

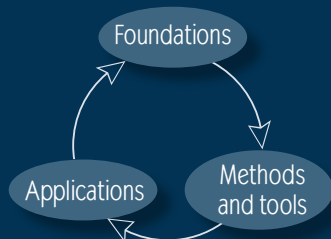


VERIMAG

www-verimag.imag.fr

RESEARCH LABORATORY

Methods and tools
for building embedded systems
of guaranteed quality



VERIMAG

DISTRIBUTED AND COMPLEX SYSTEMS

Abstractions and tools for designing distributed and complex systems with extra-functional properties: hard and soft real-time, security, performance.

HYBRID SYSTEMS

Exporting methods and tools for verification of algorithms to domains and disciplines where models involve real-time clocks or continuous systems defined by differential equations.

SYNCHRONOUS GROUP

Synchronous languages and their related implementation and validation methods for complex embedded systems, with applications in consumer electronics, transportation control systems, sensor networks.

IMPLEMENTATION OF EMBEDDED SYSTEMS

Cost-effective programming of correct and efficient embedded application software on multi-core processors.

PUBLICATIONS

About 90 publications annually, including 15 international journals and 60 international conferences, funded by local or national grants or by industrial partners.

BUDGET (2008)

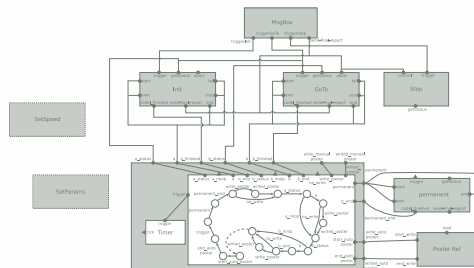
Annual global budget (excluding statutory salaries): about 2.5 MEuros, over 90% of which is from national or international funding agencies or direct industrial contracts.

HUMAN RESOURCES

95 employees including:
31 permanent researchers
30 PhD students
21 Postdocs and research engineers



Data robot



BIP component-model

→ Verification of a BIP model with D-finder, code generation with BIP, and integration into existing software

VERIMAG

A LEADING RESEARCH CENTER IN EMBEDDED SYSTEMS

AWARDS

- 2007: **Turing award**, the highest recognition in Computer Science, to Joseph Sifakis, shared with Ed Clarke and Alan Emerson
- 2004: **Michel Monpetit Prize** of the French Academy of Science to Paul Caspi and Nicolas Halbwachs
- 2002: **CNRS Silver Medal** to Joseph Sifakis



Joseph Sifakis

TECHNOLOGY TRANSFER

- The **Lustre programming language** and its compilation principles are integrated into the SCADE tool (Esterel Technologies) used by Airbus for the design and validation of its critical real-time systems.
- The **TGV test case generation** technology was used in Telelogic's Object Geode development environment (with IRISA), which is connected to the IF validation platform.



A380: software development based on SCADE

IMPACT ON RESEARCH

VERIMAG laboratory has a pioneering role in several domains:

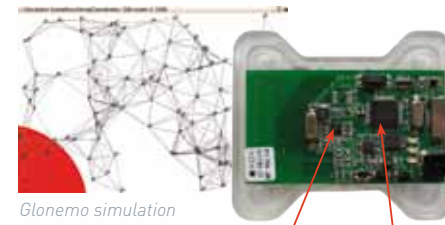
- **Model-checking** (Turing Award)
- **Synchronous languages** (Michel Monpetit Prize)
- **Timed and hybrid systems** modeling and verification
- **Predicate abstraction and invariant generation** - taken up and further developed e.g. in SAL (SRI) and Slam (Microsoft)

STRUCTURING THE RESEARCH COMMUNITY

- 1989: Co-founder of the conference on **Computer-Aided Verification (CAV)**, top conference in its area
- 1998: Co-founder of the conference on **Hybrid Systems: Computation and Control (HSCC)**
- 2001: Co-founder of the **EmSoft** conference, one of the main conferences on foundations for embedded software development
- 2002-2011: Coordination of the **ARTIST European Network of Excellence on Embedded Systems Designs**, gathering 35 major European teams in the area
- 2003: Co-founder of the conference on **Formal Modelling and Analysis of Timed Systems (FORMATS)**
- Since 2007: Head of the **CARNOT Institute on «Intelligent Software and Systems»** in Grenoble



RESEARCH TOPICS



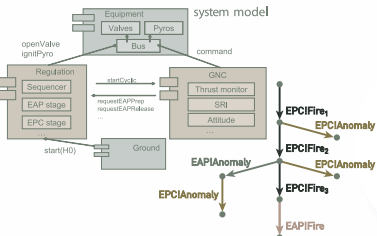
Glonemo simulation

CC1100 MSP430
A sensor node

→ Simulation of a wireless sensor network detecting a pollution cloud for analysis of energy consumption



