Review
Brussels, January 23rd, 2009

Achievements and Perspectives:

Operating Systems and Networks

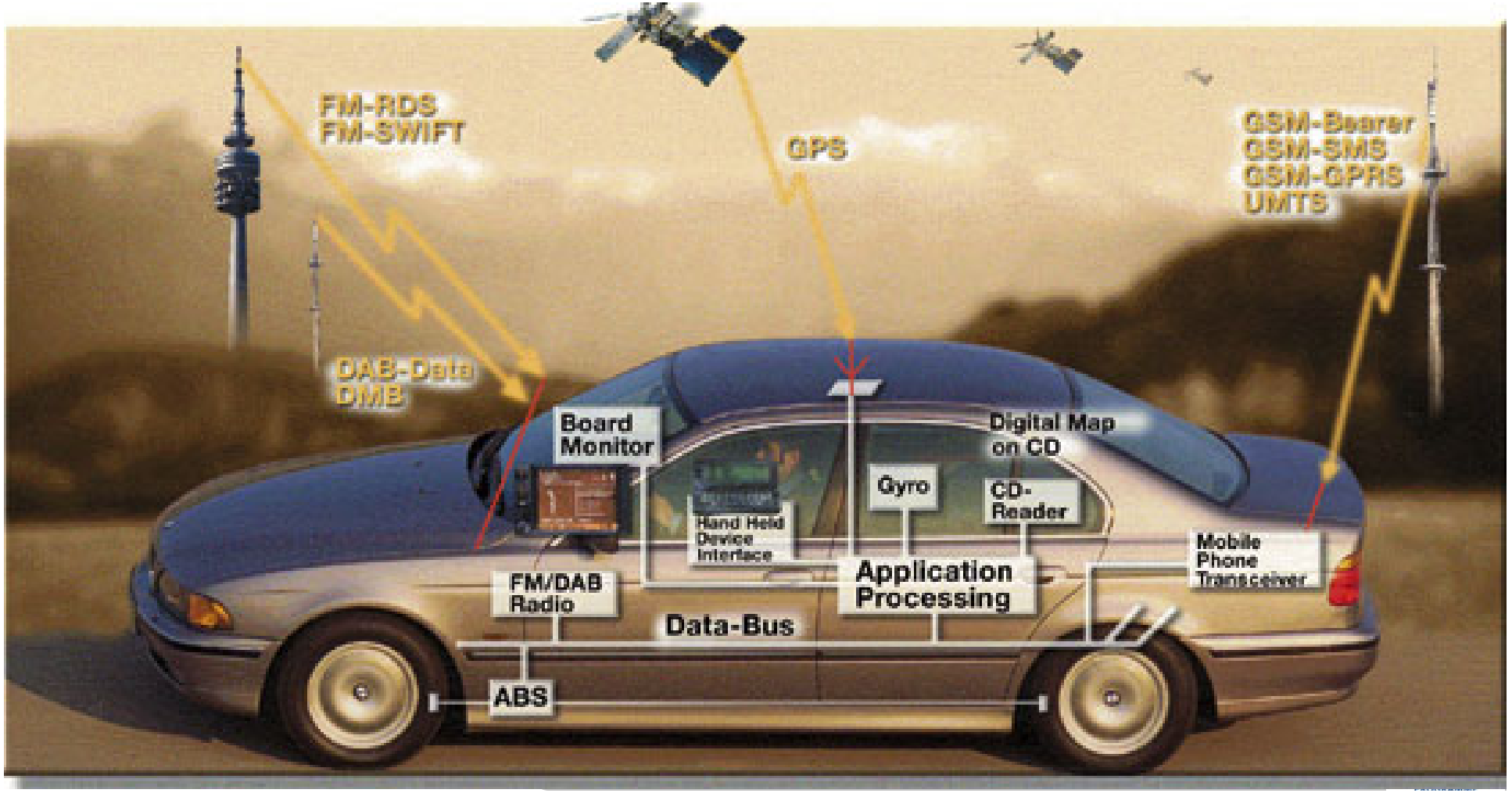
Cluster leader: Giorgio Buttazzo
Scuola Superiore Sant'Anna
Pisa, Italy

Outline of the Presentation

- **Objectives**
- **Partners and activities**
- **Achievements**
- **Future plan**

Embedded Systems

Embedded systems are becoming more complex, and characterized by dynamic behavior and distributed organization

