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Team AtlanMod

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Production, Operation, and Evolution*

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1. Team

Faculty Members

Jean Bézivin [Team Leader, until June 2010, Professor, HDR]

Jordi Cabot [Team Leader, since July 2010, Associate Professor, École des mines de Nantes]

Frédéric Jouault [Associate Professor, École des mines de Nantes]

Massimo Tisi [Associate Professor, since September 2010, École des mines de Nantes, INRIA PostDoc before]

Technical Staff

Hugo Brunelière [Engineer, École des mines de Nantes since March 2010, INRIA Modelplex until February 2010]

Guillaume Doux [Engineer, IDM++, Université de Nantes]

Vincent Mahé [Engineer, IDM++, since May 2010, Université de Nantes]

Jean-Sébastien Sottet [Engineer, Lambda, until April 2010]

Cauê Avila Clasen [Engineer, CESAR]

Salvador Martínez Perez [Engineer, since April 2010, OPEES]

Wolfgang Kling [Engineer since February 2010, ARMINES, GALAXY, Internship before February 2010]

Carlos Gonzalez [Engineer, CESAR, since November 2010]

PhD Student

Kelly Garcés [until September 2010, Collaboration with Ascola, ARMINES]

Post-Doctoral Fellow

Robert Tairas [since November 2010]

Visiting Scientists

Javier Canovas [from April to July 2010]

Soichiro Hidaka [May 2010]

Administrative Assistant

Hanane Maaroufi [Part-time]

Other

Francisco Murcia [Internship since September 2010]

2. Overall Objectives

2.1. Presentation

Model Driven Engineering (MDE) is a software engineering paradigm that advocates for the rigorous use of (software) models 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. The basic assumption of MDE is that the classical programming code is often not at the right representation level for managing all these facets even if, at some point of the process, executable code will usually be generated from some abstract representation level. It has been shown that adoption of MDE increases productivity and quality of the software systems under development.

In this sense, AtlanMod is developing pioneering solutions to solve core research challenges in MDE and to ensure its successful application on relevant industrial problems.

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 has progressively developed a complete modeling framework [45] [9] that is now well accepted in the scientific community. This framework provides core MDE components (described in several research papers e.g., [4] [5] [47] [49] [3]) for (meta)model definition and manipulation. The iterative definition of this conceptual framework has been validated by the construction of several experimental concrete toolboxes. The first generation (sNets, based on semantic networks) was built in Smalltalk in the 90's [43]. The second one is the current AmmA (for AtlanMod Model Management Architecture) toolbox available in Eclipse. This is at the same time a research platform and an industrial toolbox.

The AmmA platform is based on the conclusion that MDE is in fact a branch of language engineering (this was one of the outcomes of a Dagstuhl school that we co-organized in 2004 [44]). More precisely a metamodel is now considered as the definition of the abstract syntax of a language, usually a Domain Specific Language (DSL). This idea is central in the AmmA toolbox that may be viewed as a DSL building framework composed itself of a number of primitive DSLs. The four most known AmmA DSLs are KM3 [4] (a DSL for metamodel specification), TCS [5] (a DSL for textual syntaxes), ATL [7] [6] (a DSL for model transformation), and AMW [49] (a DSL for representing model correspondences). All these mutually dependent tools are available under *Eclipse.org* (projects or components: M2M, ATL, TMF, MoDisco, AM3, AMW). They are currently in use in research, teaching, and industry and they have a broad user community.

2.3. Highlights

The following item list describes the main highlights of the year for the AtlanMod team:

- Opening of new research lines (Modeling as a Service, Quality of models, process and people aspects of MDE, and Model-Driven Cartography focused on the Business-IT alignment industrial challenge).
- Changes on the team structure and leadership. Jordi Cabot replaces Jean Bézivin as team leader in July. Two more permanent members join the team (a research engineer and an associate professor) plus an INRIA postdoc and several research engineers linked to the team's projects.
- First edition of the MDE diploma: a Post-Master's Specialization in Model Driven Engineering officially recognized by the French Ministry of Industry

3. Scientific Foundations

3.1. MDE Foundations

MDE can be seen as a generalization and abstraction of object technology allowing to map more abstract organizations on class-based implementations. In MDE, (software) models are considered as the unifying concept [45].

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. Therefore, 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 metamodel. 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 metamodel 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 [4] and [46]. 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 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. One of the first papers to discuss metamodel-based transformation was [10].

