Year 4 Review
Dresden, March 16th, 2012

Cluster

Achievements and Perspectives :

Hardware Platforms and MPSoC Design

leader : Jan Madsen (DTU)

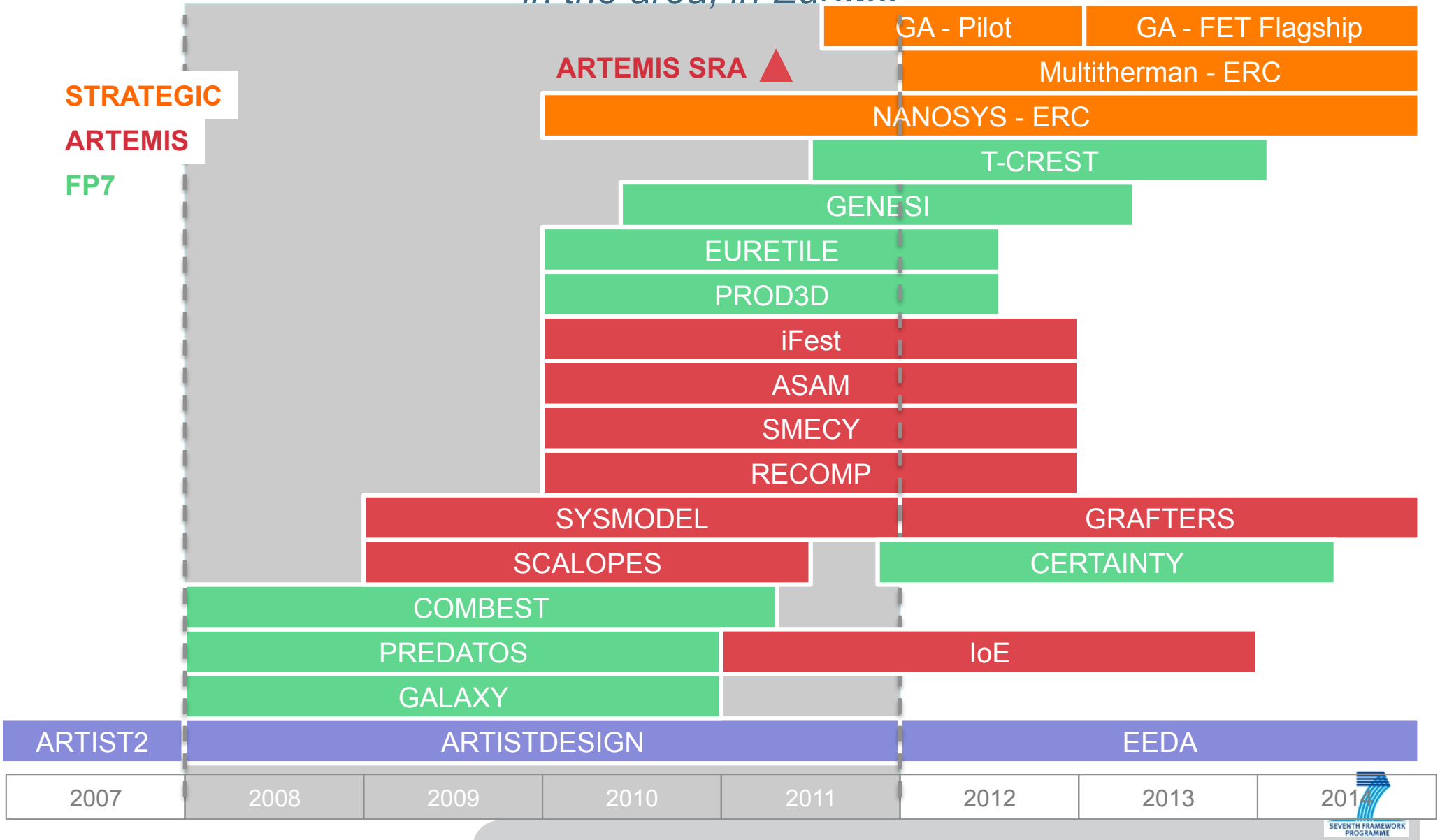
Luca Benini (UNIBO)

Overall High-Level Objectives and Vision

- Focus on Design and Analysis
- Hardware architecture and software components in their interaction
- Tools for accurate estimation
- Growing importance of resource awareness in embedded systems
- Design methodology
  - Scales to massively parallel and heterogeneous multiprocessor architectures
  - Allows for predictable system properties
  - Uses the available hardware resources in an efficient manner
- Adaptivity
  - Robustness
  - Life-time management
  - Resilience

