Year 3 Review
Brussels, December 14th, 2007

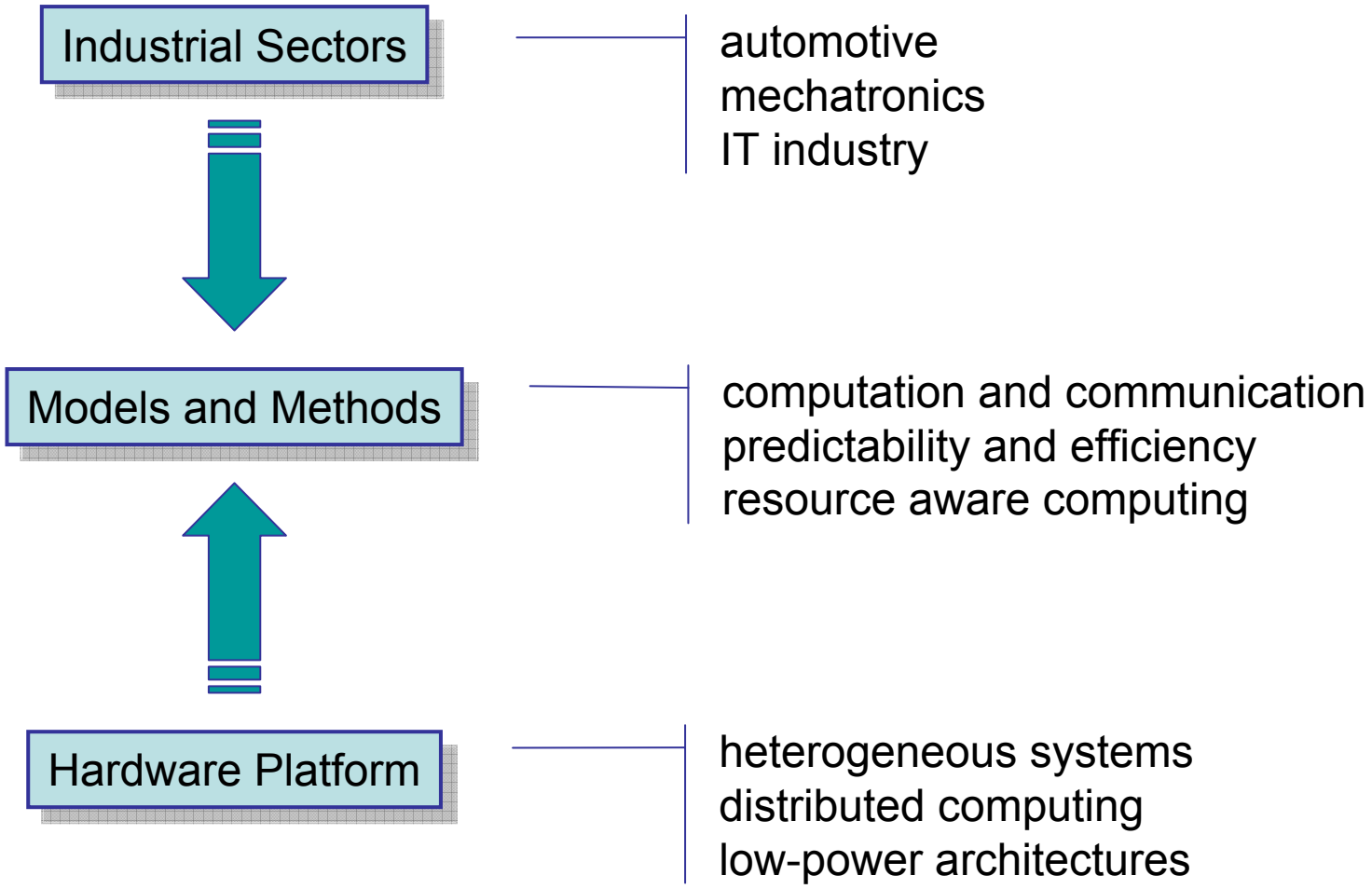
Achievements and Perspectives :

Execution Platforms

Cluster leader : Jan Madsen

Technical University of Denmark

High-Level Objectives



High-Level Objectives

The cluster on execution platforms will consider

- the *hardware* architecture and *software* components in their *interaction*,
- investigate *models and methods* for accurate *estimation* of important properties (energy, timing),
- provide the designer with adequate support for *design space exploration* and *optimisation*.

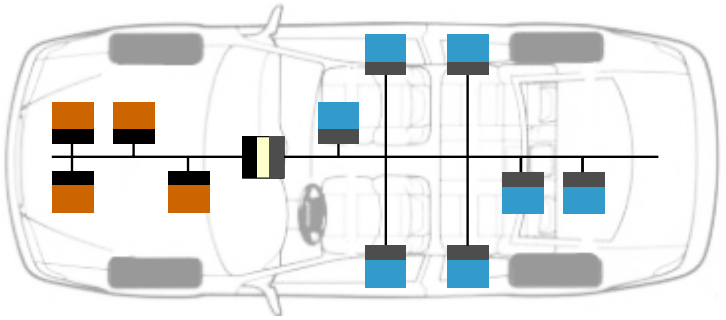
Challenges and Research Trends

- Resource Aware Computing
- Communication Centric Systems
- Predictability and Efficiency