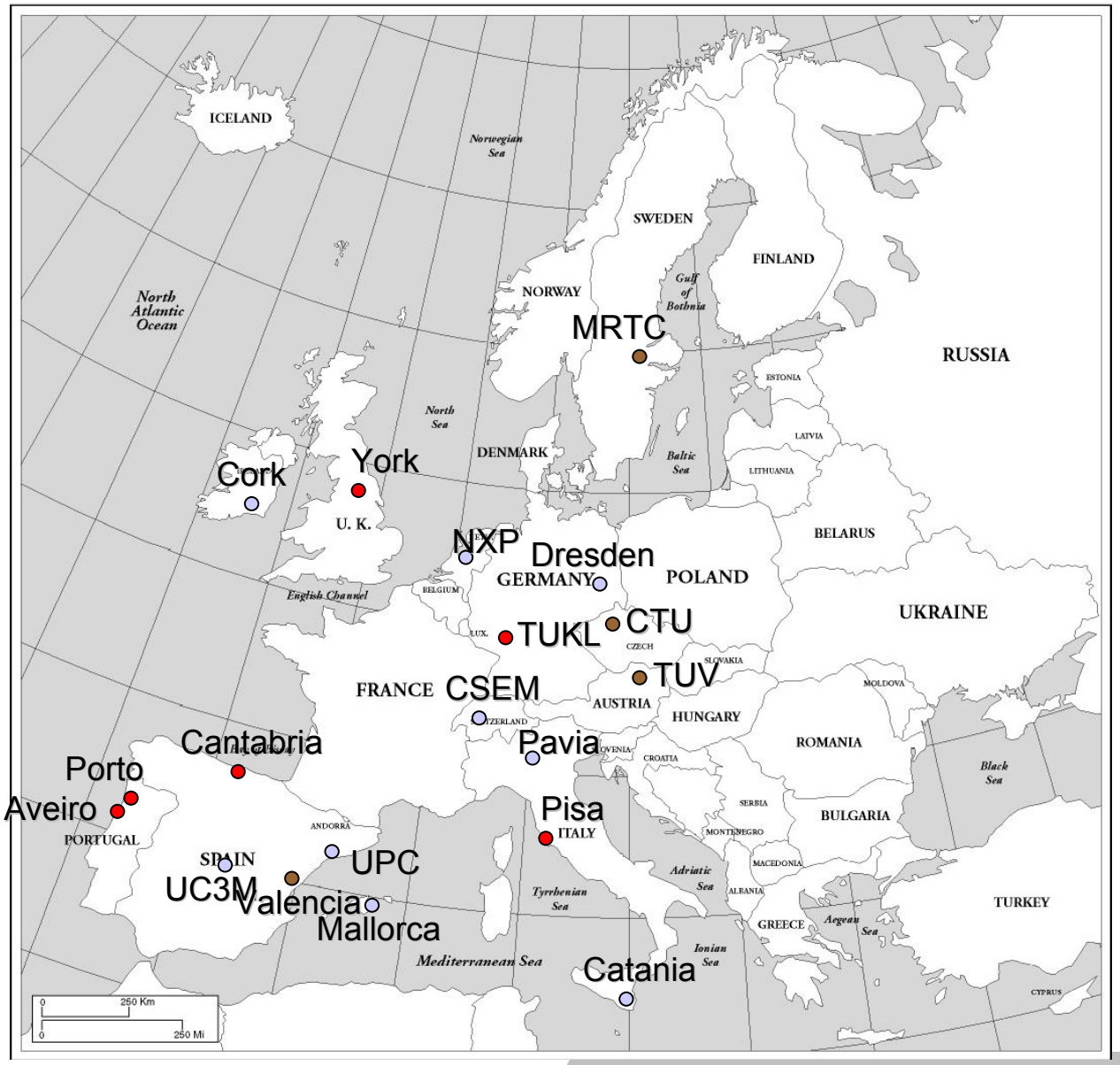


Cluster objectives

Provide a more efficient and predictable support (at the OS and Network level) to the development of future embedded systems. In particular:

- Allow simple and flexible resource management to control the growing complexity;
- Take advantage of multi-core platforms;
- Support distributed computing to deal with the ubiquitous nature of the computing infrastructure;
- Increase system adaptivity to react to environmental changes.

