



# Introducing SegraVis: A European Research Training Network on *Syntactic and Semantic Integration of Visual Modeling Techniques*

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***Abstract.** This first installment of the column on Visual Modeling Techniques will present the objectives, partners, and activities of the SegraVis network, introduce four of the partner sites in more detail, and report on the School on Foundations of Visual Modeling Techniques recently organized by the network.*

**Keywords:** visual modeling techniques, research training network

## 1 Why we are here

SegraVis is a European Research Training Network under the Fifth Framework, running from October 2002 until September 2006. Besides a collaborative research project in the area of visual modeling, the network implements a structured training programme for researchers in this field, especially in the early stages of their career. With this aim, the SegraVis network offers two kinds of training activities.

**Research-training grants:** In cooperation with leading researchers in one of the network sites, post-doctoral researchers and doctoral students advance the state of the art in visual modeling techniques, thus acquiring knowledge and skills for their own carrier.

**Network activities:** At schools, tutorials, and workshops organized by the network, participants broaden their knowledge, present their own ideas, and get in touch with the experts.

This first edition of the column has the purpose of introducing the network, its partners, objectives, and activities. Moreover, we will give a more detailed report on the School on *Foundations of Visual Modeling Techniques*, held in May 2004 at Schloss Dagstuhl as the major training event of the network, and take a closer look at the scientific specialties of four of the 12 network sites.

*Enquiries for open positions can be sent **at all times** to the local coordinators or the network manager, as listed in the following section.*



# SegraVis

## Permanent Call for Applications

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## 2 Who we are

The 12 network members from five European countries are listed below together with the key researchers.

- *Universität Paderborn (Germany)*, the principal contractor, with Gregor Engels (network coordinator), Wilhelm Schäfer, and Reiko Heckel (network manager)
- *Universitaire Instelling Antwerpen (Belgium)* with Dirk Janssens (local coordinator) and Serge Demeyer
- *Universitat Politècnica de Catalunya, Barcelona (Spain)* with Fernando Orejas (local coordinator), Jordi Cortadella, and Gabriel Valiente
- *Technical University of Berlin (Germany)* with Hartmut Ehrig (local coordinator), Herbert Weber, and Gabi Taentzer
- *University of Bremen (Germany)* with Hans-Jörg Kreowski (local coordinator) and Martin Gogolla
- *University of Kent at Canterbury (United Kingdom)* with Peter Rodgers (local coordinator)
- *Leiden University (The Netherlands)* with Grzegorz Rozenberg (local coordinator) and Joost Kok



- *University College London (United Kingdom)* with Wolfgang Emmerich (local coordinator) and Anthony Finkelstein
- *Università degli Studi di Milano, Bicocca (Italy)* with Mauro Pezzé (local coordinator), Carlo Ghezzi and Luciano Baresi (both at Politecnico Milano)
- *Technical University of Darmstadt (Germany)* with Andy Schürr (local coordinator)
- *Università di Pisa (Italy)* with Ugo Montanari (local coordinator) and Andrea Corradini
- *Università di Roma, La Sapienza (Italy)* with Francesco Parisi-Presicce (local coordinator), Paolo Bottoni, and Stefano Leviaidi

The most important people are, however, those for whom the network has been set up: the young researchers with a grant at one of the **SegraVis** sites. If you are interested who they are and what is their personal experience, go to [www.segravis.org](http://www.segravis.org) and follow the menu to *grants / experience*.

### 3 What we are doing

In this section, we motivate and describe the research topic, objectives, and approach of the network, give an overview of the main scientific events and a more detailed report on the **SegraVis** school.

#### Topic

Both in software engineering and in the more classical engineering disciplines, the use of visual notations, e.g., for documentation of requirements or communication with customers, has a long tradition. Driven by the increasing complexity of the problems such notations have become more elaborate and evolved towards *visual modeling techniques* with their own methodology and tool support.

The reasons for the success of visual modeling techniques are manyfold. Visual representations are direct and intuitive, simplifying the communication between developers and their customers. They are extremely effective at delivering useful abstractions of industrial-scale systems. This is evidenced by the success of the UML and its paradigm of model-driven development. The *Unified Modeling Language* with its many sub-languages and dialects is, indeed, one of the two main foci for the research in this project, as well as *graph- and net-based modeling techniques* like graph transformation, high-level or timed Petri nets, flow diagrams, or domain-specific net-like notations.

Model-driven approaches to software development, where models are *the* central artifacts, require precise definitions for modeling languages, their syntax and semantics, their notions of consistency and refinement, as well as their mappings into implementations. However, languages are subject to continuous evolution, and different constellations and dialects are required in different application domains, organizations, and even individual projects. In order to support model-driven development in a variety of contexts, we must find efficient ways of designing languages and processes, accepting that definitions are subject to change and extension and that tools need to be delivered in a timely fashion.