Many other operations may be considered as transformations as well. For example verifications or measurements on a model can be expressed as transformations [47]. 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 [1]. This means that the transformation program Mt can be expressed as a model and as such conforms to a metamodel MMt . This allows a 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 [44]. 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 (with KM3 for example [4]). Models specified with those DSLs can then be manipulated by means of model transformations (with ATL for example [3]).

When following the previously described principles, one may take advantage of the uniformity of the MDE organization. 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. Considering models of products (e.g., software artifacts like UML) and models of processes (e.g., software processes like SPEM) may lead to a dual process/product organization. Considering transformation models, weaving models, and

traceability models as special cases of correspondence models may also lead to simplicity and efficiency of implementations. These are some of the use cases that are being explored in the team.

4. Application Domains

4.1. Introduction

It is difficult to define a precise applicability domain for MDE because, by definition, the scope is the largest. Generic tools developed by the AtlanMod team may apply as well to information systems and to embedded systems. MDE is not even restricted to software engineering, but also applies to data engineering [48] and to system engineering [41]. There are a lot of problems in these application domains that may be addressed by model transformation techniques.

The AmmA tools are being currently used in projects related to embedded systems, like Lambda, Edona, OPEES, etc. The domains addressed by these projects are mainly automotive, aeronautics, and transportation. Since our tools are offered as open-source, we may notice that several groups have used them in quite different areas like: Critical software, Real time, Formal methods, Web engineering, Ontology engineering, Web semantics, etc.

In the next sections we focus on three specially interesting domains on which we have applied our MDE techniques.

4.2. Reverse Engineering

One important and original domain that is being investigated by the AtlanMod team is the reverse engineering of legacy code. Here again this spans through a spectrum of application domains, the legacy being coded in such languages as ADA, Java, COBOL, C, C++ or even FORTRAN. We have shown how the reverse engineering practices may be advantageously revisited with the help of MDE and open-source tooling. The team has set up the MoDisco project [21][38][40] (see 5.5) under *Eclipse.org* to investigate this and to federate the international research efforts in this domain. The main idea is that a metamodel may precisely express what we want to extract from a low-level legacy code. For example we can define a rational process to extract business rules from COBOL legacy programs. The rise in abstraction allowed by MDE may bring new hopes that reverse engineering can now move beyond ad-hoc practices. The MoDisco Eclipse project is being referenced by the OMG ADM (Architecture-Driven Modernization) normalization initiative.

4.3. Model-driven System Interoperability

Historically the first application area of MDE was code generation from abstract models. A typical example is generation of Java code from UML models or of platform-dependent from platform-independent software artifacts. As discussed above, the subject of reverse engineering was the second major historical application field for MDE, with the discovery of structured precise models from heterogeneous and often unstructured systems.

In the recent period however, MDE has been used as a solution for system interoperability. In this new context, transformations are performed while systems are in execution. For example, a set of transformations may keep two different tools synchronized, by exchange of structured data or even by interpretation of complex events. This approach revisits tool interoperability by explicitly representing the associated metamodels (if needed, deduced from the tool API or storage format), defining mappings between them and using those mappings to automatically generate transformations between them. Our proposal to the CESAR (see 7.6) reference technology platform uses these ideas for defining the notion of virtual tool. The establishment of correspondences between technical spaces (e.g., Eclipse Modeling and Microsoft DSL tools or OSLO [20]) follows a similar schema.

4.4. Model-Driven Cartography

A new important topic AtlanMod started investigating on this year is how to use Model-Driven Engineering concepts and techniques to solve cartography problems. In both the business and IT worlds, companies are now using many different software tools covering multiple inter-connected domains and related features. Because of the high complexity and heterogeneity of these organizations, it is more and more important to be able to have a real clear vision of the actual situation in terms of considered tools and various relationships (either already existing or potential) between them. The representation and use of this knowledge, called Cartography, is fundamental in the process of evaluating/measuring deployed architectures, but also for specifying their future evolutions or even elaborating on brand new solutions. Having a clear and comprehensible cartography of a given situation is also required in many other contexts such as reverse engineering or tool interoperability in general, which are domains we are also actively working on. The main challenge raised by this general problem is about the effective management and understanding of a possible huge amount of metadata on all the considered software artifacts. These metadata can be of various and varied kinds, depending on the targeted goal(s) and the corresponding chosen viewpoint(s). Related to this problem, AtlanMod has notably worked on a Model-Driven Cartography prototype named Portolan, and also experimented on cartography visualizations [31].

