cellular / smart phones and tablets.

Cross-platform and multi-device design, implementation and deployment is a barrier for today's IT solution providers, especially SME providers, due to the high cost and technical complexity of targeting development to a wide spectrum of devices, which differ in format, interaction paradigm, and software architecture.

AutoMobile will exploit the modern paradigm of Model-Driven Engineering and code generation to dramatically simplify multi-device development, reducing substantially cost and development times, so as to increase the profit of SME solution providers and at the same time reduce the price and total cost of ownership for end-customers.

AutoMobile will rely on modeling languages such as IFML (Interaction Flow Modeling Languages) and on tools like WebRatio.

8.3.2. Collaborations in European Programs, except FP7

Program: CORE Multi-annual thematic research programme. Fonds National de la Recherche Luxembourg.

Project acronym: TOOM

Project title: Testing Orders of Magnitude

Duration: September 2013 - August 2015

Coordinator: SnT/University of Luxembourg

Other partners: the iTrust company, EBRC, Inria Rennes/University of Nantes and the UFPR (Brazil).

Abstract: Over the last decade, large-scale systems drew much attention due to scalability and resiliency features. Many popular large-scale data-oriented systems (i.e., BigData), including, Peer-to-peer (P2P) and MapReduce, reached millions of users and processed petabytes of data, such as: Hadoop, Skype, Bittorrent, and Gnutella. The main reason is due to a decentralized manner to remove potential performance bottlenecks and centralized points of failure. Recently, cloud computing is gathering all these BigData systems underneath its layers (e.g. Paas, Saas, Iaas) to free developers from large-scale issues, such as: deployment, distribution, resiliency, security, and performance. Several companies around the globe rely on cloud computing to build robust and reliable services for their business operations (e.g. eBay, Amazon, Skype) mainly to handle heavy load conditions (e.g. seasonal sales, Internet-scale malicious attacks). Testing robustness and reliability of cloud computing services is a hard activity, the state of the art shows that the existing testing techniques suffer to handle aspects, such as: the scale of the cloud, the dynamism of the nodes, and the amount of data and load. In general, these testing techniques rely on a combination of unit tests with some mocking approach that may hide the cloud aspects and may not be suited for large-scale testing. The TOOM project is planned to present a solution for testing robustness of cloud computing services built on top of P2P technology to address scalability and dynamism aspects. The main contributions lie on two main steps. The first one is to validate the overall resilience and reliability of cloud services. The second one is to reproduce large-scale stress loads, such as Distributed Denial of Service (DDoS) and peak loads, either gathered from the real load traces or synthetically generated. We plan to leverage data warehouse technology to house real load traces and use them during testing. To generate synthetic loads, we plan to use known load patterns or adapt them to new load trends. To assess the effectiveness of the TOOM outcomes, we will reproduce stress loads submitted by P2P technology across the cloud infrastructure on top of step-stress testing methodologies. In this manner, we can progressively increase the load in orders of magnitude up to a peak load. Then, we will measure the effectiveness either by code coverage whether the SUT is open-source, by the quality of service (QoS) of the SUT, or by the coverage of network and computing components used by the cloud computing services.

8.4. International Initiatives

8.4.1. Inria International Partners

8.4.1.1. Informal International Partners

The three main research partners of the team are:

- Politecnico di Milano (Italy) - DB Group, specially with Marco Brambilla
- TU Wien (Austria) - BiG Group, specially Manuel Wimmer
- Politecnica de Catalunya (Spain) - GESSI Group, specially Xavier Franch

8.5. International Research Visitors

8.5.1. Visits of International Scientists

This year, the following visitors did a research stay with AtlanMod:

- Galina Besova (University of Paderborn, Germany), May-July
- Javier Criado (University of Almeria, Spain), October

8.5.1.1. Internships

Camilo Alvarez

Subject: Transformations from Legacy Models to the Cloud

Date: from Apr 2013 until Aug 2013

Institution: University of Los Andes (Colombia)

Matthieu Allon

Subject: Interoperability and traceability between modeling languages and standards

Date: from February 2013 until Aug 2013

Institution: University of Science and Technology of Nantes (France)

8.5.2. Visits to International Teams

No long term visits.