Industrial Sectors and Needs

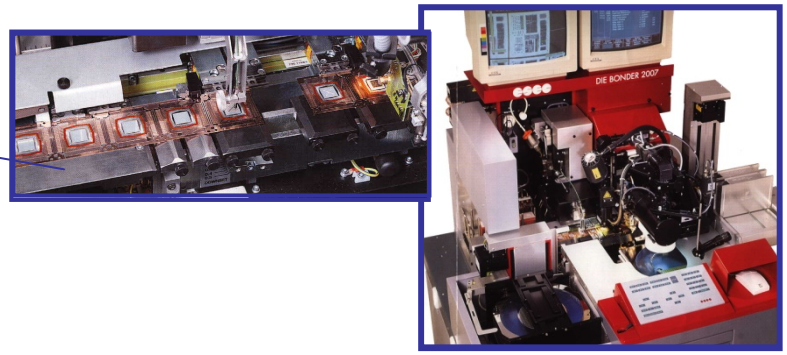
- Automotive

increasingly distributed
complex integration



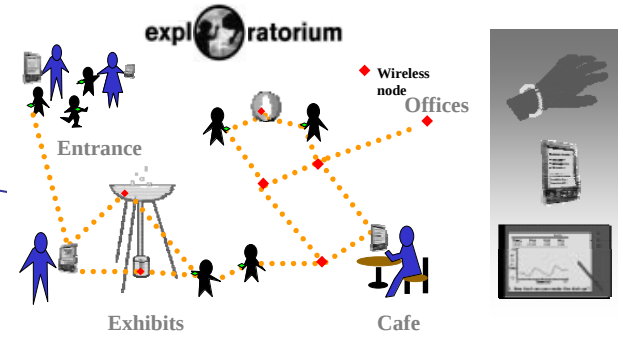
- Mechatronics

increasingly networked
predictability



- IT Industry

resource awareness
short product cycles
distributed operation



Integration and Building Excellence

- Mechanisms for integration:
  - Summer Schools
  - Tutorials at major conferences
  - Joint publications
  - New research projects with industrial partners
  - Cooperation with other research groups
- Integration activities:
  - Workshop Models of Computation and Communication at ETH Zurich (Nov. 2006)
  - ETH Zurich has been organizing and participating in the CASTENESS Workshop (Jan 2007)
  - ETH Zurich has been organizing the workshop "Foundations and Applications of Component-based Design", October 26th 2006, Seoul.
  - ETH Zurich has been organizing a Dagstuhl Seminar 04.03.2007-09.03.2007: "Quantitative Aspects of Embedded Systems".
  - ETH Zurich has been the general chair of the ARTIST2-sponsored conference ARCS'07: "Architecture of Computing Systems", March 2007.

Integration and Building Excellence

- Integration activities cont.:
  - TU Eindhoven has organised and given a tutorial on system-level performance modelling at the fifth ACM-IEEE International Conference on Formal Methods and Models for Codesign (MEMOCODE'2007), May 30 - June 1st, Nice, France.
  - TU Eindhoven has organised a workshop on Models of Computation and their application in the design of multi-processor systems, May 2007.
  - TU Eindhoven (Twan Basten) has co-organized ACSD 2007, the 7th International Conference on Application of Concurrency to System Design. ACSD was held in Bratislava, Slovak Republic, 10-13 July 2007.
  - DTU has been the program chair for the DATE'07 conference, "Design, Automation, and Testing Europe", that took place in Nice, France, April 16-20, 2007.
  - DTU has organized an ARTIST2 sponsored PhD course on "Advanced Topics in Embedded Systems", that took place at IMM, DTU, Lyngby, Denmark, June 4-12, 2007.
  - DTU has been co-organizing a workshop on "Tool Platforms for Embedded System Modelling, Analysis and Validation", related to CAV'07 which took place in Berlin, Germany, July 1-2, 2007.

Integration and Building Excellence

- Integration activities cont.:
  - Linköping has given a tutorial at the "International Workshop on Embedded Systems 2006".
  - TU Braunschweig has organized together with ETH Zürich and University of Notre Dame the tutorial "Extensible Frameworks for System-Level Analysis of Real-Time Systems" at the Real-Time and Embedded Technology and Applications Symposium (RTAS).
  - TU Braunschweig participated in the "Workshop on Models and Analysis for Automotive Systems" at the Real-Time Systems Symposium (RTSS).
  - TU Braunschweig has been organizing the Embedded Software Track at the major European conference on design automation DATE (Design Automation and Test in Europe) that took place April 16-20, 2006.
  - TU Braunschweig has given a lecture with the title "Supporting Predictable Design Using Formal Analysis Techniques" at the ARTES summerschool.
  - TU Braunschweig was invited to participate in the special session on "Virtual Automotive Platforms" at the renowned Design Automation Conference (DAC).
  - TU Braunschweig was invited to participate in the ARTIST workshop on "Tool Platforms for Modelling, Analysis and Validation of Embedded Systems" at the conference on ComputerAided Verification (CAV).