5. Software

5.1. Introduction

The scheme followed until now by the team to develop high quality software that may attract a large user base (with the benefits this provides: visibility, feedback,...) consist in 1 - identifying relevant research problems for which we develop an initial proof of concept, 2 - releasing the proof of concept as open source contribution to the community and integrate its feedback, 3 - promote it towards a normalization status (*de jure* or *de facto*) and 4 - if the proof of concept becomes successful and starts to attract a large user base we partner with a technology provide to create a commercial-quality level (but still open source) version of the tool. This last step is necessary because, technical quality is just one of the many factors that companies analyze when deciding whether to take the risk of adopting a new tool. Examples of other factors that influence this decision are: user support, good documentation or usability aspects. Research groups cannot invest resources on these non-core research aspects. The technology provider can help the research group developing these aspects in exchange of visibility and the possibility of selling services around the tool [37].

The most ancient tool developed in the team is the ATL model transformation language. In this case the transfer state has been recently reached and we are presently working on the last phase of the process. MoDisco is approaching the same status and other tools of the team are following the same path.

We name AmmA (see 5.8) the set of software tools developed by the AtlanMod team. Until now we have used the Eclipse foundation as underlying platform of all our tools but we may consider alternative platforms in the future (see as an example our new Modeling as a Service initiative [36]).

For each tool we just indicate the main contact since most team members contribute at one point or the other in the development of several tools.

5.2. The ATL Model Transformation Language

Participant: Frédéric Jouault [contact].

URL: <http://www.eclipse.org/m2m/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].

Due to the previous iterations, the architecture of the ATL model transformation language is highly modular and based on a generic model engineering virtual machine and on a bootstrapped compiler itself running on this virtual machine. The central idea in Frédéric Jouault's Ph.D. thesis [50] of using MDE tools to build other MDE tools (or using DSLs to build other DSLs) has been quite productive. Seeking conceptual simplicity also led to implementation efficiency since ATL currently provides one of the most efficient solutions for model transformation.

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.

5.3. AMW (AtlanMod Model Weaver)

Participant: Frédéric Jouault [contact].

URL: <http://www.eclipse.org/gmt/amw/>

AMW is a component-based platform for model weaving that can be used to establish and manage abstract correspondences between models. The platform is generic and based on the Eclipse contribution mechanism: components are defined in separate plugins. The plugins are further interconnected to create the model weaver workbench. Components for user interface, matching algorithms and serialization of models may be plugged as necessary. We extended the Eclipse EMF architecture for model manipulation to coordinate the weaving actions. We use the EMF reflective API to obtain a standard weaving editor which adapts its interface according to metamodels modifications. The ATL transformation engine is plugged as the standard transformation platform. AMW is released as open-source software under the Eclipse Public License and available as an Eclipse plugin. AMW is being used by more than 40 user sites, including research labs and major companies (NASA, BAE, Versata, Obeo, etc.).

5.4. TCS (Textual Concrete Syntax)

Participant: Frédéric Jouault [contact].

URL: <http://www.eclipse.org/gmt/tcs/>

It is often necessary to define concrete syntaxes for metamodels, which only define abstract syntaxes. TCS is a language in which context-free concrete syntaxes can be defined by specifying how each concept of a metamodel is represented textually. Once such a definition has been defined in the form of a TCS model, it is possible to: 1) parse programs into models, 2) pretty-print models into programs, and 3) edit programs with a rich text editor supporting syntax highlighting, code completion, outline, text hovers, hyperlinks, etc. Many textual languages have already been specified with TCS: 1) within AmmA (see 5.8) with ATL, KM3, TCS itself, etc. 2) in other contexts with SQL, LOTOS, EBNF, etc. TCS currently generates ANTLR v3 grammars that are LL(*).

5.5. MoDisco (Model Discovery)

Participant: Hugo Brunelière [contact].