9. Dissemination

9.1. Scientific Animation

9.1.1. Organization

In 2013, the AtlanMod team has coorganized the following events:

- J. Cabot has coorganized the OCL and Textual Modeling Workshop (OCL'13)⁸ co-located with the MoDELS conference.
- J. Cabot was tutorials co-chair for the MoDELS conference.

9.1.2. Editorial Boards

Participation to editorial boards of scientific journals:

- Jordi Cabot: Journal of Object Technology, International Journal of Information System Modeling and Design, Software and Systems Modeling

9.1.3. Reviewing of International Journals

AtlanMod members have collaborated in the reviewing process for the following journals this year

- Hugo Bruneliere: Elsevier Advances in Engineering Software (ADES)
- Jordi Cabot: IEEE Software, IEEE Transactions on Software Engineering Journal, Journal of Systems and Software, Information and Software Technology Journal, Software and Systems Modeling Journal, Data and Knowledge Engineering Journal, Science of Computer Programming journal, Journal of Web Engineering journal
- Javier Canovas: Software and Systems Modeling Journal, Journal of Object Technology.
- Massimo Tisi: IEEE Software, Science of Computer Programming journal, Journal of Software: Practice and Experience, Information and Software Technology Journal, Software and Systems Modeling Journal, Journal of Object Technology.
- Gerson Sunyé: IBM Journal of Research and Development, Journal of System and Software, Distributed Computing Journal, Software: Practice and Experience Journal

⁸<http://ocl2013.inf.mit.bme.hu/>

9.1.4. Program Committee members

Participation to conference program committees:

- Jordi Cabot:
 - International: World Wide Web Conference, International Conference on Model-Driven Engineering Language and Systems, Software Language Engineering conference, European Conference on modeling foundations and applications, International Conference on Web Engineering, Transformation Tool Contest, International Conference on Conceptual Modeling, International Conference on Advanced Information Systems Engineering, Model Driven Web Engineering Workshop.
 - National: French national conference on MDE, Spanish national conference on MDE.
- Javier Canovas:
 - International: International Conference on Cyber, Physical and Social Computing, ACM European Computing Research Congress, International Conference on Web Engineering, Model-Driven Web Engineering workshop, International Conference on Model Driven Engineering Languages and Systems, Workshop on Modeling Social Media, International Conference on Knowledge Management and Knowledge Technologies.
- Massimo Tisi:
 - International: International Conference on Engineering of Complex Computer Systems, International Conference on Current Trends in Theory and Practice of Computer Science, International Conference on Software Engineering and Advanced Applications, International Conference on Web Information Systems and Technologies, International Conference on Model Transformation, Transformation Tool Contest, Workshop on Domain-Specific Modeling, Extreme Modeling Workshop, Academics Modelling with Eclipse Workshop.
- Gerson Sunye:
 - International: 25th International Conference on Software Engineering and Knowledge Engineering (SEKE 2013), 2nd International Workshop on Large-Scale Testing (LT 2013), 1st International Workshop on Testing The Cloud (TTC 2013).

9.1.5. Research Evaluation Committees

- Jordi Cabot: Reviewer for Spanish CICYT Research Projects Call

9.1.6. Steering Committees

Participation in Steering Committees of Research Conferences:

- Jordi Cabot: International Conference on Model Transformation

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

License: M. Tisi, Projet IPIPIP, 8h, L2, Ecole des Mines de Nantes

License: M. Tisi, Projet Integrateur PRIME, 12h, L3, Ecole des Mines de Nantes

License: M. Tisi, Programmation, 40h, L2, Ecole des Mines de Nantes

License: M. Tisi, Bases de Données, 33h, L3, Ecole des Mines de Nantes

License: M. Tisi, Interaction Homme-Machine, 14h, L3, Ecole des Mines de Nantes

License: S. Martínez, Bases de Données, 33h, L3, Ecole des Mines de Nantes

License: S. Martínez, Interaction Homme-Machine, 14h, L3, Ecole des Mines de Nantes