Integration Achieved

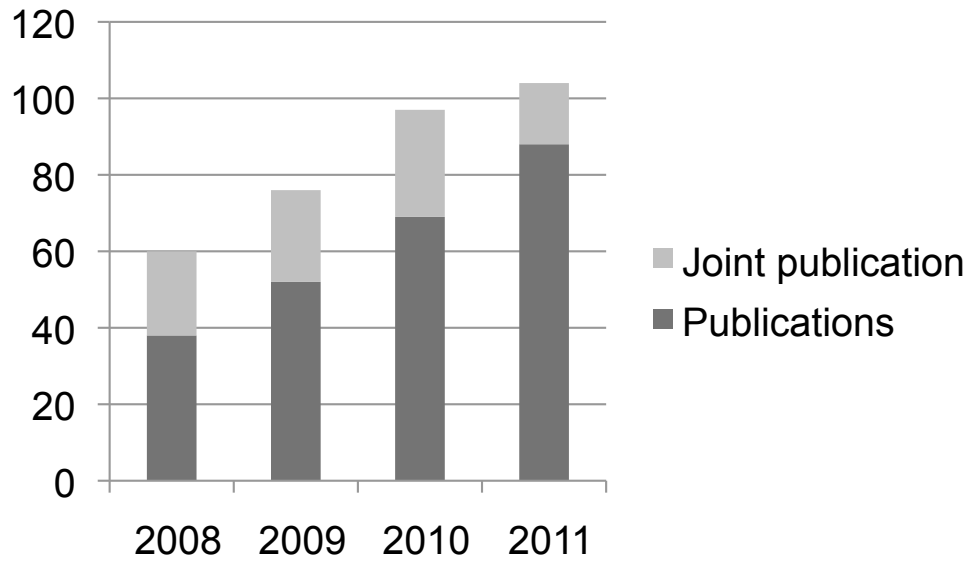
in the area, in Europe



Building Excellence

in the area, in Europe

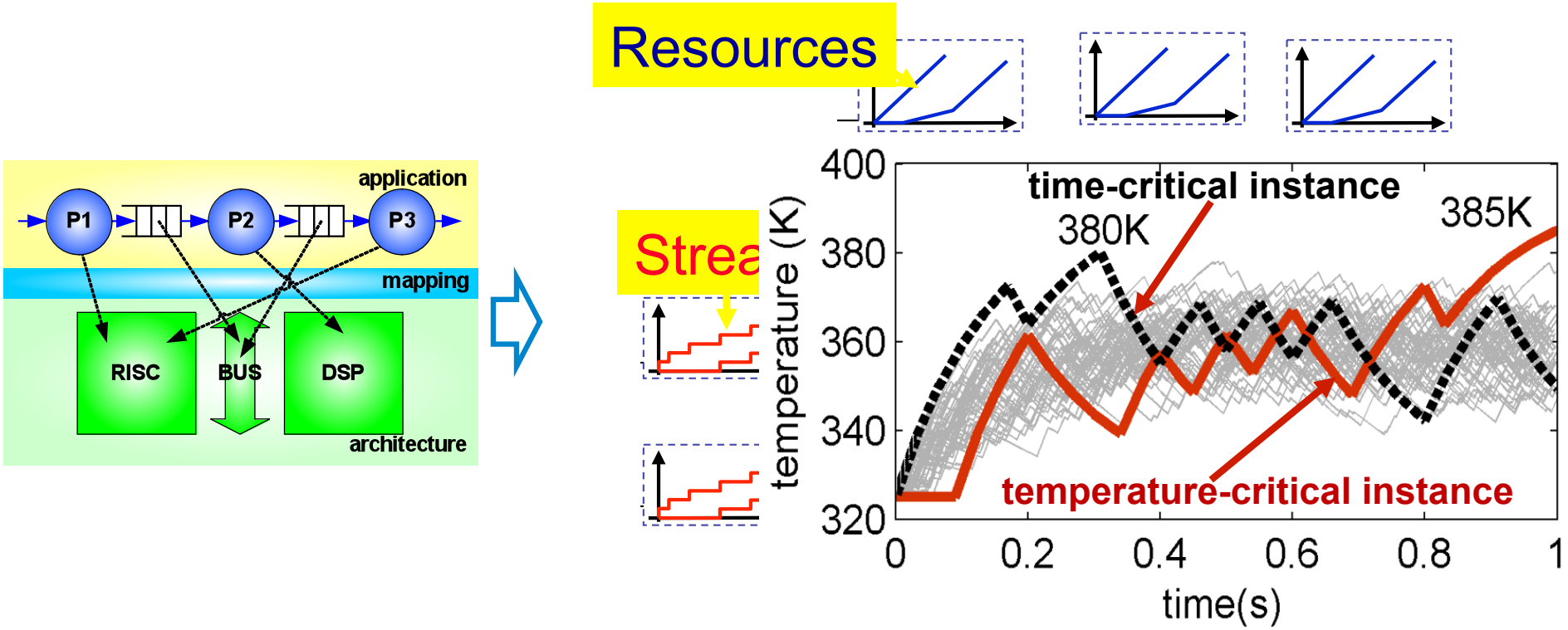
- 337 publications
  - 27% joint
  - Several best papers
    - Cluster got all 3 best papers at ESWeek 2009
- 8 tools
- 3 spin-offs
- 9 workshops
- 19 tutorials
- 10 special sessions
- 64 invited talks