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

MoDisco (for Model Discovery) is an Eclipse component that gathers contribution from several academic and industrial partners in the field of model driven reverse engineering. The goal of the project is to federate common efforts in the transformation of legacy systems into models. The extraction process is metamodel driven, i.e. (1) all extracted models conform to a given metamodel and (2) the discoverer itself is generated from the metamodel, usually in a semi-automatic way. In some cases the legacy system is structured which greatly facilitates model extraction. For example if the legacy is composed of code (e.g., ADA, COBOL, Java, Visual Basic, etc.), the grammar and the target metamodel may be jointly used in order to generate the discoverer. Once the model has been extracted from the legacy, it can be measured, understood or manipulated by way of model transformations in languages like ATL. MoDisco has close relations with the OMG Architecture Driven Modernization (ADM) Task Force, for which the project provides reference implementations of its main standards like the Knowledge Discovery Metamodel (KDM), Software Measurement Metamodel (SMM) and others to come. Moreover, the Eclipse EMFT EMF Facet project has been very recently 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. The goal of EMF Facet (<http://www.eclipse.org/modeling/emft/facet/>) is to work on providing a generic and dynamic (i.e. the original model is actually not altered) model extension mechanism, based on the runtime execution of queries (possibly in ATL, OCL, Java, etc) on the extended model(s).

5.6. AM3 (AtlanMod MegaModel Management)

Participant: Hugo Brunelière [contact].

URL: <http://wiki.eclipse.org/index.php/AM3>

The AtlanMod Megamodel Management tool offers several functionalities for modeling in the large [2], i.e. for handling several related models (either terminal models, metamodels or transformation models) that can be reused. The main component in AM3 is a generic megamodel manager that allows the user to browse and manipulate a set of related models. This manager knows the semantic relations between all these models. These relations are often associated to a given weaving model allowing not only navigating the traces between models, but also the traces between model elements. Since the links are stored externally as weaving models, the participating models do not get polluted and may be used as they are. Furthermore it is possible to handle multiple traceability chains going through similar models. The generic tool for megamodel management has been used by different partners for several use cases like operationalization of chains of transformations.

5.7. Portolan (Model-Driven Cartography)

Participant: Hugo Brunelière [contact].

URL: http://www.emn.fr/z-info/atlanmod/index.php/Model-Driven_Cartography

Model-Driven Engineering (MDE), with its simple core principles and set of base generic techniques (meta-modeling, model transformation, model weaving, etc), provides the relevant support for designing and implementing Cartography solutions. The proposed Portolan prototype is a concrete illustration of both a model-based and model-driven Cartography platform. Thus, the objective of Portolan is to facilitate the identification of interoperability solutions between tools by: 1) discovering (at least semi-automatically) maps of given situations in terms of deployed tools and relationships between them; 2) easily navigating and editing these maps; 3) augmenting or specializing them with both manually-entered and computed information; 4) visualizing them, using different customizable ways, in order to facilitate their understanding. This recently developed generic tooling for cartography has already been used during the first action of our collaboration with BNP Paribas, as well as in the context of the IDM++ project.

5.8. The AmmA ToolBox

ATL, AMW, TCS, MoDisco, and AM3 are among the most important *Eclipse.org* components produced by the AtlanMod team. However there are also other components and a lot of functionalities, examples, and use cases made available and necessary to express solutions to many problems. The whole set of contributions composes the AmmA platform.

6. New Results

6.1. Model Transformation

Model transformation and in particular our ATL model transformation language continues playing a key role in our MDE strategy. During 2010 the new results on this area have been:

- The development of an execution algorithm for live incrementality in ATL, with the implementation of a prototype, to immediately propagate to the target model any change performed to the source model (avoiding the complete recomputation of the target model from scratch) [28].
- An improvement in the productivity of HOT development in ATL, obtained by analyzing the set of public transformations from our user base, detecting recurrent and time-expensive patterns, and proposing an alternative for them in the form of a HOT library and some extensions to the ATL language [34].
- Formalization of our industrialization strategy for ATL [37]. The resources freed in this process are invested in pursuing research on model transformation.

Additionally, we applied model transformation to two new areas:

- Performance engineering [35], with complex transformation chains.
- Aspect weaving [15] by transforming aspect specification into corresponding program transformation specification using higher-order model transformation.

6.2. Model Weaving and Model Matching

During 2010, we improved our results in model matching. The AtlanMod Matching Language [11] (AML) was notably compared to other model migration tools [33]. Additionally, we leveraged Global Model Management techniques (see 6.3) in order to automatically evaluate the quality of AML output [27].