Rather than ad-hoc solutions, a discipline of *language engineering* is required to support the definition and implementation of modeling languages with respect to their abstract syntax and well-formedness



rules, operational and denotational semantics, consistency and refinement relations, and model transformations.

It is the aim of the project to develop this engineering approach, to demonstrate its applicability to a range of modeling languages, including the UML as well as graph- and net-based approaches, to employ and improve visual modeling techniques in specific application domains, and to influence the direction of global industry standards in this area.

With this motivation, the network has defined the following research goals.

## Objectives

According to their focus and level of generality, we distinguish between *meta-level objectives (M)*, *language-specific objectives (L)*, and *domain-specific objectives (D)*.

**M. Meta-level objectives.** The primary objective of the project is to develop *meta-level solutions* for the definition, integration, and implementation of visual modeling techniques, providing support for

*M1. syntax and well-formedness;*

*M2. static and dynamic semantics;*

*M3. analysis and verification;*

*M4. modularity, refinement, and transformation.*

Orthogonally, but at the same level of generality, solutions are sought for

*M5. integration of visual modeling techniques both at the syntactic and at the semantic level;*

*M6. integrated meta CASE tool support.*

**L. Language-specific objectives.** Two classes of visual modeling techniques, the UML family of languages and graph- and net-based modeling languages, shall serve as practical test cases for the meta-level solutions.

*L1. Engineering the UML family* includes

- the definition of syntax and semantics of a UML profiles to test the approach, as well as the evaluation of these definitions for usability and tool support;
- the comparison and possible alignment of M1-M6 with OO meta-modeling approaches currently practiced in industry, including the meta-object facility MOF and XML-based approaches.

*L2. Integration and classification of graph- and net-based techniques* aims at reducing the gap between formally well-founded modeling techniques based on graphs and nets and approaches used in practice. This includes



- the definition and implementation of mappings between domain-specific notations used by application experts and general-purpose formalisms based on graphs and nets;
- a systematic specification and classification of graph and net-based approaches which makes explicit the semantic choices and properties to guide the potential user;
- an integration of domain-specific graph- and net-based languages with the UML, e.g., by means of profiles or transformations, which allows modelers to use both techniques within the same development process.

#### **D. Domain-specific objectives**

The third objective of the network is to employ and improve visual modeling techniques in specific application domains, including (but not limited to)

- D1. modeling support for software evolution and refactoring;*
- D2. modeling of component-based software architectures;*
- D3. specification of applications with mobile soft- and hardware.*

The means for achieving these objectives are discussed next.

#### **Approach**

In text-based programming and specification languages, abstract syntax trees or algebraic terms are the core models for most language-related tasks. In visual modeling techniques it is often convenient to represent the abstract syntax of diagrams by *abstract syntax graphs*, either instances of a meta model as in the case of the UML, or generated by a graph grammar. Hence, for dealing with syntax and semantics definitions, analysis and transformation of models, the primary approach is the generalization of classical, tree-based solutions to graphical structures.

The basic technology for this generalization is provided by the concepts, theory, and tools of graph transformation, a rule-based approach in the tradition of Chomsky grammars, attribute grammars, and term rewriting, i.e., those rewriting techniques that provide the foundation of textual language technology and compiler construction.

For a more detailed overview (with references) of the individual approaches to the meta level objectives, the reader is referred to [www.segravis.org](http://www.segravis.org) under *resources / deliverables*.

#### **Activities**

The network regularly organizes and supports a number of workshops and conferences:

- The *International Conference on Graph Transformation (ICGT)* is held bi-annually in September or October. Its first installment took place in 2002 in Barcelona (Spain) October 2002. The second



ICGT will be in Rome (Italy) September 28 - October 2, 2004 in collocation with the *Conference on Visual Languages and Human-Centric Computing (VL/HCC)*.

Satellite events of relevance to the network's objectives include workshops on

- Visual Languages and Formal Methods (with VL/HCC);
- Petri Nets and Graph Transformations;
- Term Graph Rewriting;
- Graph-Based Tools;
- Software Evolution through Transformations;

as well as tutorials on

- Foundations and Applications of Graph Transformation;
- DNA Computing and Graph Transformation.