License: J. Cabot, Projet IPIPIP, 8h, L2, Ecole des Mines de Nantes

License: J. Cabot, Model-driven Engineering, 45h, L1, Ecole des Mines de Nantes

Master: J. Cabot, Master MIAGE - Object Constraint Language, 4h, M1, Université de Nantes
 Master : G. Sunyé, Genie logiciel, 90h, M1, Université de Nantes
 Master : G. Sunyé, Verification et tests, 56h, M1, Université de Nantes
 Master : G. Sunyé, Nouveaux usages de l'informatique pour l'entreprise, 23h, M1, Université de Nantes
 Master : G. Sunyé, Developpement du logiciel, 44h, M1, Université de Nantes
 Master: J. Canovas, Master MIAGE - Domain Specific Languages, 6h, Université de Nantes.
 License: J. Canovas, Projet IPIPIP, 8h, L2, Ecole des Mines de Nantes

9.2.2. Supervision

PhD : Valerio Cosentino, Extraction and refactoring of Business Logic from Legacy Applications, December 19th, 2013, Jordi Cabot, Patrick Albert
 PhD : Tam Le Nham, Model-Driven Software Engineering for Virtual Machine Images Provisioning in Cloud Computing, Université de Rennes 1, December 10th 2013, Jean-Marc Jézéquel, Gerson Sunyé
 PhD in progress : Carlos A. González, Pragmatic Model Verification, Jordi Cabot
 PhD in progress : Salvador Martínez Pérez, Automatic reconstruction and analysis of semantic network security policies from deployed security components, Jordi cabot and Frédéric Cuppens
 PhD in progress : Olivier Finot, Oracles du test de transformation de modeles, Université de Nantes, Septembre 2010, Christian Attiogbé (Directeur), Jean-Marie Mottu, Gerson Sunyé

9.2.3. Juries

Jordi Cabot was a member of the jury of the thesis of Thang Quyet Pham (Telecom Bretagne), Jad MATAR (Ecole Centrale Nantes) and Aymeric Hervieu (Inria/IRISA)

9.3. Popularization

In June 2013, the team participated to the organization of the seminar “Logiciels de qualité : modélisation et vérification” at “Journées scientifiques de l’Université de Nantes”. The seminar had more than 50 participants, from industry and academia.

Moreover, since several years, the AtlandMod team is already very involved in the open source community, notably via its constant activity within the context of the Eclipse Foundation. This activity actually takes different forms: creation and leading/development of Eclipse projects (under *Eclipse.org* or *Eclipse Labs*), participation to the major worldwide community events (i.e.; EclipseCon North America and EclipseCon Europe), organization of events targeting the local community (i.e. Eclipse DemoCamps), etc.

This year again, the team has been active and visible in terms of concrete contributions to the community. The main remarkable items are the following ones:

- Leading of the MDT MoDisco project (Hugo Bruneliere), the Eclipse reference project concerning model-driven reverse engineering;
- Commitment to other projects directly under *Eclipse.org*: MMT ATL and EMFT EMF Facet (Hugo Bruneliere);
- Commitment to other projects under *EclipseLabs*: EMFTToCSP (Jordi Cabot, Carlos Gonzalez) and Virtual EMF (Caue Clasen, Jordi Cabot);
- Creation and development of a new incubation project under *Eclipse Labs*: Collaboro (Javier Canovas);
- Organization of an official Eclipse DemoCamp in Nantes, on the 28th of June 2012, for locally promoting the Eclipse Juno release including the MoDisco, ATL and EMF Facet team’s projects (Hugo Bruneliere, in collaboration with the Obeo company);
- Publication of a paper on MoDisco in the European ERCIM NEWS Journal 88, dedicated to Software Evolution (Hugo Bruneliere and Jordi Cabot, in collaboration with the Mia-Software company);
- Presentation of talks during the two main Eclipse events (Hugo Bruneliere): at EclipseCon North America 2012 about EMF Facet, at EclipseCon Europe 2012 about Collaboro.

Generally, the team visible presence under Eclipse is also an efficient way to continue active collaborations with industrial partners, such as Mia-Software (Sodifrance) on MoDisco - EMF Facet, and Obeo on ATL.