Main Scientific Highlights and Insights Gained

- MPSoC timing analysis and optimization
  - Better understanding of the timing of multi-core systems with shared resources, including temperature, reliability and effects of 3D integration
- Mixed criticality systems
- Self-powered systems
  - Harvesting energy from the environment

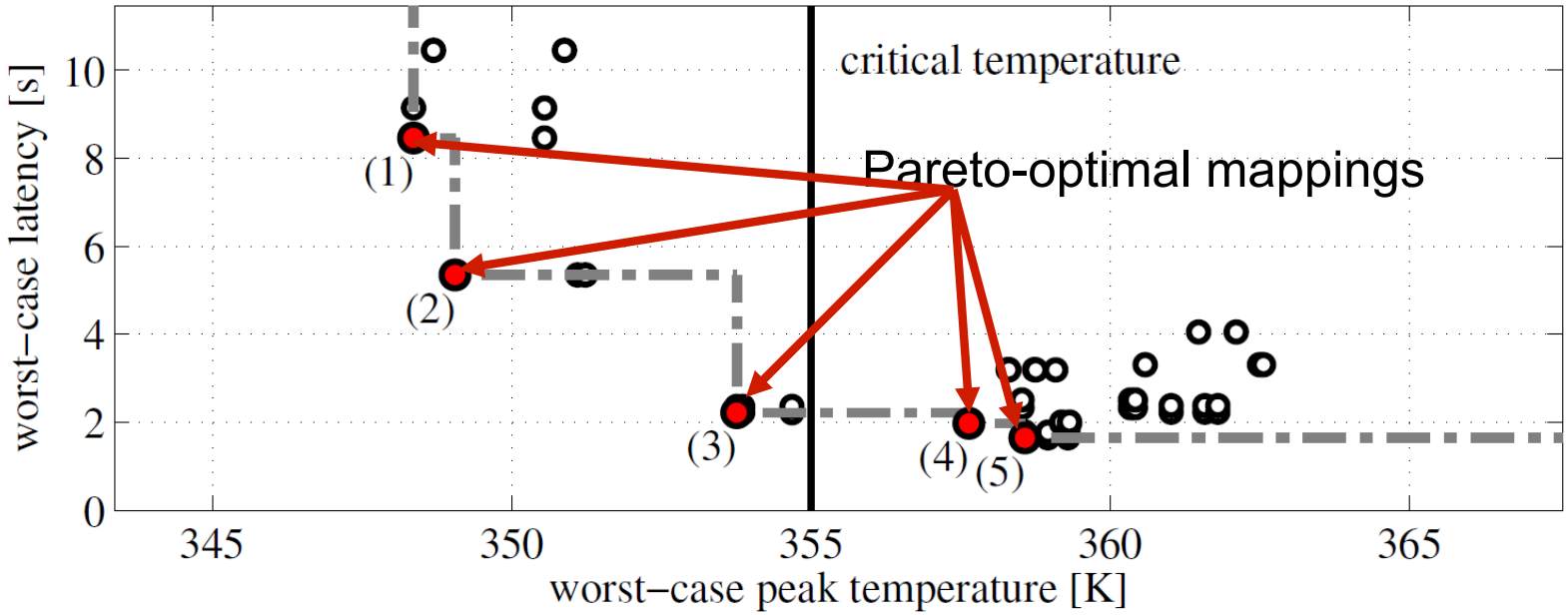
MPSoC System and Analysis Model



- real-time analysis via modular performance analysis (MPA)*
  - streams and resources represented by *arrival/service curves*
  - output: *worst-case bounds* on system timing properties – **latency, buffers, temperature**