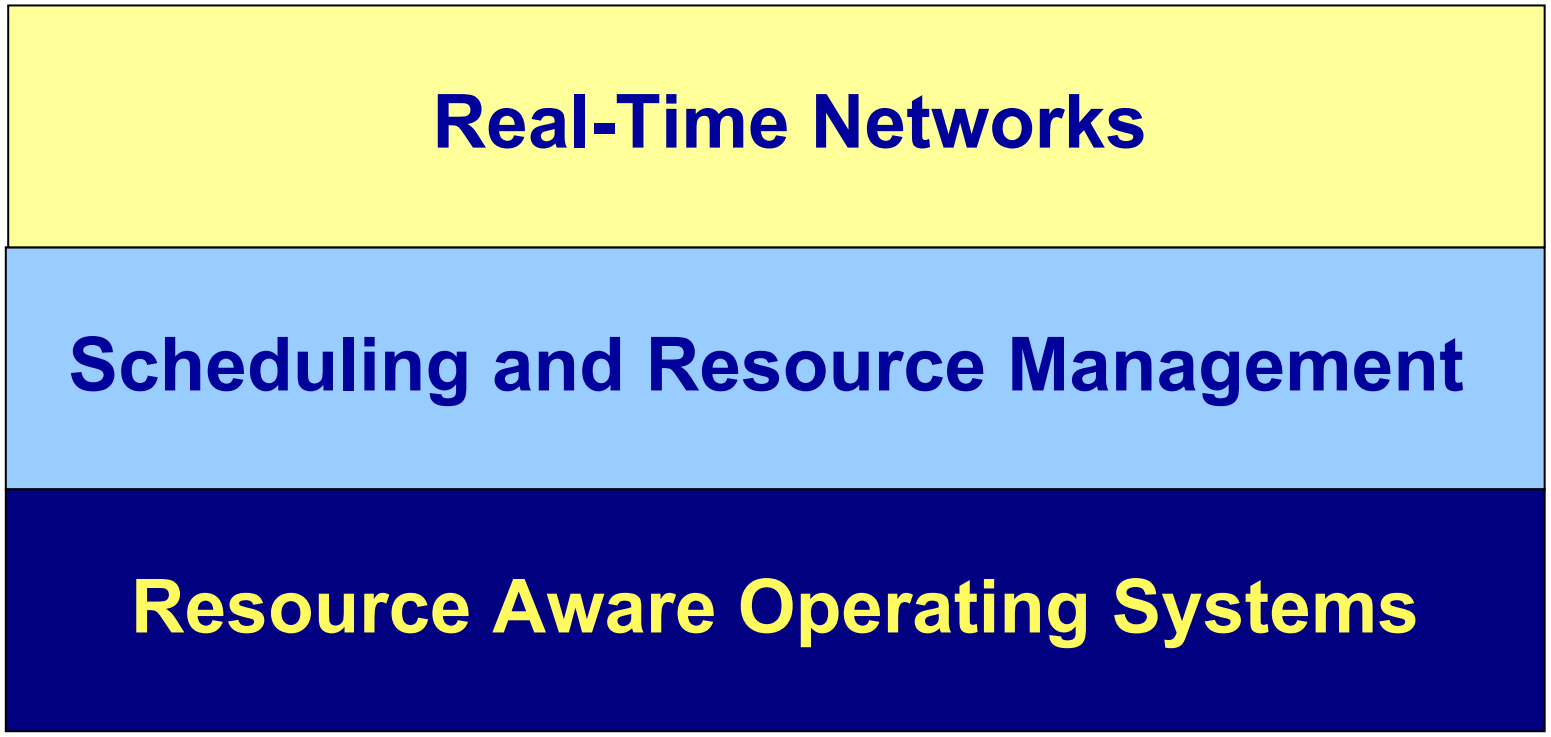
Partners	Role
Core Partners	
SSSA, Pisa (leader)	RT scheduling and RT kernels
Univ. of Aveiro	networking, distributed applications
TU Kaiserslautern	video streaming, off-line scheduling
Univ. of Cantabria	schedulability analysis and OS standards
Univ. of York	fixed priority scheduling
PI Porto	heterogeneous networks
IMEC	Low power and memory management
Affiliated Partners	
Windriver	RT operating systems
Microchip Technology	Embedded applications
NXP	QoS management in multimedia systems
Evidence	kernels and tools for RT systems
UP Catalonia	control methodologies for RT systems
Univ. of Catania	distributed systems
Univ. of Dresden	Microkernel architectures
Univ. of Madrid	QoS and resource management
Univ. of Pavia	RT applications and kernels