10. Bibliography

Major publications by the team in recent years

- [1] M. ALBERT, J. CABOT, C. GÓMEZ, V. PELECHANO. *Automatic generation of basic behavior schemas from UML class diagrams*, in "Software and System Modeling", 2010, vol. 9, n^o 1, pp. 47-67
- [2] D. AMELLER, C. AYALA, J. CABOT, X. FRANCH. *Non-functional Requirements in Architectural Decision Making*, in "IEEE Software", March 2013, vol. 30, n^o 2, pp. 61-67, <http://hal.inria.fr/hal-00822203>
- [3] H. BRUNELIÈRE. *An Open Source-Based Approach for Industrializing Research Tools*, in "OW2Con 2011, Session "Open Source Innovation Catalyst" - ICT Labs, IRILL", Paris, Issy Les Moulineaux, France, November 2011, <http://hal.inria.fr/hal-00639559/en>
- [4] J. BÉZIVIN, F. BUETTNER, M. GOGOLLA, F. JOUAULT, I. KURTEV, A. LINDOW. *Model Transformations? Transformation Models!*, in "Model Driven Engineering Languages and Systems, 9th International Conference, MoDELS", Genova, Italy, LNCS, Springer Berlin / Heidelberg, October 1-6 2006, n^o 4199, pp. 440–453
- [5] J. CABOT, R. CLARISÓ, E. GUERRA, J. DE LARA. *Verification and validation of declarative model-to-model transformations through invariants*, in "Journal of Systems and Software", 2010, vol. 83, n^o 2, pp. 283-302
- [6] J. CABOT, R. PAU, R. RAVENTÓS. *From UML/OCL to SBVR specifications: A challenging transformation*, in "Inf. Syst.", 2010, vol. 35, n^o 4, pp. 417-440
- [7] J. CANOVAS, F. JOUAULT, J. CABOT, J. GARCIA MOLINA. *API2MoL: Automating the building of bridges between APIs and Model-Driven Engineering*, in "Information and Software Technology", October 2011 [DOI : 10.1016/J.INFSOF.2011.09.006], <http://hal.inria.fr/hal-00642154/en/>
- [8] F. JOUAULT, F. ALLILAIRE, J. BÉZIVIN, I. KURTEV. *ATL: a Model Transformation Tool*, in "Science of Computer Programming", 2008, vol. 72, n^o 3, Special Issue on Second issue of experimental software and toolkits (EST), pp. 31–39
- [9] B. MARCO, J. CABOT, M. WIMMER. , *Model-Driven Software Engineering in Practice*, Morgan & Claypool, September 2012, 182 p. , <http://hal.inria.fr/hal-00755006>
- [10] A. VIGNAGA, F. JOUAULT, M. C. BASTARRICA, H. BRUNELIÈRE. *Typing artifacts in megamodeling*, in "Springer Journal on Software and Systems Modeling", February 2011, vol. 10, n^o 1 [DOI : 10.1007/s10270-011-0191-2], <http://www.springerlink.com/content/j212100qq405n5q1/>, <http://hal.archives-ouvertes.fr/hal-00589277/en/>

Publications of the year

Articles in International Peer-Reviewed Journals

- [11] D. AMELLER, C. AYALA, J. CABOT, X. FRANCH. *Non-functional Requirements in Architectural Decision Making*, in "IEEE Software", March 2013, vol. 30, n^o 2, pp. 61-67, <http://hal.inria.fr/hal-00822203>