modular performance analysis (MPA) http://www.mpa.ethz.ch

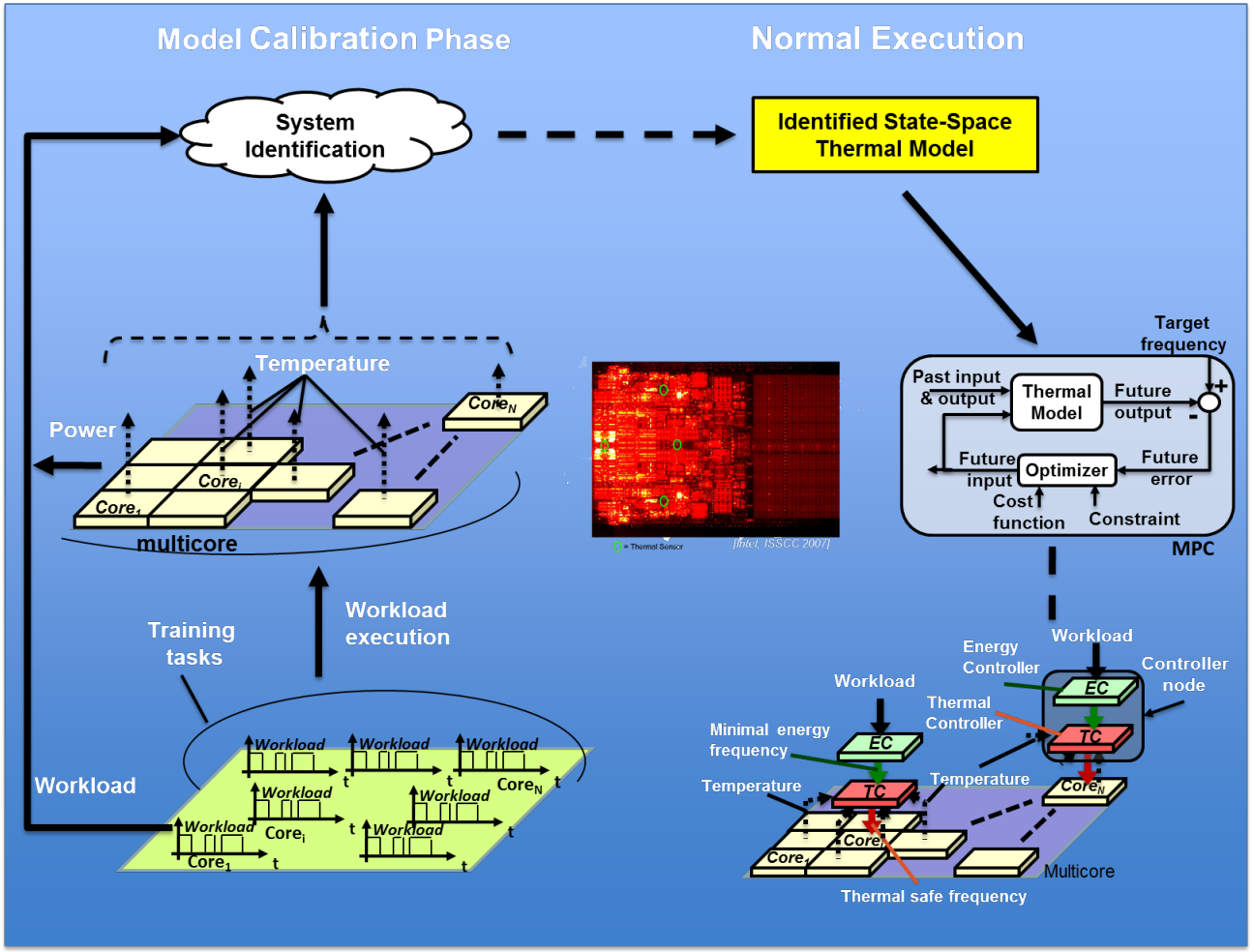
Thermal Analysis Model in System-Level Design Space Exploration



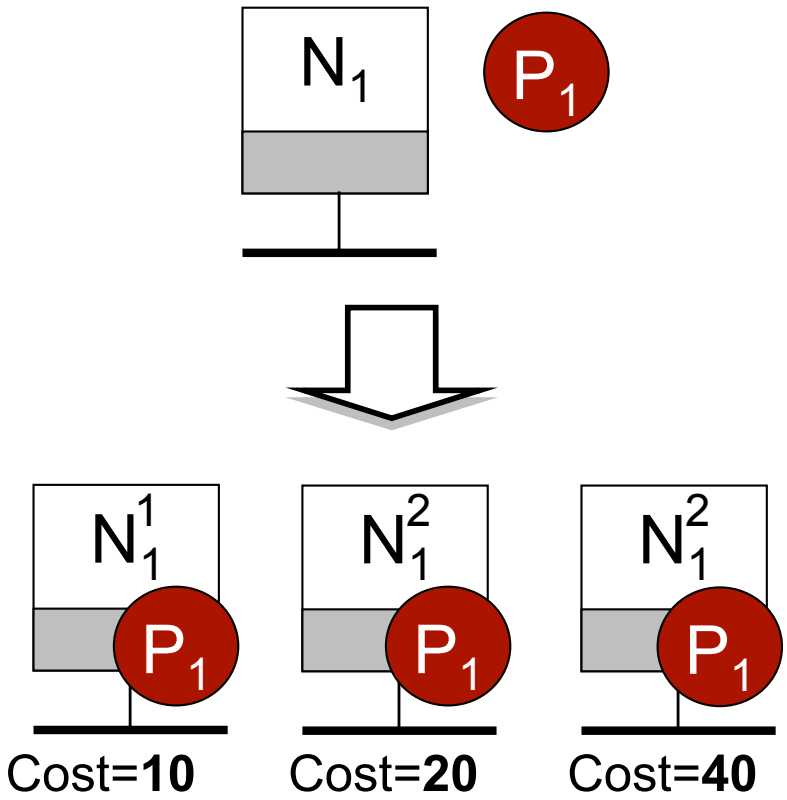
- **experimental set-up:** MJPEG decoder executed on MPARM platform & HotSpot simulator (50 candidate mappings analyzed)
- **objectives:** worst-case peak temperature and overall worst-case latency (both evaluated with MPA)

Power, Thermal and Reliability Aware Resource Managment for Multicores Systems (UNIBO, Intel Lab)