*While the deadlines of the main conferences ICGT and VL/HCC have passed, **satellite workshops are still accepting submissions**, check the respective Web pages at [www.dsi.uniroma1.it/icgt2004/](http://www.dsi.uniroma1.it/icgt2004/) and [HCC-URL](#).*

- The *Workshop on Graph Transformation and Visual Modeling Techniques (GT-VMT)* is usually associated with major conferences, e.g., 2002 with ICGT and 2004 with ETAPS, both in Barcelona.
- The *Workshop on Application of Graph Transformation with Industrial Relevance (AGTIVE)* has been held 1999 in Kerkrade (The Netherlands) and 2003 in Charlottesville, Virginia (USA).
- The *Workshop on Uniform Approaches to Graphical Specification Techniques (UniGra)* is held bi-annually with ETAPS, i.e., 2001 in Genova (Italy) and 2003 in Warsaw (Poland).
- The *Symposium on Visual Languages and Formal Methods (VLFM)* has been held as part of the IEEE Conference on Human-Centric Computing (HCC), 2001 in Stresa (Italy) and 2003 in Auckland (New Zealand), and is continued as a satellite workshop of VL/HCC 2004 in Rome.

As major training event, the network organized the School on *Foundations of Visual Modeling Techniques*, held in May 2004 at Schloss Dagstuhl.

## School

The School has been held in the week of May 3 – 7 at the International Conference and Research Center for Computer Science at Schloss Dagstuhl, Germany. Due to its cosy atmosphere and self-contained organization, the center provides an excellent venue for such a school, where informal meetings of participants among each other and with the lecturers are as important as the scientific program.

The School had about 55 participants, one third of them external to the network, plus 14 lecturers. The concept of the school has been to provide tutorial-like introductions to fundamental solutions for



the meta-level tasks M1 – M4, to present examples of applications to specific languages and problem domains, and to offer the opportunity for practical experience in applying techniques and tools in sample projects. With this aim, four different kinds of lectures were offered.

1. *Introductory Lectures* in the form of a keynote by Jean Bézivin and an opening address by Gregor Engels did set up the general motivation and problem space, organized the solution domain according to the meta-level objectives into categories M1 - M4, and gave some background on the SegraVis project as a whole. A mini tutorial on graph transformation by Reiko Heckel provided technical background required by the following lectures.
2. At *Meta-level Tutorials* attendees were introduced to the meta-level solutions for defining and implementing visual modeling techniques, providing a systematic discussion of problems and requirements and a survey of known solutions. To broaden the view, each topic was covered by (at least) two speakers, respectively presenting the classical point of view as well as the solutions more specific to the approach of the network, i.e.

M1: Uwe Kastens and Mark Minas on *Syntax and Well-Formedness*

M2: Peter Mosses and Hans-Jörg Kreowski on *Operational and Denotational Semantics*

M3: Mauro Pezzé, Luciano Baresi, and Reiko Heckel on *Model-based Testing and Analysis*

M4: Andy Schürr and Martin Große-Rhode on *Integration, Refinement, and Transformation*

3. *Exercises* have been offered on a daily basis, following the topics of the tutorials. Under the guidance of the lecturers, attendees could choose among different techniques and tools to solve the respective problems. A running example, prepared by Gabi Taentzer and Reiko Heckel, has been used throughout. Detailed solutions will be discussed during the Workshop on Graph-based Tools at ICGT 2004 in Rome.
4. *Tool Presentations* have covered tools and meta tools for visual modeling techniques provided by lecturers and attendees. A corresponding survey has been given on the first day by Gabi Taentzer.
5. As *Scientific Highlights*, invited speakers of the community have offered high-level scientific talks on interesting applications of visual modeling techniques and graph transformation to important and solid research areas in computer science, i.e.

- András Pataricza on *Modeling and Transformations: An Engineering View*
- Hartmut Ehrig on *Transformation of Petri Nets*
- Francesco Parisi-Presicce on *Specification and Analysis of Security Policies*

## 4 May we introduce to you

Finally, let us introduce in more detail four of the 12 sites of the network with their key researchers, topics, and projects. To date, all four groups have positions for research training grants available. Please contact them if you are interested.



## **Paderborn**

The SegraVis team at the University of Paderborn (Germany) consists of two research groups: The Database and Information Systems Group led by Gregor Engels and the Software Engineering Group headed by Wilhelm Schäfer. Both groups have considerable experience in graph transformation systems, their theory, semantics, implementation, and analysis, as well as their application in the context of UML-based software development.

Gregor Engels is the coordinator of the network and with Reiko Heckel, the network manager, co-organizer of the School (see above). The group specializes in operational semantics, consistency and transformation of UML models, model-based testing, stochastic and timed methods, as well as in applications to software architectures, mobility, multimedia applications and Web services.

The Software Engineering Group of Wilhelm Schäfer is well-known for its work on implementing graph transformation in the UML CASE tool Fujaba and applying it in the design of safety critical and real-time systems, as well as in high-school courses on object-oriented programming. Jointly the two groups contribute to all objectives of the network.