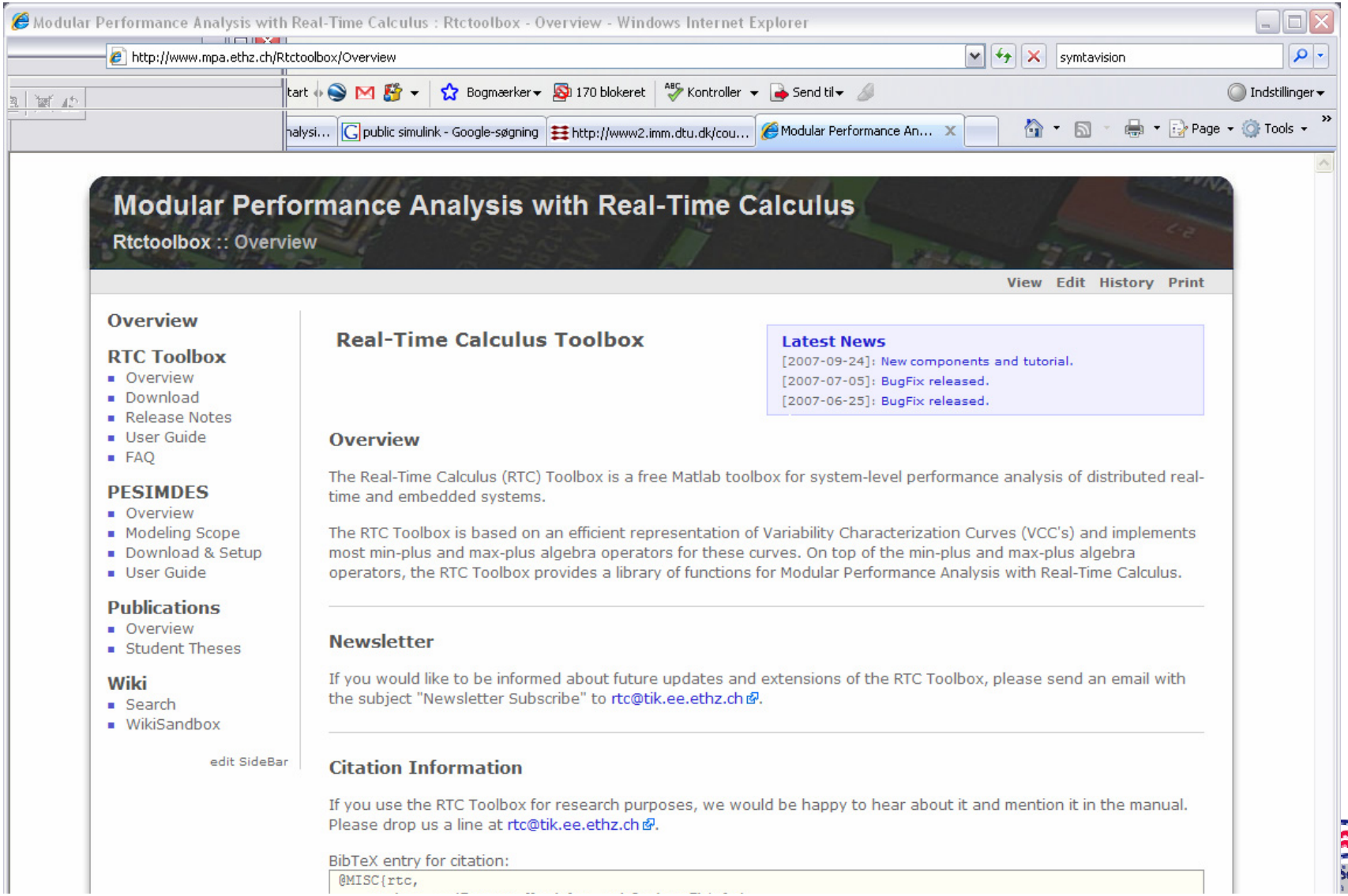
Overall Assessment and Vision at Y0+3

- There has been substantial progress in integrating different research directions and view points.
- Indicators that show this clearly are (a) the joint participation in summer schools, workshops and tutorials and (b) the number and quality of joint publications, and (c) the integration of tools.
  - 20 new joint publications
  - 15 individual cooperation results as described in the cluster report
- Cross-layer design is a key issue in embedded systems. The classical view of a strict layering according to chosen abstraction levels does not work any more because of the importance of non-functional constraints and limited resources.
- Therefore, completely new concepts are necessary that enable the integrated modeling and design under predictability AND efficiency constraints.

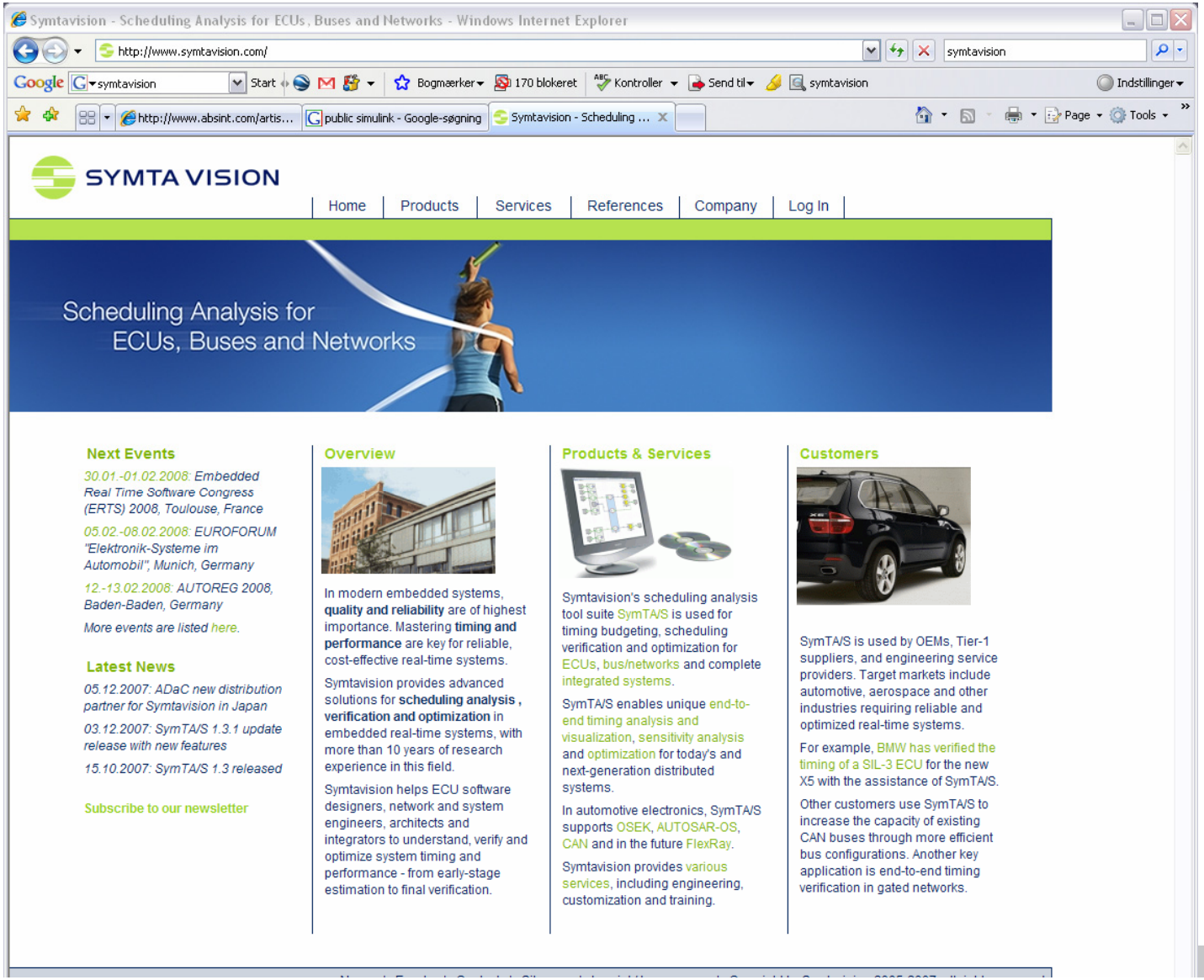
Scientific Highlights

- Performance Analysis Frameworks
  - MPA (ETH Zurich)
  - SymTA/S (TU Braunschweig)
- Energy Scavenging in Sensor Networks
  - ETH Zurich – University Bologna
  - 4 new joint publications
- Fault tolerant Embedded Systems
  - DTU – LiU
  - 3 new joint publications
- A Timed-Automata Model of ARTS
  - DTU – AAU
  - Joint research project (DaNES)