6.3. Global Model Management

In order to represent metadata about model transformation more accurately, we have worked on a functional typing system for megamodeling [16]. The basic idea is to consider transformations as functions, and to give them functional types. With this approach, Higher-Order Transformations can notably be represented correctly: their output is not simply a transformation model, but a model transformation as well [1].

We have also used model weaving and Global Model Management (GMM) jointly in order to better support inter-DSL coordination [29].

Finally, we have applied GMM to a problem outside of MDE: the management of Eclipse plugins [39]. This work notably demonstrates that megamodeling may be used to represent non-MDE systems, and to operate on them.

6.4. Model-driven interoperability

In 2010, we have made some progress in the understanding of how MDE may be used to represent tools in order to enable interoperability between them [22] and applied this knowledge to the specific scenario of bridging the Eclipse and Microsoft modeling tools [20]. This scenario is specially challenging since the interoperability must be achieved both at the model and metamodel levels.

We have also experimented with reuse and interoperability of two graphical tools [14]: Graphviz¹, and GMF² (Graphical Modeling Framework).

¹<http://www.graphviz.org/>

²<http://www.eclipse.org/modeling/gmp/>

6.5. Reverse Engineering

With the end of the ModelPlex project we have consolidated and promoted the results achieved in our MoDisco Model-driven reverse engineering project [21][38][40]

6.6. Modeling and the web

During this year, we have launched the MaaS (Modeling as a Service) initiative [36] where we explore the possibility of providing modeling and model-driven engineering services from the cloud. Some topics that would fit in this area would be: collaborative and distributed modeling tools, model transformation engines in the cloud, modeling mash-ups (combining model-driven engineering services from different providers), global model management and scalable model-based services in the cloud to deal with very large models and model transformations.

Apart from the previous topic (focused on using the web and the cloud for modeling), we have also worked on applying MDE to solve web engineering problems:

- Development of safe web interface interactions [18].
- Management and synchronization of tests written at the different abstraction levels (computation-independent, platform-independent and platform-specific) of a model-driven Web application [32].
- Definition of a search engine on heterogeneous sources (following the paradigm of *Search Computing*), using a model-driven perspective [19].

6.7. Social aspects of MDE

All the technical work on MDE must be complemented with a better understanding of how users apply MDE in practice. Otherwise we may end up designing techniques that do not fit their needs. This is even more important for companies willing to adopt MDE. We must carefully analyze the social and organizational changes that companies must undergo in order to successfully introduce MDE techniques as an important part of their development processes. This part has been largely ignored and causes the failure of many MDE projects. In particular, during this year we have been working on the following aspects:

- Integrating non-functional aspects in model-driven development processes to ensure that the quality properties of the system at run-time satisfy the user expectations [17]
- Proposing a new approach for modeling software processes that helps companies to visualize and understand the (social) requirements imposed by a software process [25] and to adapt the process to their own reality [26].
- Increasing the expressivity of modeling languages to facilitate the task of designers. In particular we have targeted the design of datawarehouses [24].

6.8. Quality in MDE

In MDE, quality of modeling artifacts (models, metamodels,...) have a direct effect on the quality of the running system (specially in forward engineering, where the system is automatically generated from the models and thus defect in the models generate defects in the code). During this year we have published some results on the validation and verification of model transformations [13][23] and on the generation of executable operations [12]

7. Contracts and Grants with Industry

7.1. IP Modelplex (2006-2010)

Participants: Hugo Brunelière, Jean Bézivin, Frédéric Jouault.

The MODELPLEX project (<http://www.modelplex.org>), with Thales, IBM, Sodifrance, SAP, etc, aims at defining a coherent infrastructure for the development of complex systems, where complexity corresponds to several factors like size, heterogeneity, dynamic evolution, distribution and subsystem autonomy. Examples of highly heterogeneous systems are legacy systems that have been built and adapted on long period of time, using different technologies. Model driven reverse engineering, global model management (megamodeling) or model transformation for interoperability are also important problems which we addressed more particularly in this project. The project successfully ended with the official final review in May 2010 at the European Commission.

7.2. EDONA, Paris Competitvity Cluster "System@tic" (2007-2010)

Participants: Frédéric Jouault, Jean Bézivin.