- Thermal effects become a scalability wall for manycores due to hot spots
- Solution: Dynamic operating point control with feedback from HW/SW sensors
- Optimal control: maximize performance & minimize energy at safe temperature
- Based on a fully distributed, scalable Model Predictive Control approach
- Includes estimation and auto-calibration of internal thermal models



Fault tolerance optimization with harden processors (LiU, DTU)



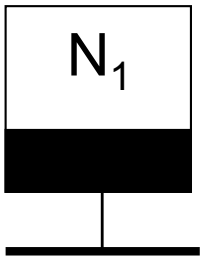
Several hardening versions:

Increase in reliability /
Decrease in process failure probabilities

Increased execution time of processes

Increased hardware cost

Application Example

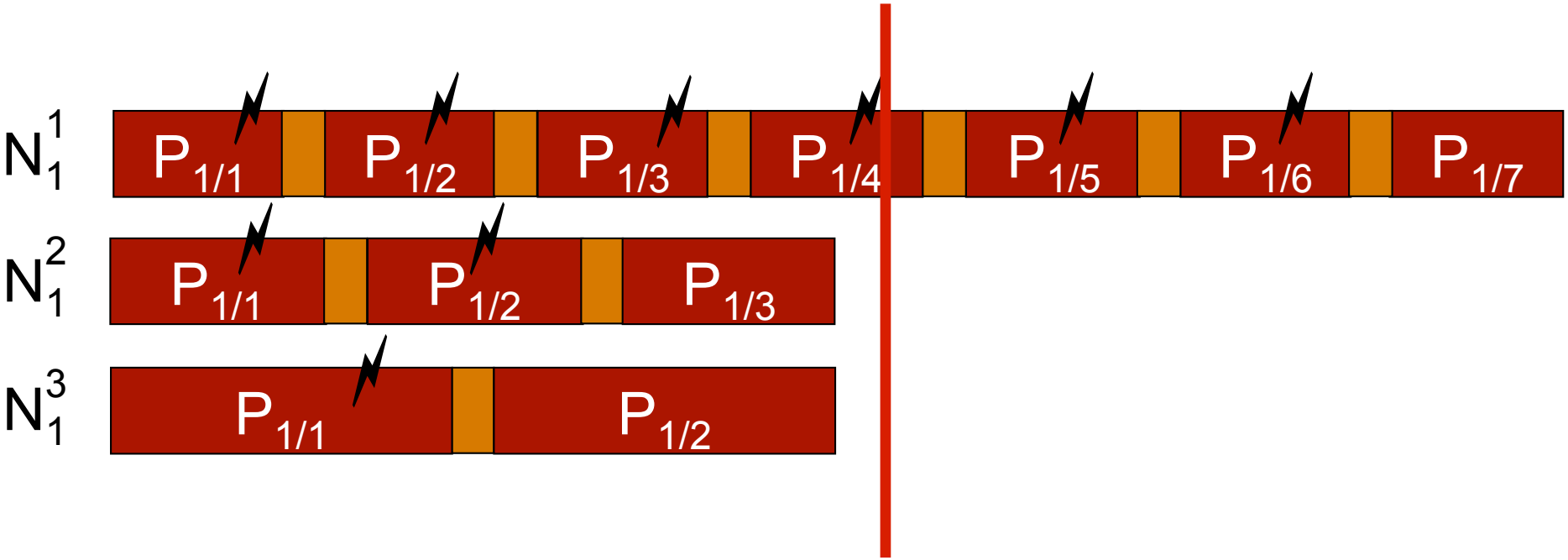


$\rho = 1 - 10^{-5}$

$\mu = 20$ ms

$D = 360$ms

N_1	h = 1		h = 2		h = 3	
	t	p	t	p	t	p
P_1	80	$4 \cdot 10^{-2}$	100	$4 \cdot 10^{-4}$	160	$4 \cdot 10^{-6}$
Cost	10		20		40	



Viacheslav Izosimov from LiU awarded *Best PhD thesis in embedded systems* at DATE 2012