MPA: Modular Performance Analysis



SymTA/S


Symtavision - Scheduling Analysis for ECUs, Buses and Networks - Windows Internet Explorer
http://www.symtavision.com/
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Scheduling Analysis for
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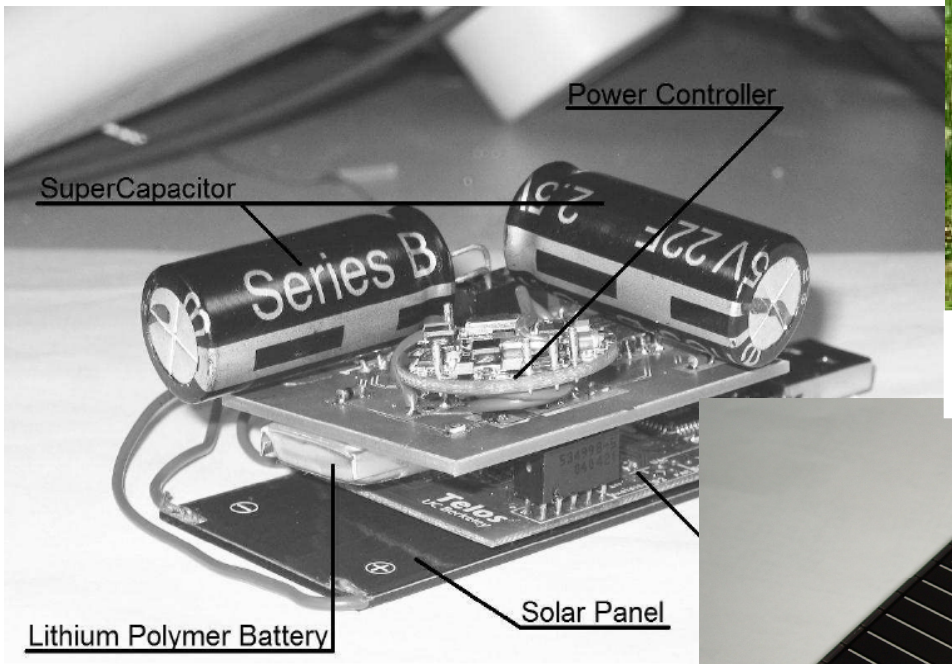
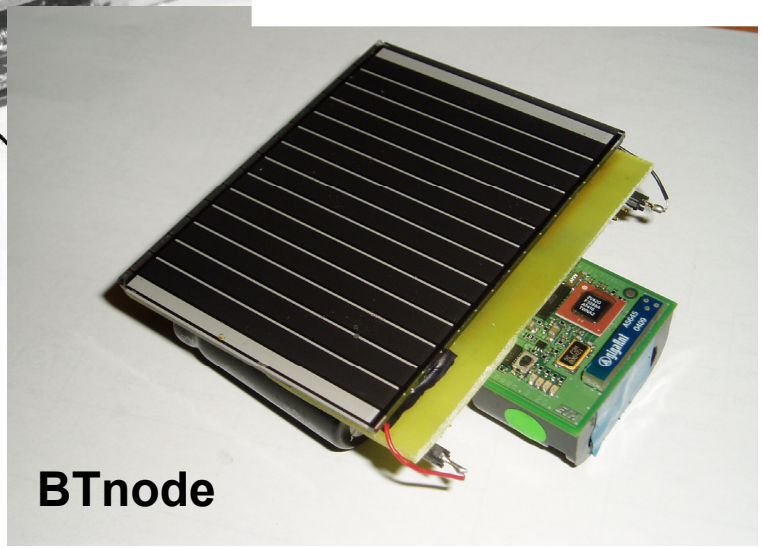
Next Events
30.01.-01.02.2008: Embedded Real Time Software Congress (ERTS) 2008, Toulouse, France
05.02.-08.02.2008: EUROFORUM "Elektronik-Systeme im Automobil", Munich, Germany
12.-13.02.2008: AUTOREG 2008, Baden-Baden, Germany
More events are listed here.
Latest News
05.12.2007: ADaC new distribution partner for Symtavision in Japan
03.12.2007: SymTA/S 1.3.1 update release with new features
15.10.2007: SymTA/S 1.3 released
Subscribe to our newsletter
Overview
In modern embedded systems, quality and reliability are of highest importance. Mastering timing and performance are key for reliable, cost-effective real-time systems.
Symtavision provides advanced solutions for scheduling analysis , verification and optimization in embedded real-time systems, with more than 10 years of research experience in this field.
Symtavision helps ECU software designers, network and system engineers, architects and integrators to understand, verify and optimize system timing and performance - from early-stage estimation to final verification.
Products & Services
Symtavision's scheduling analysis tool suite SymTA/S is used for timing budgeting, scheduling verification and optimization for ECUs, bus/networks and complete integrated systems.
SymTA/S enables unique end-to-end timing analysis and visualization, sensitivity analysis and optimization for today's and next-generation distributed systems.
In automotive electronics, SymTA/S supports OSEK, AUTOSAR-OS, CAN and in the future FlexRay.
Symtavision provides various services, including engineering, customization and training.
Customers
SymTA/S is used by OEMs, Tier-1 suppliers, and engineering service providers. Target markets include automotive, aerospace and other industries requiring reliable and optimized real-time systems.
For example, BMW has verified the timing of a SIL-3 ECU for the new X5 with the assistance of SymTA/S.
Other customers use SymTA/S to increase the capacity of existing CAN buses through more efficient bus configurations. Another key application is end-to-end timing verification in gated networks.

