

Final Review  
Brussels, December 12th, 2008

*Achievements and Perspectives :*

# Real Time Components

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# Outline

- High Level Objectives
- Landscape at start of ARTIST2
- Overall Results
  - Component-Based Design of Heterogeneous Systems
  - Platform for Modeling and Analysis
  - UML Profile for Modeling and Analysis of RTES
- Events, Collaboration
- Assessment at end of NoE
- Continued Future Work

# Industrial Relevance

- Industrial Sectors:

- Automotive

- 70 - 90% of all innovations in automotive rest on embedded systems,
    - 50 - 70% of total development costs of ECUs is for embedded software

- Avionics

- 40% of Systems price represented by Embedded Systems
    - 100€ is cost per line of certified level A SW Code

- Railways

- International Interoperability of train safety systems

- Construction/Building

- 40% of primary energy use from Building Sector (in U.S.)
    - Coordination of safety, power management, ....
    - Substantial savings by using Embedded Control and Wireless Technology

- Industrial needs:

- **Reduce development time and cost** despite increase of size and complexity
  - **Increase quality, efficiency, reliability** of products and services with new functionalities for end user.

# Industrial Challenges

## Component-Based Development

Aims to provide techniques and methods

- to **guide, optimise and assess systems architecture choices**
  - against business and operational criteria (cost, minimization of system interfaces, mass, safety, reliability ...)
- to **design, validate, verify, certify/qualify** products
  - by assembling predefined or specific building blocks (components)
- to **reduce development time and cost**
  - by enabling reuse and structuring

## Industrial Efforts (examples)

- Automotive: Autosar
- Avionics: IMA

## Core Partners

- Univ. of Cantabria (Julio Medina)
- CEA (Sebastien Gérard, Francois Terrier)
- EPFL Lausanne (Tom Henzinger)
- France Telecom R&D (Jacques Pulou, Thierry Coupaye)
- INRIA (Albert Benveniste, Jean-Marc Jezequel)
- OFFIS (Werner Damm, Bernhard Josko)
- PARADES (Alberto Ferrari, Alberto Sangiovanni-Vincentelli)
- Uppsala University (Bengt Jonsson, Wang Yi)
- VERIMAG (Paul Caspi, Susanne Graf, Joseph Sifakis)
- TU Vienna (Hermann Kopetz, Peter Puschner)

# Affiliated Partners

- EADS (David Lesens)
- Esterel Technologies (Alain Leguennec)
- Mälardalen (Ivica Crnkovic)
- Thales (Veronique Fabre)
- Timisoara (Marius Minea)

## High-Level Objectives

### Component-Based Design of Heterogeneous Systems

- Unifying framework for Composition of Heterogeneous Systems
- Techniques for handling QoS and resource properties when Interfacing and Composing systems of components.
- Industrial Liaison: seminars and projects with industry

### Platform for Component Modeling and Verification

- Synchronize European efforts on Model-Based Development, by connecting/integrating tools into chains:
  - common formats, connections, collaborative work

### Development of UML for Real-Time Embedded Systems

- Develop, promote MARTE profile f. Modeling and Analysis of RTES,

## Partial landscape at start of ARTIST2

### Component-Based Design of Heterogeneous Systems

- Tools for System Design: Ptolemy, Metropolis
- Embryos of theories for heterogeneous compositions: BIP, Tag Systems
- Few component models for RTES
- Distributed Architectures: TTA

### Platform for Component Modeling and Verification

- Modeling and Verification tools: IF/Kronos, UPPAAL/TIMES, MAST but few tool chains

### Development of UML for Real-Time Embedded Systems

- SPT profile of UML, quite limited.



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The RTC Cluster contains the leading groups on these topics

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# Results: CBD of Heterogeneous Systems

- Evolution of BIP for modeling heterogeneous systems  
[VERIMAG,INRIA,FTR&D]
  - Conceptual results: algebra of connectors, semantics of distributed execution, compositional verification of absence of deadlock, etc.
  - Implementation results: simulator, connection to Fractal/Think, mapping from SPEEDS component representation,
- Several results on “Models of Computation”
- Implementing synchronous models on asynchronous architectures  
[INRIA, PARADES, SSA, Verimag]
- Reasoning about reliability of distributed implementations  
[EPFL,PARADES]