Ariane 5



«Correct start-up» property synthesised by IF and UML architecture model

→ Post-accident validation using Lustre and IF

COMPUTER-AIDED SECURITY

Computed-aided engineering methods for a systematic approach to security:

- Foundations of security
- Computer-aided verification of cryptographic primitives
- Software engineering for security
- Tools for verification of the Common Criteria
- Information flow and non-interference analysis
- Testing and monitoring of security properties
- Secure e-voting

SYSTEMS-ON-A-CHIP

Virtual prototyping for systems-on-a-chip based on Transaction-Level-Modeling (TLM):

- Validation methods and tools for SystemC
- Component-based design and transformation of Transaction Level models
- Non-functional properties at the transaction level (time, energy)

SOFTWARE VERIFICATION

Developing theory and tools for scalable software verification:

- Multi-threading and dynamic recursive data structures
- Verification tools for real-world C/C++/Java programs
- Complexity analysis of verification problems
- Assertion checking and termination proofs

FROM UNDECIDABILITY TO PRACTICE

IMPLEMENTATION OF EMBEDDED SYSTEMS

Platform-dependent techniques:

- Support for correct-by-construction integration of components
- Property-aware code generation for multi-processors
- Time and space predictable dynamic memory management
- Multi-threaded and distributed implementations of synchronous programs

HYBRID SYSTEMS

Enriching the analysis toolbox for engineers and scientists in various domains:

- Theoretical and algorithmic foundations
- Reachability analysis for continuous and hybrid systems
- Scheduling and performance evaluation
- Monitoring temporal properties
- Systematic simulation and test generation
- Applications: control, analogue circuits, multi-core computing, systems biology

VERIFICATION AND VALIDATION TECHNIQUES

Verification and validation is crucial throughout the design cycle:

- Model checking and verification based on abstract interpretation
- Simulation and early execution
- Contract-based verification

WIRELESS SENSOR NETWORKS

Providing formal models and virtual prototyping tools for studying energy consumption in wireless sensor networks:

- Distributed and fault tolerant approach to system design
- Dedicated formal, executable and global models for energy consumption
- Definition of notions of refinement and abstraction for energy models
- Faithfulness and calibration of simulators

LANGUAGE DESIGN FOR EMBEDDED SYSTEMS

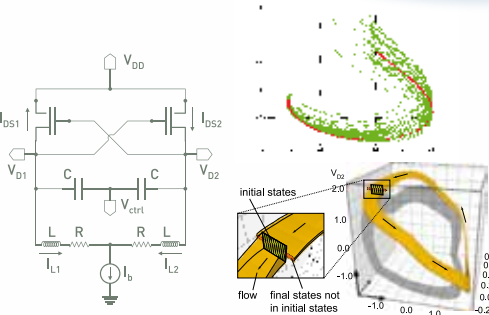
Coping with the growing complexity of embedded hardware and software requires high-level domain-specific languages and associated implementation methods:

- Languages and tool support for parallel programming
- Non-deterministic languages for virtual prototyping and simulation
- Aspects and components for synchronous languages, Lustre

COMPONENT-BASED DESIGN OF EMBEDDED SYSTEMS

Modular component framework for Behavior - Interaction - Priority (BIP):

- Structural and compositional verification of programs
- Component-based design of multi-core systems
- Property enforcement and controller synthesis



Analog circuit

Trajectory based verification

→ Set based verification of oscillation properties

NEW FRONTIERS FOR VERIFICATION TECHNOLOGY

MASTERING HETEROGENEITY

FROM AN ART TO SCIENCE

ABSTRACTION AND TOOLS FOR DEFINING EFFECTIVE SOLUTIONS

$i++;$

$P:\{x>0\}y++$

$f(t)=2.6$

$x+y/2$

$n \leftarrow n+1$

stop

$*P=NULL;$

$a \cdot b$

$P:\{a|c\}=1$

$x \neq 2$



Grenoble: the capital in the French Alps, is one of the main research and high technology centers in Europe:

- 21 000 researchers, 60 000 students
- 4 international research centers, ESRF, ILL, IRAM, EMBL
- 5 national research centers: CNRS, INRIA, CEA, INSERM, Cemagref
- 2 international competitiveness clusters: Minalogic and Tenerrdis

Leading centre in Information and Communication Technologies:

- 35 000 direct industrial and academic positions, including 2 000 researchers, engineers, postdocs and PhD students
- 1 000 engineering and master students graduating every year
- 2 Carnot Institutes: LSI and CEA LETI
- Many major companies in Information and Communication Technologies