Energy Scavenging in Sensor Networks



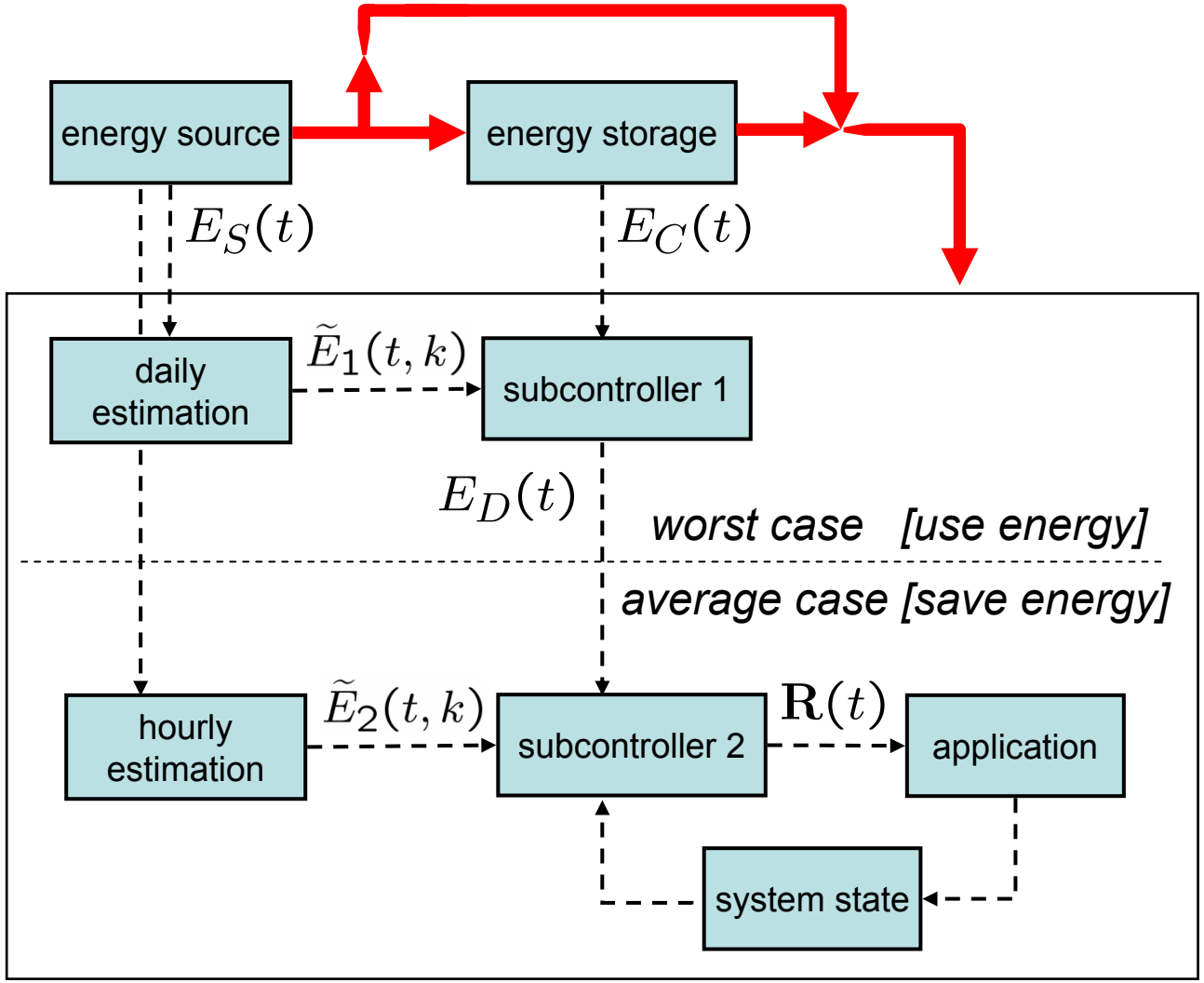
[Prometheus: Culler]

[Heliomote: Srivastava]



BTnode

Hierarchical Control Design



Hierarchical Control Design

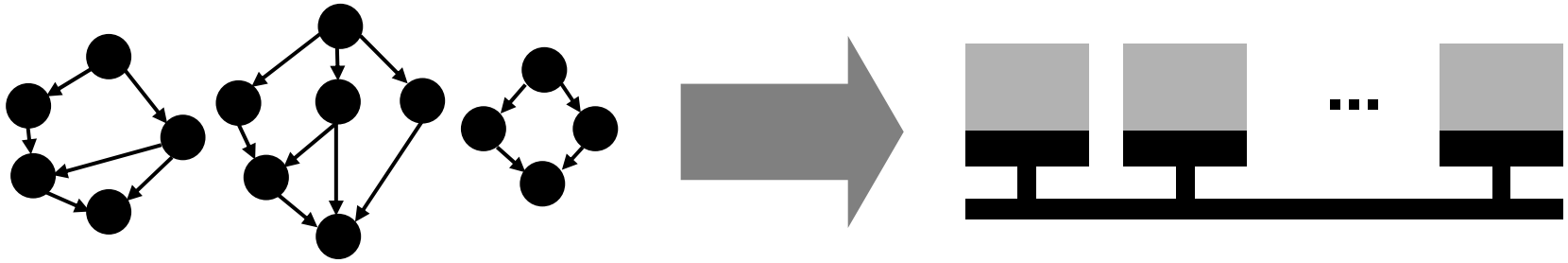
- Benefits
  - The upper layer avoids depletion of the energy storage and increases robustness of the system
  - The complexity of the online controller is reduced significantly

control design	N_{CR}	storage (real numbers)	ops (worst case)
single controller	1049	28323	52449
hierarchical, subcontroller 1	30	1920	3689
subcontroller 2	161	2898	4829
Reduction:		**83.0 %**	**91.0 %**