MAX – hardening-only optimization

MIN – software-level-only optimization

OPT – combined architecture

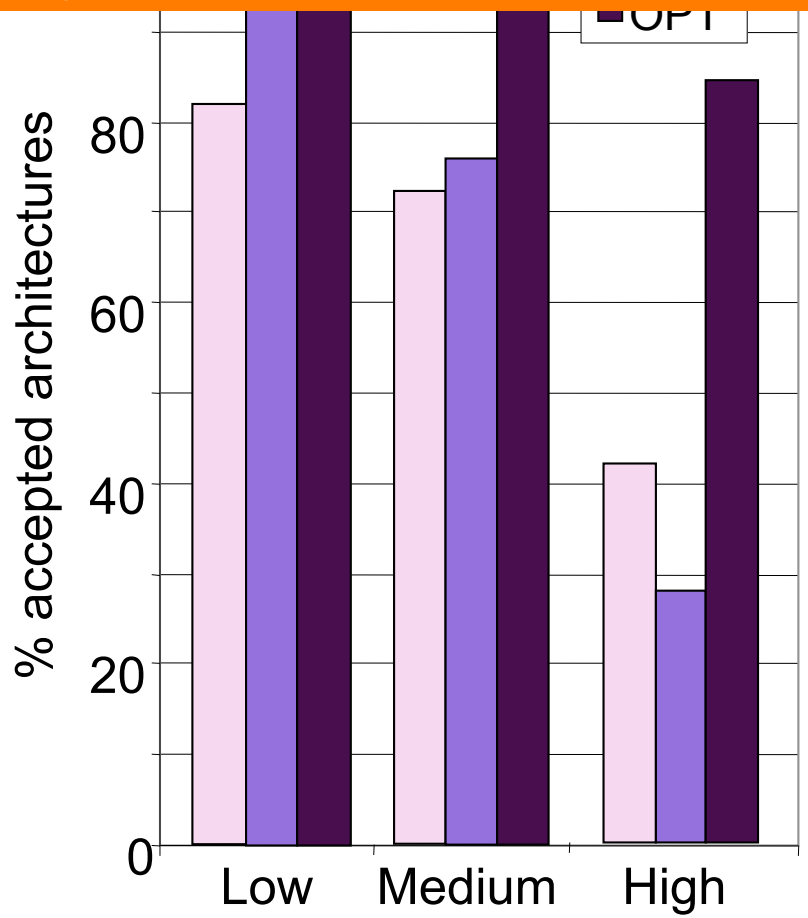
Accepted architecture:

- Cost constraint
- Time constraints
- Reliability goal

Hardening performance degradation (HPD) 5%

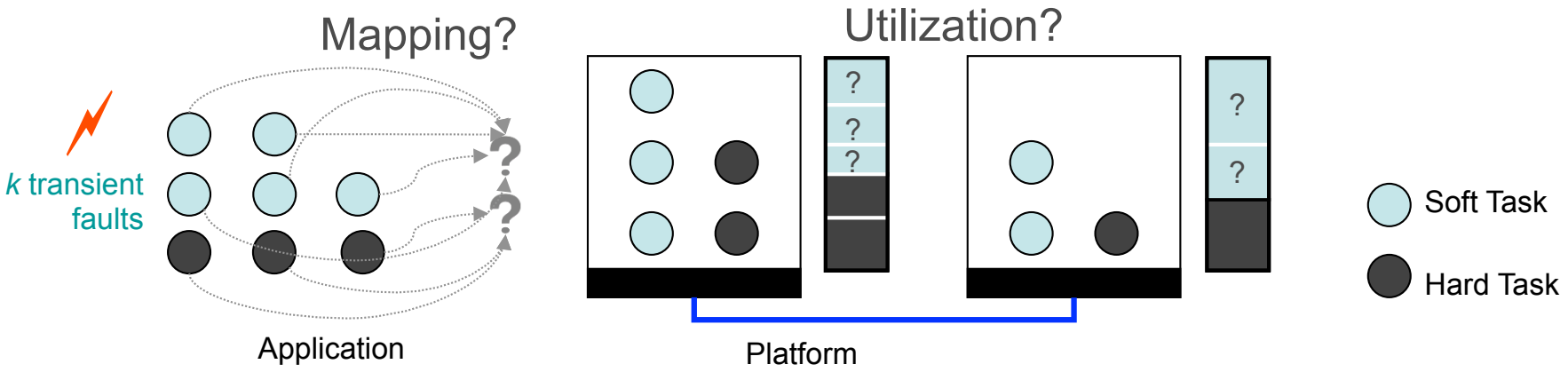
Performance difference between the least hardened and the most hardened versions

Maximum cost 20



% accepted architectures in relation to different technologies (fault rates)

Task Mapping and Bandwidth Reservation for Mixed Hard/Soft Fault-Tolerant Embedded Systems



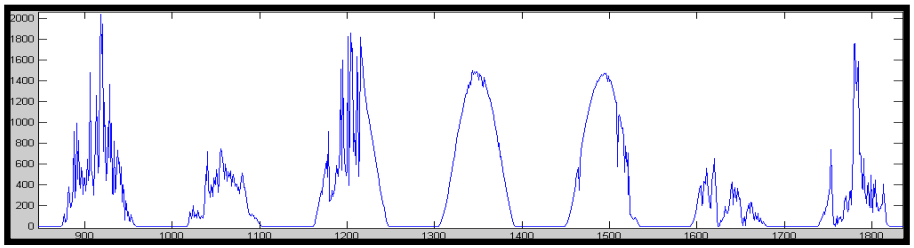
- Given: A mixed hard/soft fault-tolerant application and a distributed platform
- Determine: Mapping and Utilization
- Such that:
  - ***Deadlines for all hard real-time tasks are satisfied (Even in case of faults)***
  - ***Probability of meeting of deadline for soft tasks is maximized***

HW/SW Energy Harvesting Techniqes (UNIBO, ETHZ, DTU)