The EDONA project (<http://www.edona.fr>), which stands (in French) for Environments of Development Open to the Standards of the Car, is a project of the pole of competitiveness System@tic Paris-Area. It has as an objective the construction of an open platform facilitating the realization of chains of development trade modular, interoperable, and adaptable to the various needs of the actors and trades of the car industry. The project is directed by Renault and the form chosen for EDONA is the creation of a technological platform of reference then its specialization on applicative products of the sector. In this project, the AtlanMod team collaborates with Obeo on the industrialization of ATL.

7.3. IdM++, ANR (2008-2011)

Participants: Jean Bézivin, Hugo Brunelière, Jordi Cabot, Guillaume Doux, Frédéric Jouault, Vincent Mahé.

IdM++ (<http://www.emn.fr/x-info/idmpp/index.php/Accueil>) is a project involving ILOG, CEA, Mia-Software, Prima Solution and AtlanMod. The main goal is to investigate advanced issues in model engineering. The IDM++ consortium proposes the combination of Global Model Management and Model Configuration techniques. This approach is promoted according to the partners background in Model Driven Engineering, Constraint based programming and optimization techniques. The team is particularly in charge of WP 2, on global model management. In this context, the interoperability between various DSLs will be studied. Total allocated budget amounts to 810 kEUR of which the team is sharing 250kEUR on three years.

7.4. Lambda, Paris Competitvity Cluster "System@tic" (2008-2010)

Participants: Jean-Sébastien Sottet, Jean Bézivin, Jordi Cabot.

In the context of embedded software deployed on "off-the-shelf" execution platforms, the LAMBDA project (http://www.usine-logicielle.org/lambda/index_EN.html, System@tic Paris-Region) has two major goals: 1) to demonstrate the technical feasibility and the interest of model libraries by formalizing the key properties of execution platforms, and 2) to reconcile appropriated standards (SysML, MARTE, AADL, IP-XACT) with *de facto* standards (already implemented by widespread analysis and simulation tools). Lambda is a three-year project gathering 14 partners with an overall budget of 5.30 MEUR. LAMBDA means Libraries for Applying Model Based Development Approaches. The project started on June 1, 2008. AtlanMod is involved in Task T2.2: analysis of requirement for scalability and as part of this task has been working on developing performance tests to prove the scalability of MDE technologies.

7.5. CONICYT Chili-INRIA HOT MaTE Project (2008-2010)

Participants: Jean Bézivin, Frédéric Jouault, Hugo Brunelière.

HOT MaTE stands for Higher-Order Transformation Model and Transformation Engineering. This CONICYT-INRIA project is a collaboration with the MaTE research group from the University of Chile. The objective of this project is to advance the state of the art in model transformation, and global model management. In particular, we study how Higher-Order Transformations can be represented in a megamodel, as well as megamodel evolution. Prototypes are developed on the AmmA platform, and more especially using ATL for transformations, and AM3 for megamodeling.

7.6. CESAR, ARTEMIS JOINT UNDERTAKING (2009-2012)

Participants: Jean Bézivin, Frédéric Jouault, Cauê Avila Clasen, Carlos Gonzalez.

CESAR (<http://cesarproject.eu>) stands for Cost-Efficient methods and processes for SAfety Relevant embedded systems, and is a European funded project from ARTEMIS JOINT UNDERTAKING.

The three transportation domains, automotive, aerospace, and rail, as well as the automation domain share the need to develop ultra-reliable embedded systems to meet social demands for increased mobility and safety in a highly competitive global market. To maintain the European leading edge position in the transportation as well as automation market, CESAR aims to boost cost efficiency of embedded systems development and safety and certification processes by an order of magnitude.

CESAR pursues a multi-domain approach integrating large enterprises, suppliers, SME's and vendors of cross sectoral domains and cooperating with leading research organizations and innovative SME's. In particular, we work on the Reference Technology Platform, which aims at tool integration. We propose to achieve tool integration by means of metamodeling and model transformations [20].

7.7. GALAXY, ANR (2010-2013)

Participants: Jean Bézivin, Frédéric Jouault, Wolfgang Kling.

GALAXY (<http://galaxy.lip6.fr>) proposes to deal with the model driven collaborative development of complex systems. It is a French national project funded by ANR (ARPEGE Program), which is carried out by an industrial consortium whose partners are Industry (Airbus), Research and University (Armines -AtlanMod-, IRIT, LIP6) and Vendors and service providers (AKKA, Softeam). 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.