Fault tolerant Embedded Systems

- Given

Fault-model: transient faults



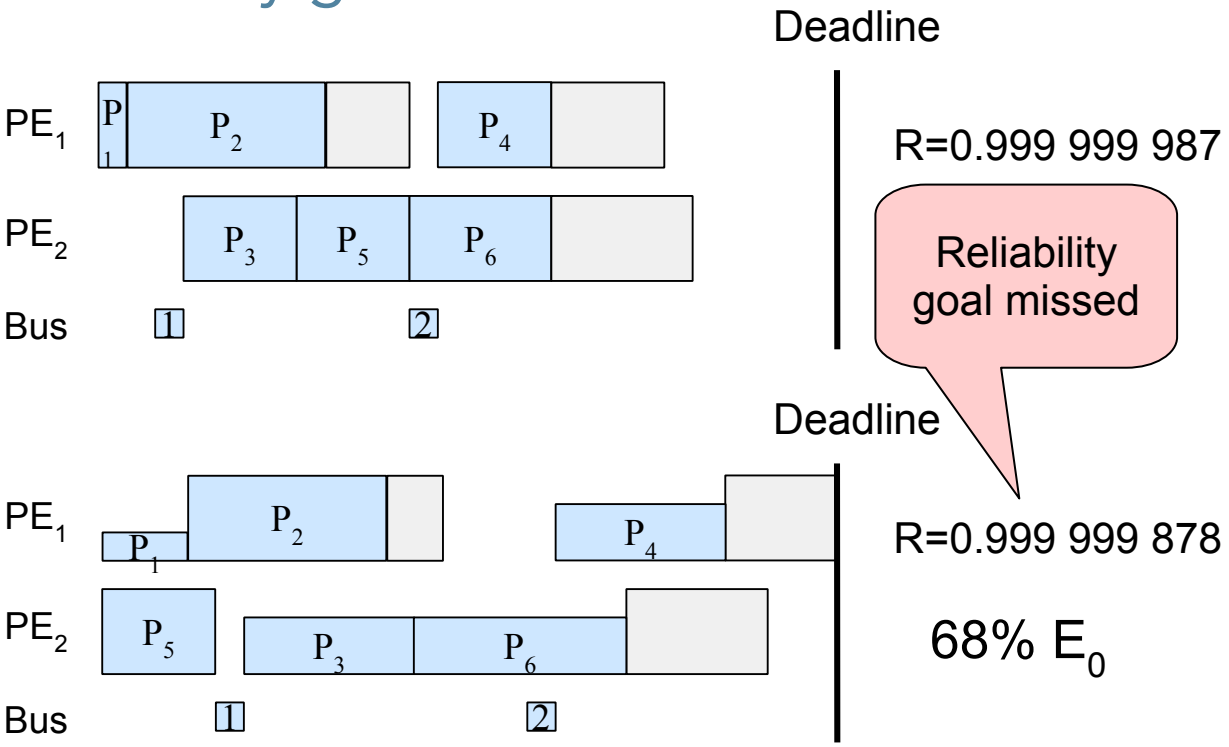
Application: set of process graphs
WCETs, message sizes, periods, deadlines

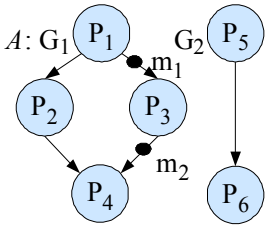
Architecture: time-triggered system

- Determine
  1. **Schedulable** and **fault-tolerant** design implementation that minimizes energy

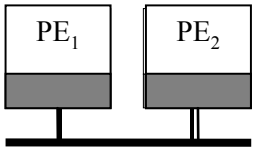
Energy/Reliability Trade-off

- Reliability goal: 0.999 999 9





	N_1	N_2
P_1	10	X
P_2	70	X
P_3	X	40
P_4	40	X
P_5	X	40
P_6	X	50



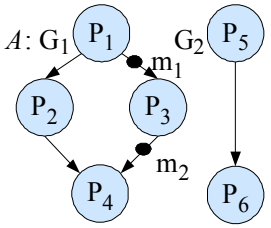
Voltage levels

N_1	100%	66%	33%
N_2	100%	66%	33%

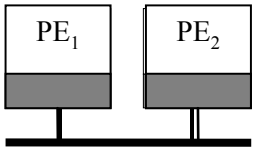
k = 1

Energy/Reliability Trade-off

- Reliability goal: 0.999 999 9
- Set reliability as hard constraint
- Trade-off 5% energy
- Meets reliability goal