Effective, long term, power supplies are limited and/or expensive

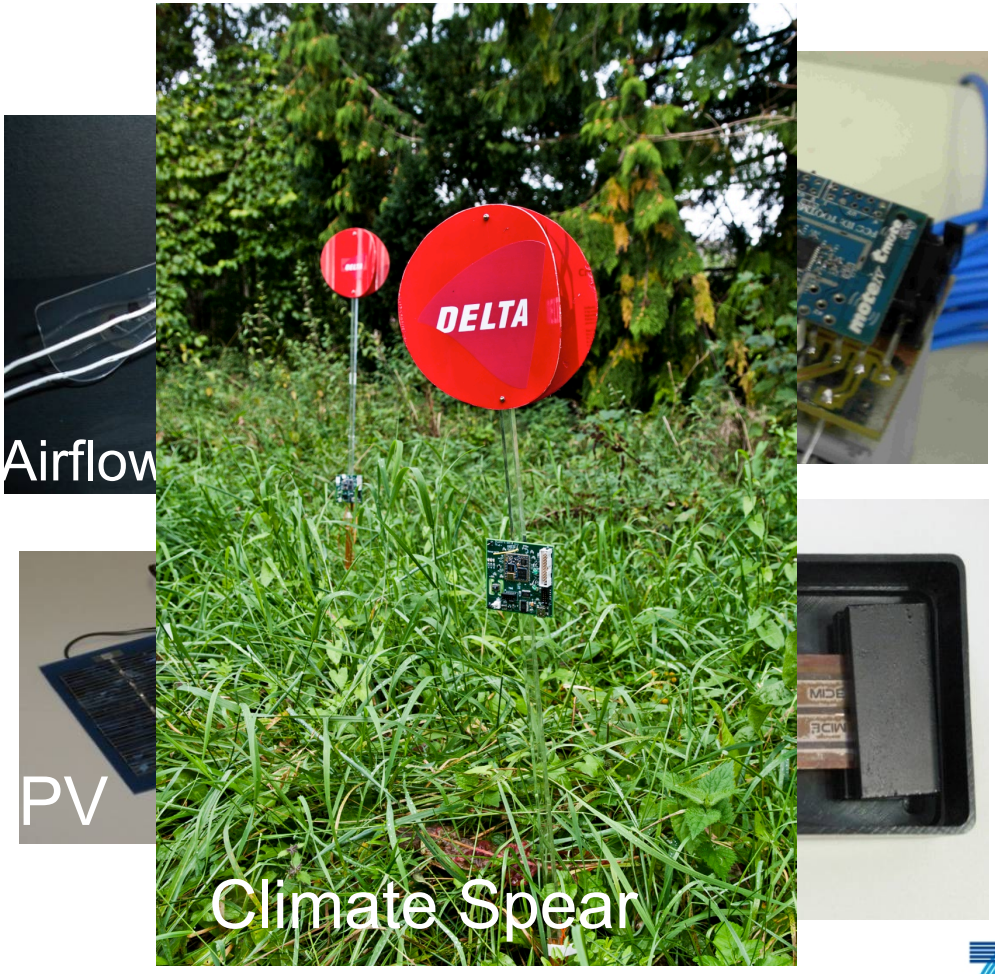
Goal

Investigate energy harvesting and management technologies that can support the operation of a smart sensor node **indefinitely**



- ✓ Conventional energy management: **How** do we **save energy** ?
- ✓ Energy harvesting management: **When** do we **use energy** ?

It's a cross-layer issue!



Joint Activities

- Timing analysis: MPSoC scheduling [resources, thermal]
  - SSCGTA-cluster and MV-cluster
  - Workshops Software Synthesis and MAP2MPSOC
- Predictability: MPSoC and NoC
- Reliability: Fault-tolerance [timing, power/reliability]
- Adaptivity: Run-time management, self-healing MPSoC

Tools and Platforms

- **SymTA/S**: Development and verification of embedded multiprocessor real-time systems (TUBS,ETHZ,SymtaVision,AbsInt)
- Analysis and optimization framework for fault tolerant distributed embedded systems (LiU,DTU)
- **MPHP**: An integration of MPA parallelization assistant and MH static memory allocation for MPSoC (IMEC,KTH,Dortmund,TU/e,DUTH)
- **MoVES**: Modelling and verification of embedded systems (DTU,AAU)
- **MPA**: Modular Performance Analysis (ETHZ,TUBS)
- **DOL**: Distributed operation layer (ETHZ,UNIBO)
- **McNoC**: Multicore network on chip (KTH,NTUA,NUDT)
- **ForSyDe**: Formal system design (KTH,DTU) integrated with SystemC