Geographical distribution of the cluster partners

- Core partners
- Affiliated partners
- Other partners

Cluster activities



Year 1 Review
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Achievements and Perspectives:

Resource-Aware Operating Systems

Activity leader: *Giorgio Buttazzo*
Scuola Superiore Sant'Anna
Pisa, Italy

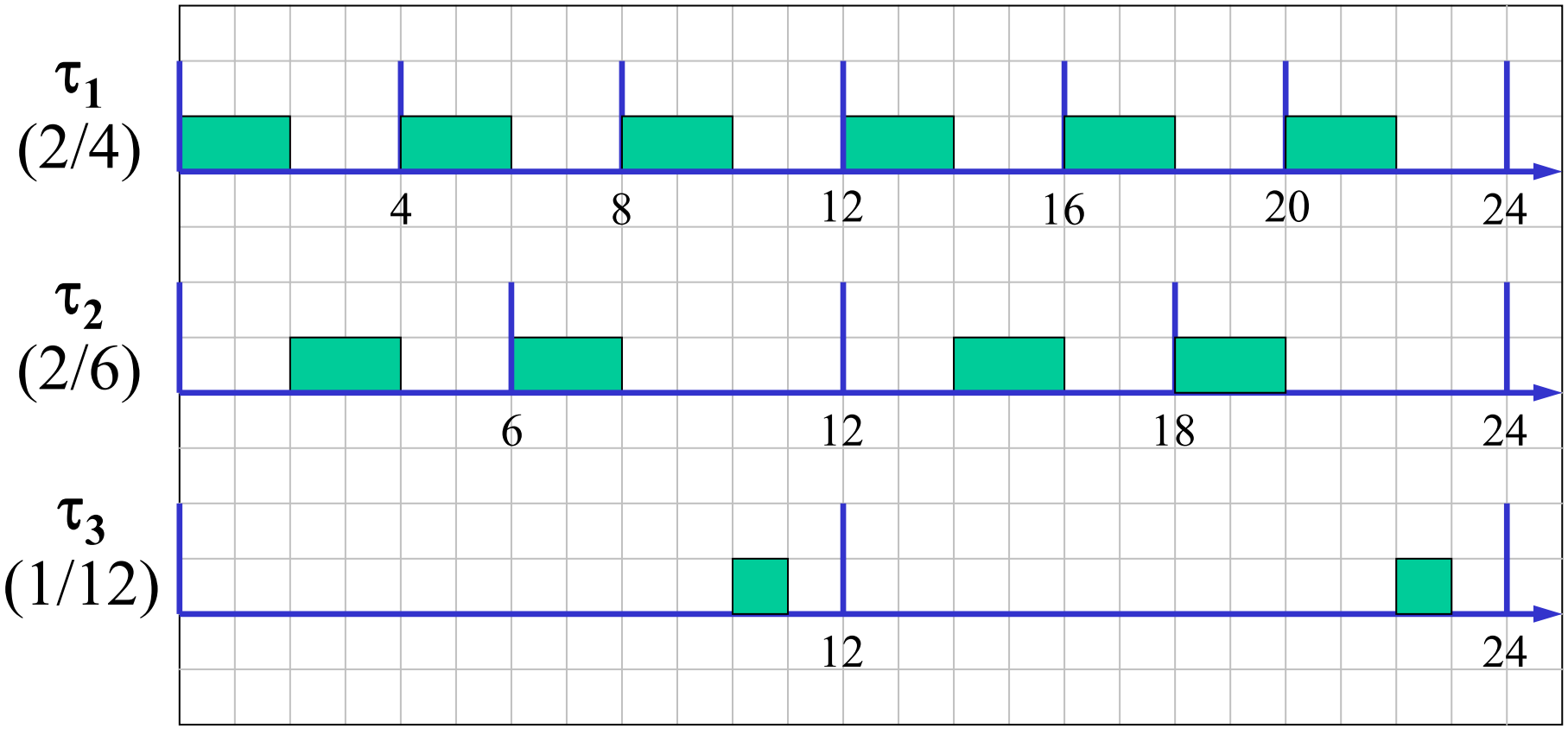
Main operating system issues

- Stringent constraints (space, weight, energy, time)
  - ⇒ Scarce resources (processing power, memory)
  - ⇒ Efficient resource usage at the OS level
- Interaction with the environment
  - ⇒ High responsiveness and timing constraints
  - ⇒ Scheduling and feasibility analysis
- Robustness (tolerance to parameter variations)
  - ⇒ Overload management and system adaptation, to cope with variable resource needs and high load variations.