7.8. OPEES, Open Platform for the Engineering of Embedded Systems (2009-2012)

Participants: Jean Bézivin, Jordi Cabot, Salvador Martinez Perez, Massimo Tisi.

OPEES (<http://www.opees.org>) stands for Open Platform for the Engineering of Embedded Systems, and is a European funded project from ITEA2. Its mission statement is "to settle a community and build the necessary means and enablers to ensure long-term availability of innovative engineering technologies in the domain of dependable or critical software-intensive embedded systems". In particular, within OPEES, our schema of open source industrial collaboration [37] (e.g. around ATL) will be tested and developed as a team contribution to this project. AtlanMod is also responsible for providing a model-driven interoperability solution for the integration of the ecosystem of OPEES components, based on metamodeling the domain data of each component and bridging, by model transformation, the specific data representations.

7.9. BNP Paribas collaboration, Action 1 "Continuity between the process modeling and software design" (2010-2011)

Participants: Jean Bézivin, Hugo Brunelière, Jordi Cabot, Vincent Mahé.

This collaboration with the BNP Paribas company started this year with a first collaborative action about studying business process modeling, and more specifically its continuity between the domain (business) and the technological (IT) spaces. Our work in this action is composed of two main parts: 1) a study of the state of the art (in both industry and research worlds, including for instance European projects) also presenting proposals of concrete solutions; 2) the implementation of an extensible Business-IT prototype, following the recommendations of the previously mentioned study. This action is planned to be followed by a next one, during the coming year, targeting other interested topics where MDE and our technologies are relevant and applicable.

7.10. MDE Expertise - Exchanging knowledge, techniques and experiences around Model Driven Engineering education (2010-2012)

Participants: Jordi Cabot, Massimo Tisi.

MDE Expertise (<http://www.learnMDE.org>) is an European Leonardo da Vinci project (LifeLong learning programme) focused on the development of common educational materials for the Model Driven Engineering (MDE) area. The main aim of the project is to transfer and adapt the education in Model Driven Engineering concepts to the local IT education societies of the partner's countries, thus improving the partners' knowledge about up to date current software development methods. This results in the best preparation for professionals competing on the IT market. Direct results include: development of common MDE teaching methods, suited for the partners' local needs and market requirements; creation of teaching materials (with online version) localized for the partners' languages and definition of tools for e-learning and knowledge exchange. Indirect effects include improving the capability of local SMEs in solving complex software design problems through modeling, and evolving the software development job market.

8. Other Grants and Activities

8.1. Regional Initiatives

In 2009, the AtlanMod team initiated a regular series of events called *Les Jeudis des Modèles*³. This event has successfully continued during 2010. Every two months approximately, an international expert from the model engineering community is invited to come and present a subject of research or innovation of interest to the scientific and industrial community. These events typically attract between 60 and 80 researchers, students and industrials. In fact, *Les Jeudis des Modèles* event has become a regional rendez-vous of the model engineering community, attracting people from Rennes, Vannes, La Rochelle, and many other places beyond Nantes. Among others, we have invited Patrick Albert (IBM), Nicolas Rouquette (NASA/JPL), Ed Merks (Macro Modeling), Ivar Jacobson (IJ company), Sridhar Iyengar (IBM) and Jon Whittle (Professor at Lancaster University). It should be noted that these visits allow us to organize different meetings between the researchers of the AtlanMod team and the various industrials attending the main presentation.

As part of our commitment to the Eclipse community, we co-organized (together with the Obeo company) an Eclipse DemoCamp event to celebrate the Eclipse Helios version release. The Eclipse DemoCamps are an opportunity to showcase all of the technology being built by the Eclipse community and, for the team, an excellent opportunity to meet other Eclipse enthusiasts in the region and show them the Eclipse tools developed by the team.

9. Dissemination

9.1. Animation of the scientific community

Participants: Jordi Cabot, Frédéric Jouault, Massimo Tisi.

³<http://www.emn.fr/z-info/jmodeles/>

In 2010, the AtlanMod team has coorganized the following events:

- 2nd International Workshop on Model Transformation with ATL⁴ (MtATL 2010) co-located with the ICMT and Tools conferences in Málaga.
- OCL and Textual Modeling Workshop (OCL'10) co-located with the MoDELS conference in Oslo.
- Model-driven Interoperability (MDI'10) co-located with the MoDELS conference in Oslo.
- Desarrollo de software dirigido por modelos (DSDM'10), Spanish national workshop on MDD

9.2. Editorial Boards and Program Committees

Participation to editorial boards of scientific journals:

- Jean Bézivin: SoSym, IBIS, JOT.
- Jean Bézivin: AITO (ECOOP), TOOLS, ICMT.