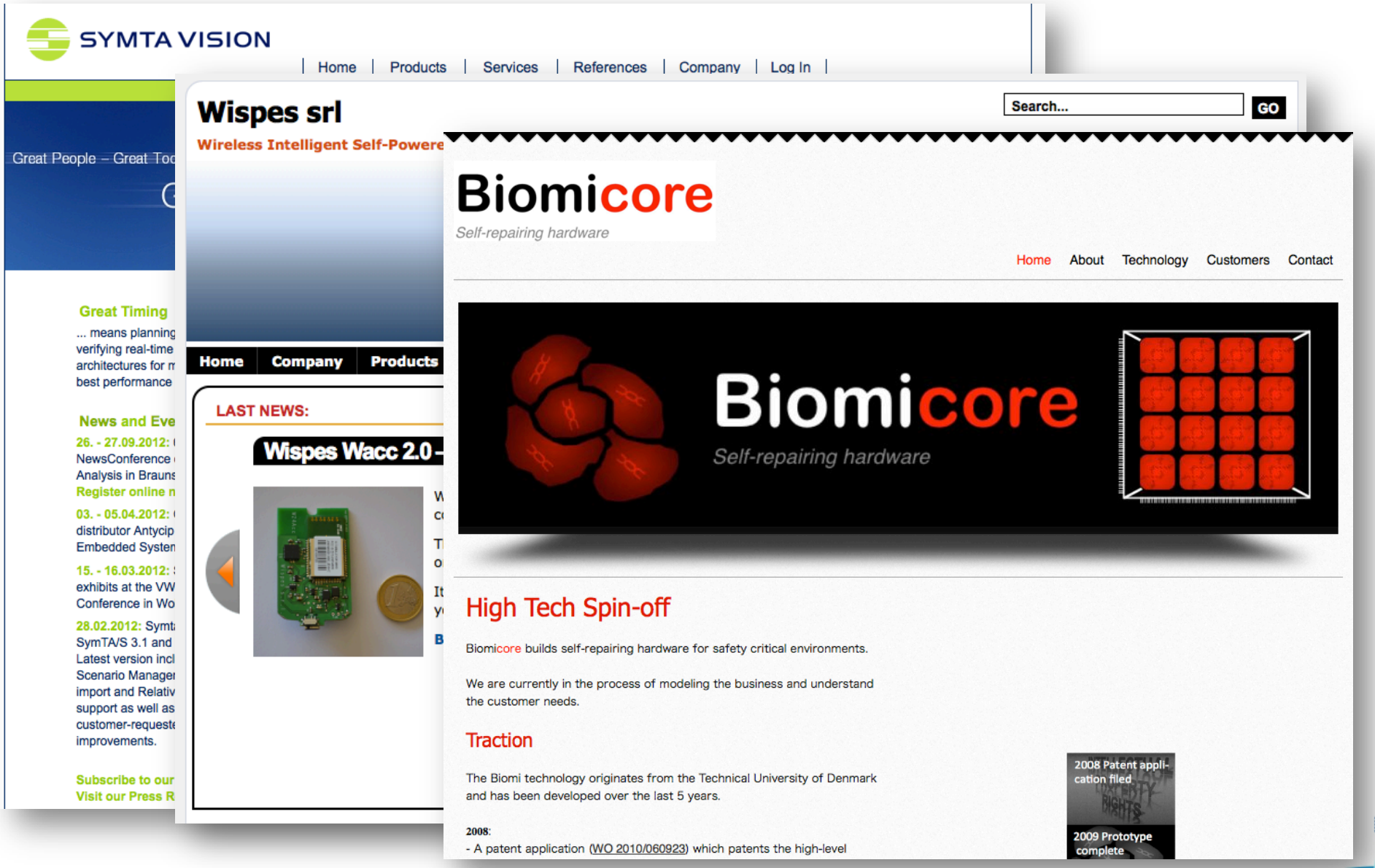
Many of the tools are used and further developed together with industry in ARTEMIS and FP7 projects

Lasting Impacts

Future interaction beyond the end of the NoE

- Research
  - Heavy influence on ARTEMIS program and projects
  - NanoTera [Swiss project 2008-2020]
  - ARAMIS [German many-core project 2011-2014]
  - Guardian Angels [EU FET Flagship]
- Education
  - iCES [Masters Program in Embedded Systems, KTH + industry]
  - Models of Multicore Programming [Masters Program in at the Sino-Danish University in Beijing, China]
  - Exchange program [KTH and Fudan University in Shanghai, China]
- Industry
  - 3 start-up companies [Symtavision, Wispes, BiomiCore]
  - Large number of “Artist” PhDs now going into industry
  - Contribution to standards [AVB, RTJava]
  - Education and awareness of Systems Engineering for Embedded Systems [4 year program in Denmark]
- Community
  - ADSIG (EDAA)

Start-up Companies



Final Overall Assessment

- The efforts to establish an integrated modeling and design methodology that can take into account predictability and efficiency constraints have successfully been continued from ARTIST2
- Focus on both multi- and many-core platforms as well as platforms for distributed networked systems
- Special emphasis on resource-awareness. Obtained a better understanding of the timing of multi-core systems with shared resources through the development of timing analysis methods that have been applied to industrial use cases
- Challenge to include and handle consequences of emerging technologies
  - 3D chip integration, variability, microfluidic biochips and self-powered wireless sensors
  - Risk assessment [insight gained from industry collaborations]

Final Overall Assessment

Embedded Systems is a *technology*
NOT just a service!