- [12] F. BÜTTNER, U. BARTELS, L. HAMANN, O. HOFRICHTER, M. KUHLMANN, M. GOGOLLA, L. RABE, F. STEIMKE, Y. RABENSTEIN, A. STOSIEK. *Model-driven Standardization of Public Authority Data Interchange*, in "Science of Computer Programming", 2013 [DOI : 10.1016/j.scico.2013.03.009], <http://hal.inria.fr/hal-00814982>
- [13] F. BÜTTNER, J. CABOT. *Lightweight String Reasoning in Model Finding*, in "Software and Systems Modeling", 2013 [DOI : 10.1007/s10270-013-0332-x], <http://hal.inria.fr/hal-00814991>
- [14] F. BÜTTNER, M. GOGOLLA. *On OCL-based Imperative Languages*, in "Science of Computer Programming", October 2013, <http://hal.inria.fr/hal-00876206>
- [15] J. S. CUADRADO, J. CANOVAS, J. GARCIA MOLINA. *Applying model-driven engineering in small software enterprises*, in "Science of Computer Programming", May 2013, <http://hal.inria.fr/hal-00869356>
- [16] O. DIAZ, G. PUENTE, J. CANOVAS, J. GARCIA MOLINA. *Harvesting models from web 2.0 databases*, in "Software and Systems Modeling", February 2013, vol. 12, n^o 1, pp. 15-34 [DOI : 10.1007/s10270-011-0194-z], <http://hal.inria.fr/hal-00823323>
- [17] G.-A. JOAQUIN, C. FRÉDÉRIC, C.-B. NORA, S. MARTÍNEZ PÉREZ, J. CABOT. *Management of stateful firewall misconfiguration*, in "Computers & Security", February 2013, <http://hal.inria.fr/hal-00869328>
- [18] A. VIGNAGA, F. JOUAULT, M. C. BASTARRICA, H. BRUNELIÈRE. *Typing artifacts in megamodeling*, in "Springer Journal on Software and Systems Modeling", February 2013, vol. 12, n^o 1 [DOI : 10.1007/s10270-011-0191-2], <http://link.springer.com/article/10.1007%2Fs10270-011-0191-2>, <http://hal.inria.fr/hal-00589277>

International Conferences with Proceedings

- [19] A. BERGMAYR, H. BRUNELIÈRE, J. CANOVAS, J. GORRONGOITIA, G. KOUSIOURIS, K. DIMOSTHENIS, P. LANGER, A. MENYCHTAS, L. ORUE-ECHEVARRIA, C. PEZUELA, M. WIMMER. *Migrating Legacy Software to the Cloud with ARTIST*, in "17th European Conference on Software Maintenance and Reengineering", Genova, Italy, March 2013, <http://hal.inria.fr/hal-00869268>
- [20] H. BRUNELIÈRE, J. CABOT, S. DRAPEAU, F. SOMDA, W. PIERS, J. D. VILLA CALLE, J.-C. LAFAURIE. *MDE Support for Enterprise Architecture in an Industrial Context: the TEAP Framework Experience*, in "TowArds the Model DrIveN Organization (AMINO 2013) workshop - a MODELS 2013 Satellite Event", Miami, United States, September 2013, <http://hal.inria.fr/hal-00869282>
- [21] F. BÜTTNER, M. EGEE, E. GUERRA, J. DE LARA. *Checking Model Transformation Refinement*, in "International Conference on Model Transformation (ICMT)", Budapest, Hungary, Springer, 2013, <http://hal.inria.fr/hal-00815008>
- [22] J. CANOVAS, J. CABOT. *Discovering Implicit Schemas in JSON Data*, in "International Conference on Web Engineering", Aalborg, Denmark, July 2013, <http://hal.inria.fr/hal-00818945>
- [23] J. CANOVAS, J. CABOT. *Enabling the Collaborative Definition of DSMLs*, in "International Conference on Advanced Information Systems Engineering", Valence, Spain, June 2013, <http://hal.inria.fr/hal-00818943>