## Results: CBD of Heterogeneous Systems

- A number of component models for RTES
  - HRC [IP SPEEDS], SAVE/ProCom [MdH], Frescor CCM [Thales, Cantabria]
- Design/synthesis of communication subsystems,
  - COSI: can optimize communication design for different cost models and constraints [Parades]
  - Time-Triggered System-on-a-chip architecture [Vienna], Targeting error containment and diagnosis, for SoC.
- Synthesis of glue and of controllers [several results]
- Unifying operational and analytical models of non-functional properties [ETHZ, Uppsala]
- Synthesizing component models and behavioral interfaces [EPFL, Uppsala, Dortmund]

# Platform for Component Modeling & Ver

Integration of tool chains:

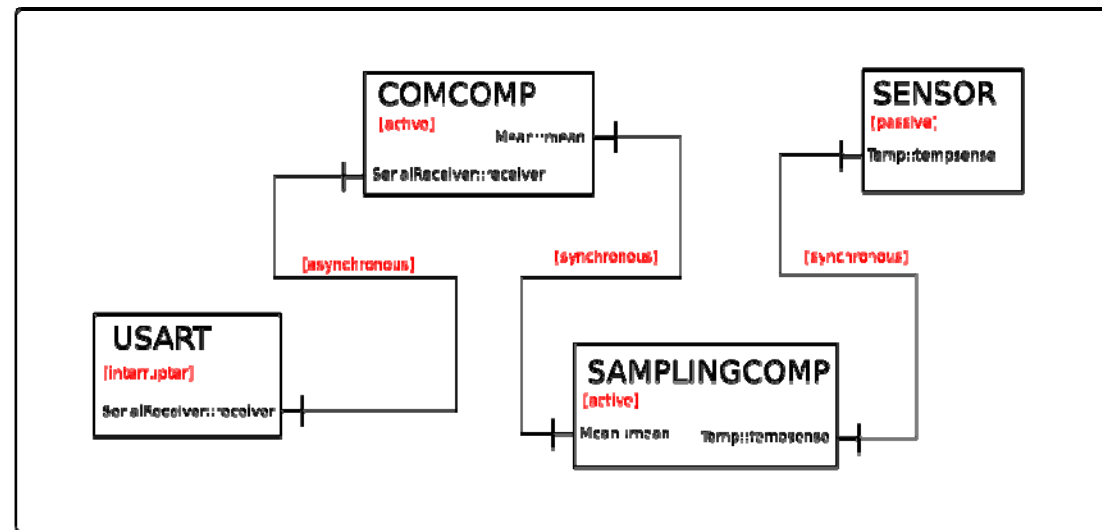
- BIP/Fractal/Think/Buzz [INRIA, VERIMAG]
  - Generation of Code from BIP Models
- Papyrus/IF/BIP/KerMeta/Giotto [CEA, INRIA, VERIMAG, EPFL]
  - from UML models (MARTE profile) to implementation
- Persiform [VERIMAG, INRIA, France Telecom]
  - UML modeling tools -- Performance Analysis tools
- EDEN-2 [VERIMAG, CEA]: IF/Agatha
  - Verification and Certification for Smart Cards
- Several others ....

## Example of new Development: Buzz

- Combines BIP and THINK frameworks
- Offering a more familiar modeling notation
- Component diagrams enriched with behavior tags