	N_1	N_2
P_1	10	X
P_2	70	X
P_3	X	40
P_4	40	X
P_5	X	40
P_6	X	50



Voltage levels

N_1	100%	66%	33%
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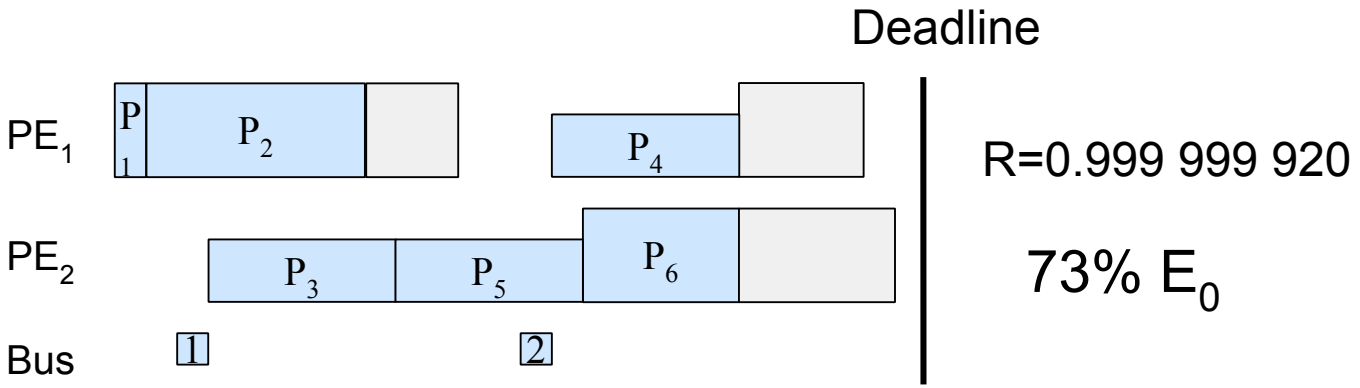
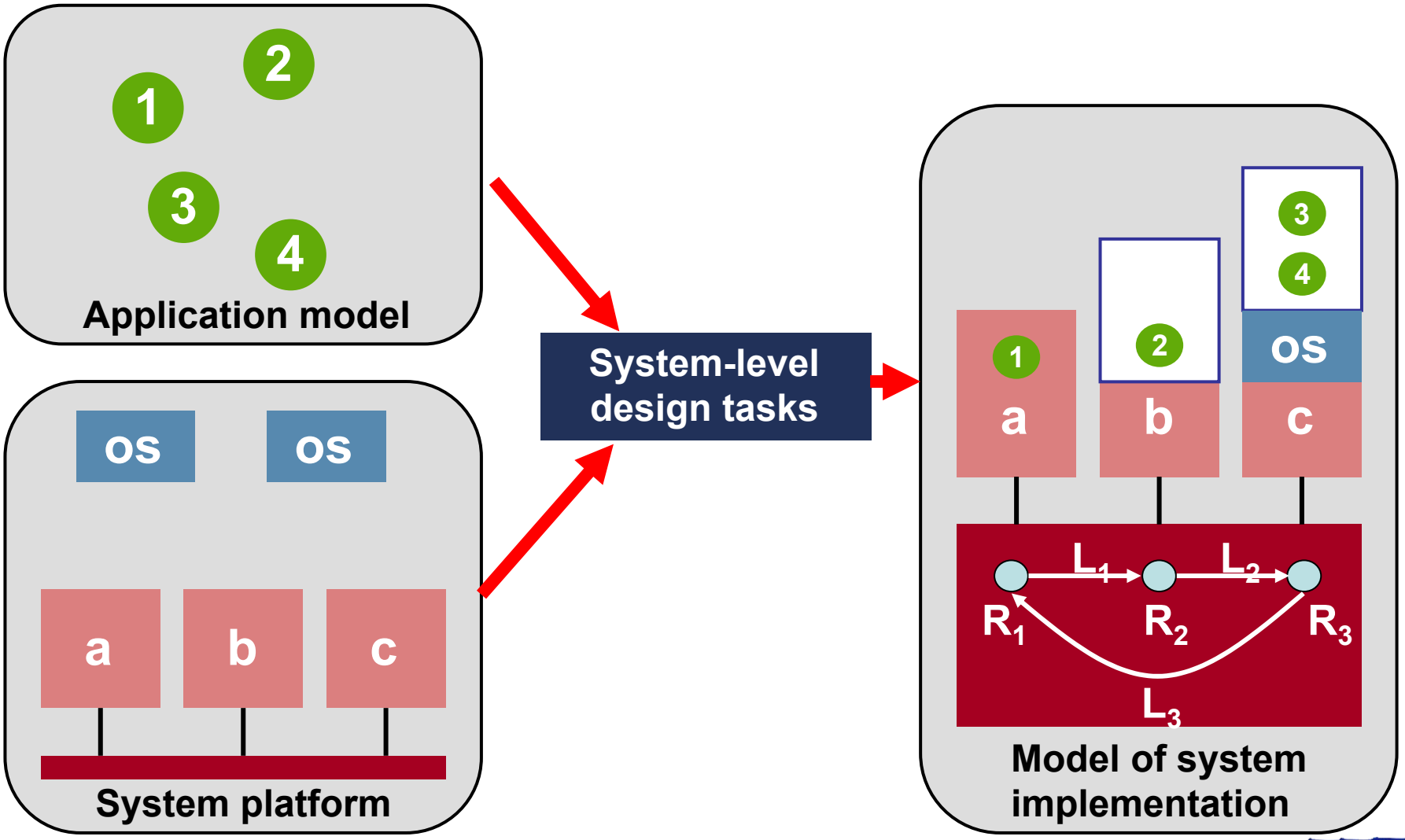
k = 1



R=0.999 999 920

73% E_0

A Timed-Automata Model of ARTS



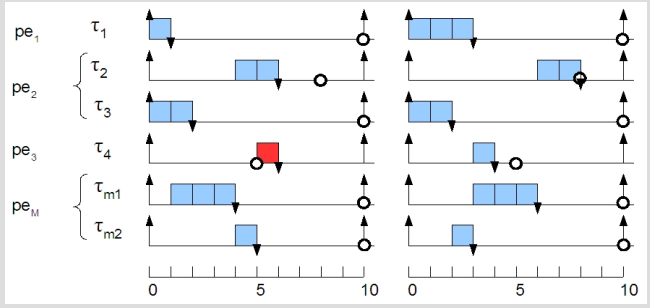
A Timed-Automata Model of ARTS

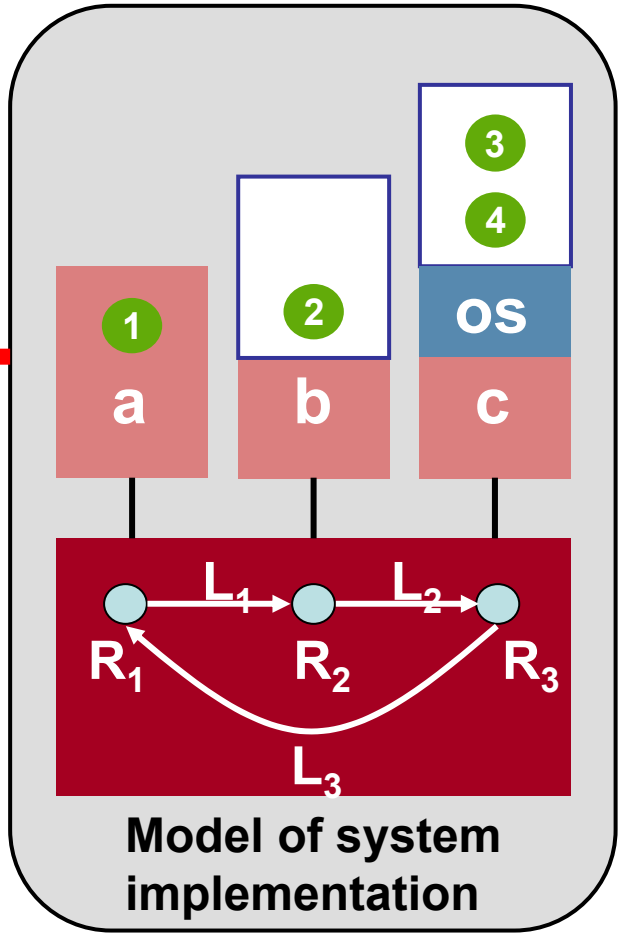
```
E<>missedDeadline

E<>totalCostUsed(Memory)>=23

E<>totalCostUsed(Energy)>=15
```