- [24] J. CANOVAS, J. CABOT, J. LÓPEZ-FERNÁNDEZ, J. S. CUADRADO, E. GUERRA, J. DE LARA. *Engaging End-Users in the Collaborative Development of Domain-Specific Modelling Languages*, in "International Conference on Cooperative Design, Visualization & Engineering", Mayorca, Spain, September 2013, <http://hal.inria.fr/hal-00869347>
- [25] V. COSENTINO, J. CABOT, P. ALBERT, P. BAUQUEL, J. PERRONNET. *Extracting Business Rules from COBOL: A Model-Based Framework*, in "Working Conference on Reverse Engineering", Koblenz, Germany, October 2013, <http://hal.inria.fr/hal-00869235>
- [26] V. COSENTINO, J. CABOT, P. ALBERT, P. BAUQUEL, J. PERRONNET. *Extracting Business Rules from COBOL: A Model-Based Tool*, in "Working Conference on Reverse Engineering", Koblenz, Germany, October 2013, <http://hal.inria.fr/hal-00869236>
- [27] V. COSENTINO, S. MARTINEZ. *Extracting UML/OCL Integrity Constraints and Derived Types from Relational Databases*, in "13th International Workshop on OCL, Model Constraint and Query Languages", Miami, United States, October 2013, <http://hal.inria.fr/hal-00869231>
- [28] V. COSENTINO, M. TISI, F. BÜTTNER. *Analyzing Flowgraphs with ATL*, in "Transformation Tool Contest", Budapest, Hungary, June 2013, <http://hal.inria.fr/hal-00819075>
- [29] D.-H. DANG, J. CABOT. *Automating Inference of OCL Business Rules from User Scenarios*, in "APSEC - 20th Asia-Pacific Software Engineering Conference - 2013", Bangkok, Thailand, P. MUENCHASRI, G. ROTHERMEL (editors), IEEE, 2013, <http://hal.inria.fr/hal-00869234>
- [30] M. GOGOLLA, F. BÜTTNER, J. CABOT. *Initiating a Benchmark for UML and OCL Analysis Tools*, in "International Conference on Tests & Proofs (TAP)", Budapest, Hungary, Lecture Notes in Computer Science, Springer, 2013, <http://hal.inria.fr/hal-00815040>
- [31] D. KOLOVOS, L. ROSE, N. MATRAGKAS, R. PAIGE, E. GUERRA, J. S. CUADRADO, J. DE LARA, I. RATH, D. VARRO, M. TISI, J. CABOT. *A research roadmap towards achieving scalability in model driven engineering*, in "Proceedings of the Workshop on Scalability in Model Driven Engineering", Budapest, Hungary, ACM, 2013, 2:1 p. [DOI : 10.1145/2487766.2487768], <http://hal.inria.fr/hal-00869267>
- [32] S. MARTÍNEZ PÉREZ, V. COSENTINO, C. FRÉDÉRIC, J. CABOT. *Reverse Engineering of Database Security Policies*, in "Database and Expert Systems Applications - DEXA 2013", Prague, Czech Republic, August 2013, pp. 442-449, <http://hal.inria.fr/hal-00869283>
- [33] S. MARTÍNEZ PÉREZ, G.-A. JOAQUIN, C. FRÉDÉRIC, C.-B. NORA, J. CABOT. *Model-Driven Extraction and Analysis of Network Security Policies*, in "Model-Driven Engineering Languages and Systems - 16th International Conference, MODELS 2013", Miami, United States, September 2013, pp. 52-68, <http://hal.inria.fr/hal-00869319>
- [34] S. MARTÍNEZ PÉREZ, G.-A. JOAQUIN, C. FRÉDÉRIC, C.-B. NORA, J. CABOT. *Towards an Access-Control Metamodel for Web Content Management Systems*, in "Model-Driven Web Engineering MDWE 2013", Aalborg, Denmark, July 2013, <http://hal.inria.fr/hal-00869324>
- [35] A. MENYCHTAS, C. SANTZARIDOU, G. KOUSIOURIS, T. VARVARIGOU, L. ORUE-ECHEVARRIA, J. ALONSO, J. GORRONGOITIA, H. BRUNELIÈRE, O. STRAUSS, T. SENKOVA, B. PELLENS, P. STUER. *ARTIST Methodology and Framework: A novel approach for the migration of legacy software on the Cloud*,

in "2nd Workshop on Management of resources and services In Cloud And Sky computing (MICAS 2013)", Timisoara, Romania, September 2013, <http://hal.inria.fr/hal-00869276>

- [36] G. SELIM, F. BÜTTNER, J. R. CORDY, J. DINGEL, S. WANG. *Automated Verification of Model Transformations in the Automotive Industry*, in "Model Driven Engineering Languages and Systems, 16th International Conference, MODELS 2013", Miami, United States, A. MOREIRA, B. SCHAETZ (editors), Springer, 2013, <http://hal.inria.fr/hal-00834058>
- [37] M. TISI, S. MARTINEZ, H. CHOURA. *Parallel Execution of ATL Transformation Rules*, in "MoDELS", Miami, United States, 2013, pp. 656-672, <http://hal.inria.fr/hal-00869269>