The university is host to the International Graduate School of Dynamic Intelligent Systems run by the departments of Computer Science, Mathematics, Business Computing, Electrical and Mechanical Engineering as a recognized center of excellence in this field. Due to its international participants, which are integrated in the different research groups, the graduate school creates a cultural (and linguistic) mix that visitors on SegraVis grants will find most inspiring.

## **Antwerp**

At the University of Antwerp (Belgium), two groups involved in the network: the group on Formal Methods in Software Engineering (FOTS), headed by Dirk Janssens, and the Lab on Software Reengineering (LORE), headed by Serge Demeyer. The FOTS group is interested in the use of techniques based on graphs and graph rewriting in the software development process, in particular model transformation and formal semantics, and the LORE group has expertise in reverse- and reengineering techniques applicable to large scale-software systems. There is a close cooperation between both groups, which jointly consist of about 10 researchers.

Within SegraVis the focus of the team is on the development of languages supporting transformations between software models, including the integration of the proposed formalisms with other models (e.g. UML models), CASE tools (e.g. Fujaba) and standards (e.g. MOF). Within this topic the team concentrates on two problem areas: on the one hand, it investigates the problem of specifying, in a way that is as much as possible platform-independent, the transformations needed for model-driven development, while at the same time supporting the process of generating concrete, and hence platform-specific, code. On the other hand, the use of rule-based and in particular graph rewriting-based techniques as a basis for a visual language for refactoring is investigated: refactorings are transformations intended to improve the structure of a system, while preserving its external behavior. Since these transformations are mostly local and triggered by the occurrence of certain patterns, graph transformation is a natural candidate for their formal description. An international workshop on the use of graph rewriting for refactoring was held in Antwerp in April 2004.



Besides SegraVis, FOTS and LORE are involved in a number of projects concerning reengineering and model-driven as well as aspect-oriented software development. As a result, the research of these groups is relevant for a broad range of the SegraVis objectives, and offers an interesting and productive environment for prospective grant holders.

## Barcelona

The SegraVis team at Barcelona consists of two groups: The Algebraic Methods Group lead by Fernando Orejas and the group on Synthesis and the Verification of Concurrent Systems headed by Jordi Cortadella.

The group of Fernando Orejas has long experience in the use of these of algebraic and transformation-based methods for defining the semantics of specification languages. The current interests of the group in relation with the network objectives are, on one hand, in the semantic integration of modeling formalisms and, on the other, in the study of component based software modeling and design.

The group of Jordi Cortadella has a strong background in the development of methods and tools for the synthesis and verification of (hardware) systems. A well-known tool developed by the group is PETRIFY, a CAD tool for the synthesis of concurrent systems modeled by Petri Nets. Currently, the main interest of the group is in the verification of timed systems using abstract interpretation techniques.

Fernando Orejas has been the local organizer of ETAPS 2004, the Joint European Conference on Theory and Application of Software which was held in Barcelona. The city itself is certainly one of the most beautiful in Europe, with a lot of potential for research in unrelated subjects, like architecture and cuisine.

## Bremen

The SegraVis team at the University of Bremen (Germany) comprises two research groups: The Group on Theoretical Computer Science (TCS) headed by Hans-Jörg Kreowski and the Database Systems Group led by Martin Gogolla.

The TCS group specializes in language-independent modeling of systems using rule-based graph transformations. This generic framework integrates existing approaches and allows for a uniform view on model transformations. In this context, transformation units as a key concept for modularity and reuse of rule-based systems are developed and applied, e.g., to define formal semantics of parts of the UML. Further important research topics are the modeling of software agents and autonomous logistic processes, syntactic methods of picture generation, algebraic specification, and DNA computing.

The Database Systems Group applies graph transformation in the context of UML-based software engineering. For example, an integrated formal semantics has been developed for the mainstream UML diagrams. The group also investigates formal specification of safe and secure systems, semantics of data base languages, formal methods in information systems design, object-oriented software development in general, and software metrics.

Both groups are associated with the Bremen Institute of Safe Systems (BISS), which aims at increasing the safety and reliability of software and embedded systems by formal methods, and the Center for Computing Technologies (TZI), the objectives of which are the research, development, and transfer of innovative computing technologies. The TCS group contributes as a member to the Logistics Research



Institute (FoLo) and the Collaborative Research Centre on Autonomous Cooperating Logistic Processes (CRC 673). Moreover, the TCS group hosts the Competence Center for Women in Science and Engineering at the University of Bremen, and Hans-Jörg Kreowski currently chairs the Forum Computer Professionals for Peace and Social Responsibility (FifF).