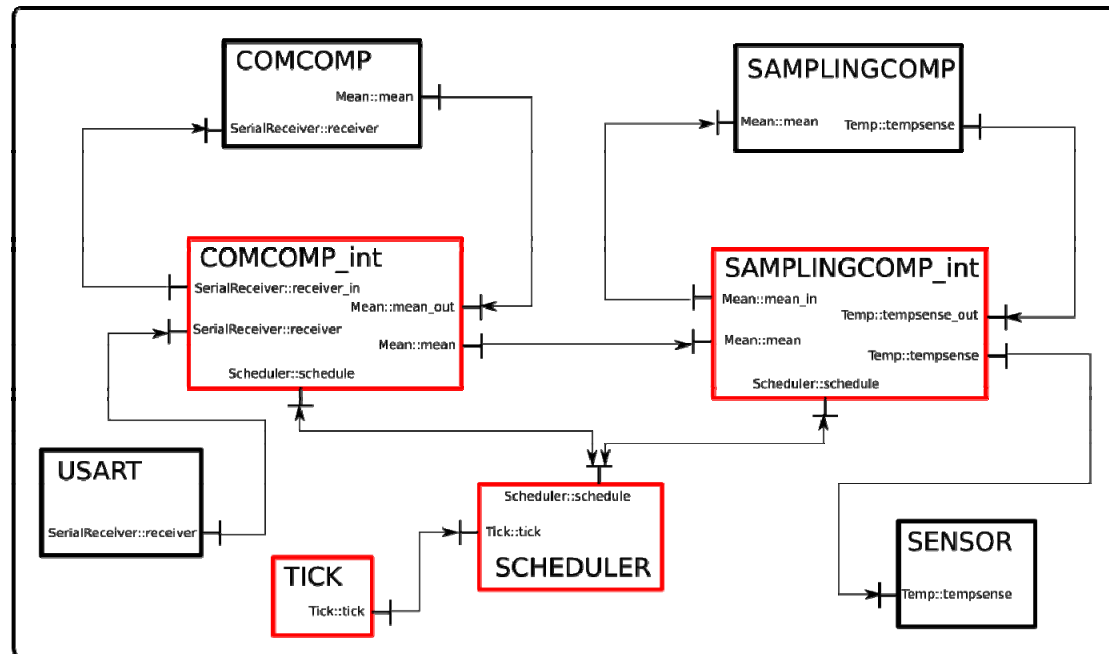
# Buzz

- Combines BIP and THINK frameworks
- Offering a more familiar modeling notation
- Component diagrams enriched with behavior tags
- Example: BUZZ wireless sensor node



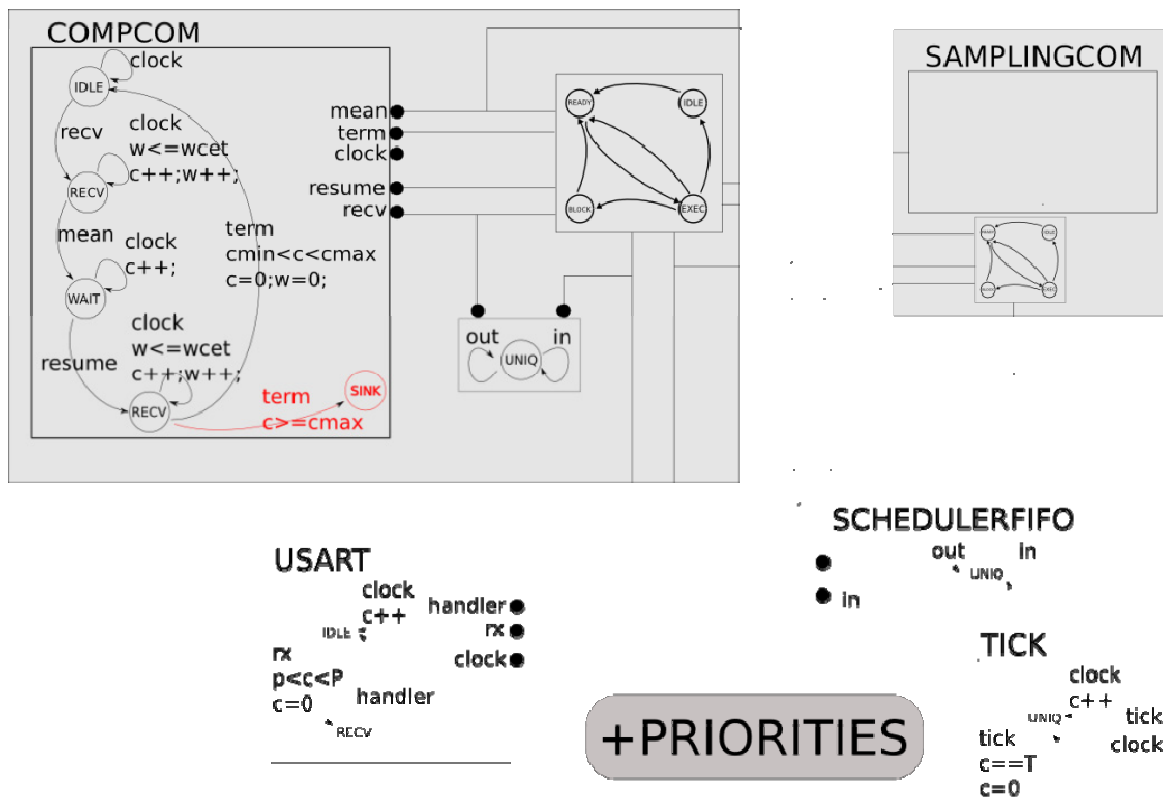
# Buzz

- Corresponding THINK Architecture (generated)



# Buzz

- Automatically generated BIP model





## UML Profile for RTES

- Finalization of the MARTE UML profile for RTES  
[Cantabria,CEA,Thales]
- Implementation of MARTE in Papyrus and RSA tools  
[CEA,Thales]
- Initiation of transformation to SymTA/S and MAST,
- Dissemination of MARTE:
  - in Collaboration Projects: ADAMS (Cantabria, CEA, Thales, Volvo), OpenEmBeDD, ATESSST (w. Volvo, KTH), TIMMO
  - Presentations at scientific fora: ECRTS 2007 and FDL2007
- New national and european projects reusing collaboration (Usine Logicielle, VERDE...)