Participation to conference program committees:

- Jordi Cabot: WWW'10, MoDELS'10, SLE'10, ECMFA'10, ICECCS'10, ICMT'10, ICWE'10, WEBIST'10, Models and Evolution - MoDELS workshop, Doct. Symp at SLE'10, Effectiveness of MDE - ECMFA workshop, Workshop on Modeling Social Media, TTC'10, ADBIS workshop on MDA, Ed. Symp at MoDELS'10
- Frédéric Jouault: ICMT 2010, MtATL'2010 (chair), GRABATS 2010, LMO'2010.

9.3. PhD and Habilitation Juries

Participants: Jean Bézivin, Jordi Cabot.

Jean Bézivin was a member of the following PhD juries:

- Rick Salay, PhD committee, University of Toronto, Toronto, Canada
- Bert Vanhooft, PhD committee, K.U. Leuven, Heverlee, Belgium
- Vadim Zaytsev, PhD committee, University of Koblenz, Koblenz, Germany

Jordi Cabot was a member of the following PhD juries:

- Pau Giner. PhD committee, Technical University of Valencia, Valencia, Spain
- Marta Ruiz. PhD committee, Technical University of Valencia, Valencia, Spain
- José Eduardo Rivera. PhD committee, University of Málaga, Málaga, Spain

9.4. Involvement in the Eclipse Community

Participants: Jean Bézivin, Frédéric Jouault, Hugo Brunelière, Guillaume Doux, Kelly Garcés.

The Amma platform components are made available on *Eclipse.org* by AtlanMod, which is involved in the Eclipse community as follows:

- Jean Bézivin is project lead of the GMT project.
- Frédéric Jouault is project lead of the M2M (Model-to-Model transformation) and TMF (Textual Modeling Framework) projects as well as lead on M2M/ATL (collaboration with Obeo), and TMF/TCS. He is also committer on GMT/AM3 and GMT/AMW.
- Hugo Brunelière is project lead of MDT/MoDisco (collaboration with Mia-Software), now including the former GMT/AM3. He is also committer on EMFT/EMF Facet (collaboration with Mia-Software) and GMT(responsible for the ongoing GMT project termination's process). He co-organized the Eclipse DemoCamp Helios in Nantes on the 9th of July 2010 (collaborative work with Obeo), and participated as a presenter to the two main community events of the year: EclipseCon and Eclipse Summit Europe.
- Guillaume Doux is committer on GMT/AM3.
- Kelly Garcés is an M2M/ATL and GMT/AMW contributor.

⁴<http://www.emn.fr/z-info/atlanmod/index.php/MtATL2010>

9.5. Invitations and Participations to Seminars

Participants: Jean Bézivin, Jordi Cabot, Frédéric Jouault, Massimo Tisi.

The AtlanMod team gave three seminars at the National Institute of Informatics (NII) in Tokyo on several aspects of Model-Driven Engineering:

- Jean Bézivin gave a seminar entitled *Issues in Domain Specific Languages (DSLs) and Model Driven Interoperability (MDI)*.
- Frédéric Jouault gave a seminar entitled *Management of Transformations*.
- Massimo Tisi gave a seminar entitled *Transforming Model Transformations*.

Jordi Cabot gave:

- A seminar entitled *Eduating in MDE* at the Univeristy of the Basque Country
- A seminar entitled *New Advances in MDE* at the University of La Rochelle
- A talk entitled *Agile and MDE: friends or foes* at the Agile Tour event in Nantes

9.6. Teaching

Participants: Jean Bézivin, Hugo Brunelière, Jordi Cabot, Kelly Garcés, Frédéric Jouault, Massimo Tisi.

The members of the AtlanMod team have taught Model-Driven Engineering to several types of students:

- **MDE Diploma.** The AtlanMod team is in charge in 2010 of a 360-hour diploma on MDE⁵.
- **EMN GSI option.** Frédéric Jouault is in charge of a 24-hour course on MDE in this EMN program (final year).

Some members of the team also have teaching duties in other fields (e.g., operating system, object-oriented programming).

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