Required specification

Model checking

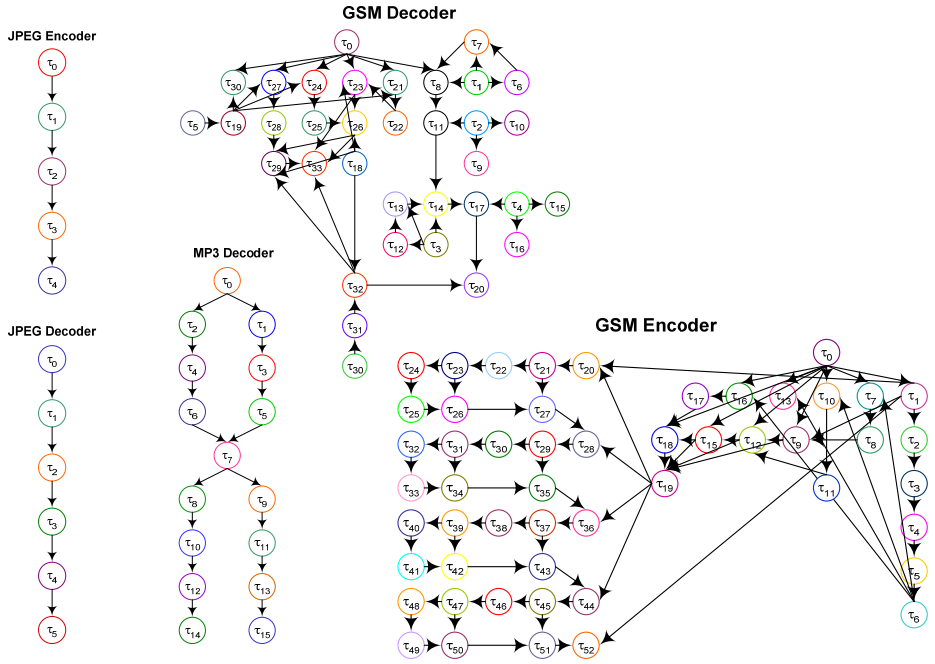
UPPAAL





Model of system implementation

Example: Smart phone



- Tasks: 114
- Deadlines: [0.02: 0.5] sec
- Execution: [52 : 266.687] cycles
- Hyperperiod: 12.500.000 cycles
- ~2.500 task executions
- Platform:
  - 6 processors, 25 MHz
  - 1 bus
- *Verified in 1.5 hours!*

Structural changes for Y4

- Jan Madsen will replace Lothar Thiele as the cluster leader of Execution Platforms

Plans for Year 4

- System Modeling Infrastructure
  - DTU and LiU will refine the model to capture fine grained combinations of several fault-tolerance techniques. LiU will do experimental evaluations using the simulation environment for distributed embedded systems.
  - TU Braunschweig will continue its work extending the semantic model of SymTA/S to efficiently cover MPSoC architectures.
  - DTU will continue the work on formalizing the ARTS model using timed automata based on UPPAAL.
  - DTU will refine its formal model to address modeling and verification issues closer to the hardware layer of the execution platform.
  - ETHZ intends to combine Modular Performance Analysis with timed automata based evaluation methods. This work will be done togehter with the affiliated parter NUS (National University Singapore). This way, there is a link and integration of MPA with (a) simulation (done in a joint work togehter with University Bologna), (b) Symta/S (joint work with TU Braunschweig) and (c) timed automata (NUS, DTU).

Plans for Year 4

- Communication-Centric Systems
  - ETH Zurich plans to build on the results of the previous year in terms of comparing different analysis methods in terms of scope and accuracy.
  - The Linköping group will continue further development of the analysis and optimization techniques for fault-tolerant and predictable distributed systems. In particular, fault tolerance for soft real-time systems will be investigated.
  - DTU and LiU will continue their collaboration on the FlexRay communication protocol.
  - DTU will continue its work on efficient NoC architectures.
  - TU Braunschweig will further investigate the application of hierarchical event models for performance verification of embedded systems.

Plans for Year 4

- Low Power Design
  - Scheduling based energy optimization for energy-scavenging wireless sensor
    - By implementing the algorithms developed at ETH Zurich on the solar scavenger prototype developed at the University of Bologna, it is planned to test the theoretical energy harvesting framework and demonstrate sustainable operation using solar energy.
    - By deploying sensor nodes – which are powered by solar energy – it is planned to demonstrate the usefulness of the theoretical results in a practical application, possibly in an outdoor setting.
  - System-level resource allocation and scheduling
    - Power optimization for nanometer platforms.
    - Mapping and scheduling for general task graphs, including complete dataflow graphs as well as models for non-deterministic behaviour (e.g. conditional task graphs).
    - Temperature aware energy optimisation.

Plans for Year 4

- Ressource-Aware Design
  - Bologna and Dortmund will continue cooperation on code generation for resource-aware embedded platforms.
  - Collaboration of DTU and Linköping will focus on adaptivity-related aspects, which will allow system reconfiguration in case of failures or changes in the environment.
  - At Linköping, work on "Predictability for Multiprocessor SoC Architectures" will be continued. Main goals include further optimization of the bus access and Controller design and synthesis. Bologna will also be involved in this work, focusing on optimizing bus controller implementation.
  - An increase in cooperation and joint activities is expected. Thanks to the pivotal role of ARTIST2, several new projects will be initiated, as they have successfully obtained FP7 funding:
    - MIMEE and PREDATOR