National Conferences with Proceedings

- [38] J. CANOVAS, S. TRUJILLO. *Retos Actuales en el Desarrollo de Lenguajes Específicos del Dominio*, in "Jornadas en Ingeniería del Software y Bases de Datos", Madrid, Spain, September 2013, <http://hal.inria.fr/hal-00869352>
- [39] V. COSENTINO, P. BAUQUEL, J. PERRONNET, P. ALBERT, J. CABOT. *Un Framework dirigé par les modèles pour l'extraction de règles métier à partir d'applications COBOL*, in "CIEL", Nancy, France, April 2013, <http://hal.inria.fr/hal-00815207>

Conferences without Proceedings

- [40] H. BRUNELIÈRE. *Introducing Collaboro: Collaborative DSL/DSML Definition*, in "EclipseCon France 2013", Toulouse, France, June 2013, <http://hal.inria.fr/hal-00869270>

References in notes

- [41] M. BARBERO, F. JOUAULT, J. BÉZIVIN. *Model Driven Management of Complex Systems: Implementing the Macroscopic's vision*, in "Proceedings of the 15th Annual IEEE International Conference and Workshop on Engineering of Computer Based Systems (ECBS 2008), 31 March - 4 April 2008, Belfast, Northern Ireland", IEEE Computer Society, 2008, pp. 277-286
- [42] J. BÉZIVIN. *From Object Composition to Model Transformation with the MDA*, in "TOOLS '01: Proceedings of the 39th International Conference and Exhibition on Technology of Object-Oriented Languages and Systems (TOOLS39)", Washington, DC, USA, IEEE Computer Society, 2001, pp. 350-354
- [43] J. BÉZIVIN. *On the Unification Power of Models*, in "Software and System Modeling", 2005, vol. 4, n° 2, pp. 171-188
- [44] J. BÉZIVIN, O. GERBÉ. *Towards a Precise Definition of the OMG/MDA Framework*, in "ASE'01, Automated Software Engineering", San Diego, USA, IEEE Computer Society Press, 2001, pp. 273-280
- [45] J. BÉZIVIN, R. HECKEL. *04101 Summary – Language Engineering for Model-driven Software Development*, in "Language Engineering for Model-Driven Software Development", Dagstuhl, Germany, J. BÉZIVIN, R. HECKEL (editors), Dagstuhl Seminar Proceedings, Internationales Begegnungs- und Forschungszentrum für Informatik (IBFI), Schloss Dagstuhl, Germany, 2005, n° 04101
- [46] J. BÉZIVIN, F. JOUAULT. *Using ATL for Checking Models*, in "Proceedings of the International Workshop on Graph and Model Transformation (GraMoT)", Tallinn, Estonia, 2005

-
- [47] J. CABOT, R. CLARISÓ, D. RIERA. *UMLtoCSP: a tool for the formal verification of UML/OCL models using constraint programming*, in "ASE", R. E. K. STIREWALT, A. EGYED, B. FISCHER (editors), ACM, 2007, pp. 547-548
- [48] G. CANFORA, M. DI PENTA, L. CERULO. *Achievements and challenges in software reverse engineering*, in "Commun. ACM", April 2011, vol. 54, pp. 142–151, <http://doi.acm.org/10.1145/1924421.1924451>
- [49] M. DIDONET DEL FABRO, J. BÉZIVIN, F. JOUAULT, P. VALDURIEZ. *Applying Generic Model Management to Data Mapping*, in "Proceedings of the Journées Bases de Données Avancées (BDA05)", 2005
- [50] F. JOUAULT, J. BÉZIVIN. *KM3: a DSL for Metamodel Specification*, in "Proceedings of 8th IFIP International Conference on Formal Methods for Open Object-Based Distributed Systems, LNCS 4037", Bologna, Italy, 2006, pp. 171–185
- [51] I. KURTEV, J. BÉZIVIN, F. JOUAULT, P. VALDURIEZ. *Model-based DSL Frameworks*, in "Companion to the 21st Annual ACM SIGPLAN Conference on Object-Oriented Programming, Systems, Languages, and Applications, OOPSLA 2006, October 22-26, 2006, Portland, OR, USA", ACM, 2006, pp. 602–616