## Industrial Liaison

- Workshop on “Integrated Modular Avionics” [INRIA, Verimag, SRI, PARADES]
  - Rome, Nov. 2007, proceedings on the WWW.
  - Participation from airplane manufacturers, system suppliers, service companies, labs, academics.
  - Similar setup as the workshop “Beyond AUTOSAR”, March 2006
- Other workshops: SPEEDS Automotive Day, SPEEDS tutorial,
- Establishment of SafeTRANS, EICOSE
- Launching of several (European projects) with significant industrial participation

## Overall Assessment at end of ARTIST2

### Component-Based Design of Heterogeneous Systems

- Developed & applied framework for composition of heterogeneous systems
- Several component models for RTES w. solid tool support
- Middleware, compilation, synthesis techniques f. communication systems

### Platform for Component Modeling and Verification

- Modeling, transformation, simulation, verification, code generation tools connected in tool chains

### Development of UML for Real-Time Embedded Systems

- Accepted UML profile, now used in application projects

# Events

## Schools:

- MOVEP'08 Summer School on Modeling and Verifying Parallel Processes, Orléans, June 2008.
- Artist2 School on Embedded Systems Design, Shanghai, China, July, 2008,
- Artist2 Summer School, Autrans, France, Sept. 2008,
- Model Driven Development f. RTES (Autrans, spring 2009)

## Workshops

- ARTIST2 workshop on Integrated Modular Avionics, Rome, Nov. 2007,
- Foundations and applications of Component-Based Design: (at EMSOFT, Salzburg, Sept. 2007)
- UML and AADL workshop at ICECCS, Belfast, April 2008,
- UML and formal methods workshop at ICFEM, Kitakyshu, Japan, Oct. 2008,
- MoVaH workshop at ICST, Lillehammer, Norway, April 2008.
- MARTES + MODEVA Workshop (at Models/UML Conference), Nashville, Oct. 2007.
- COMES (Component Models for Embedded Systems), Sigtuna, Sweden, June 2008,

## Events (ctd.)

### Workshops (ctd.)

- Formal Methods for Components and Objects, Nov. 2007, Amsterdam,
- From Embedded Systems to Cyber-Physical Systems: St. Louis, MO, April 2008
- SafeCert – Certification of Safety-Critical software Controlled Systems, Budapest, April 2008,
- SLA++P '08, Budapest, April 2008
- EAST-ADL, AADL, MARTE, Autosar harmonization workshop (within ATESSST)
- The EAST-AADL approach, (ATESSST Workshop), Stockholm, March 2008.
- 1<sup>st</sup> Int. Workshop on Model Based Architecting and Construction of Embedded Systems (at MODELS 2008)
- Swedish Embedded Systems Meeting, Stockholm, March 2008.

# Integration and Building Excellence

- Integration by connecting tools
  - SPEEDS Bus [INRIA, OFFIS, PARADES, VERIMAG]
  - BIP/Fractal/Think/Buzz [INRIA, VERIMAG]
  - Papyrus/IF/BIP/KerMeta/Giotto [CEA, INRIA, VERIMAG, EPFL]
  - > 45 Joint publications in Y4.
- Several new collaboration projects
  - Combest, EDEN-2, SPICES, OpenEmBeDD, IP-SPEEDS,
- Integration with other communities
  - Execution Platforms: common understanding of components
  - Testing, Verification: Tool connections, merge for ArtistDesign
- Forming wider communities around central themes:
  - Models of Computation, Heterogeneous composition, Convergence on views of components in different communities, industrial use of CBD (e.g., AUTOSAR)

## Future outlook

- Future collaboration in ArtistDesign
  - Merge with verification cluster
  - Transversal integration in predictability/adaptivity activity
- Further Development through European projects
  - ADAMS, ARESA, Combest, CONNECT, GENESYS, SPEEDS,
  - ARTEMIS project CESAR
- Future Challenges:
  - Maturation of component-based technology
  - New applications: buildings, networked systems
  - Bridge dichotomy between operational and analytic models
  - More robust quantitative models