Example

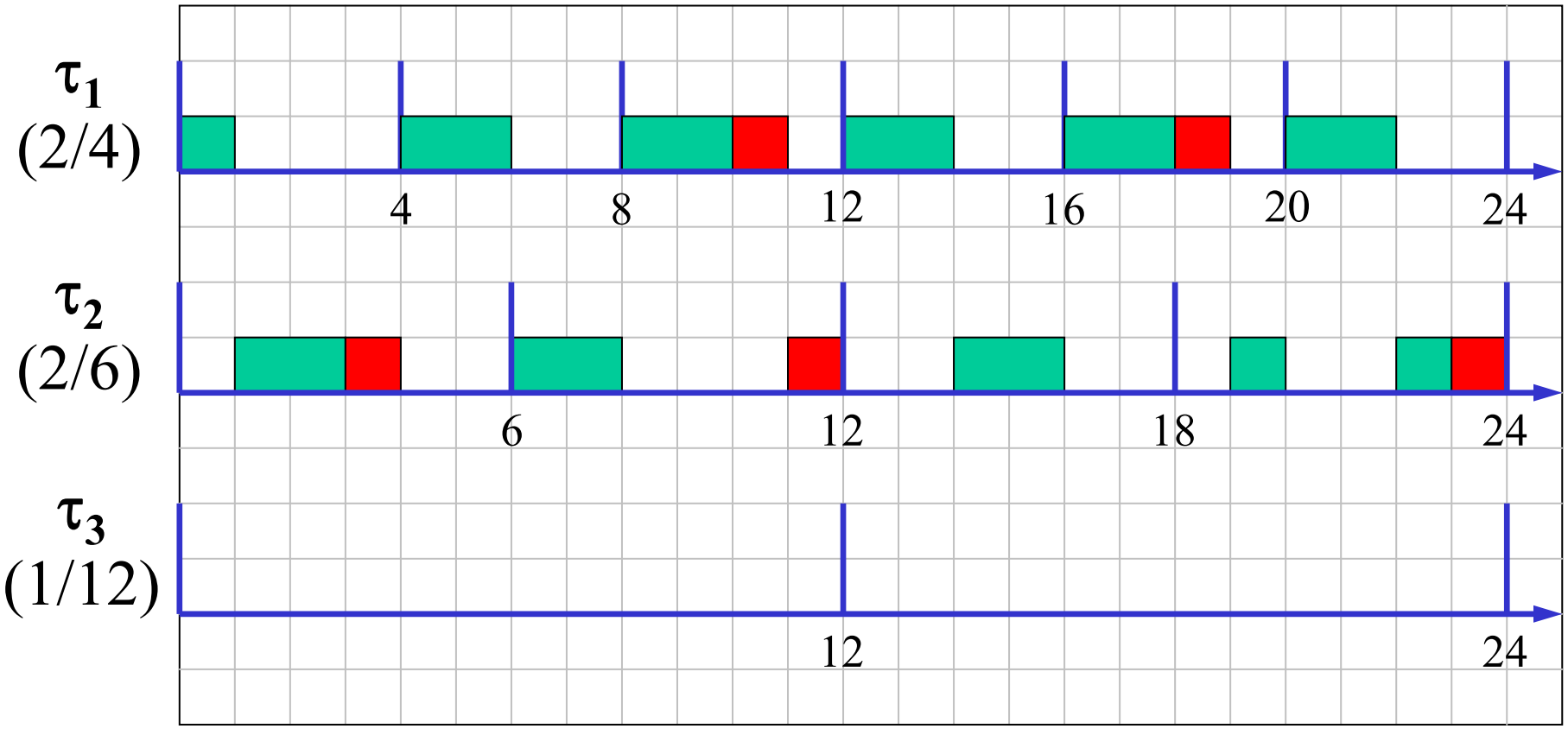
The system is predictable only if tasks behave correctly

$$U = 1/2 + 1/3 + 1/12 = 11/12 < 1$$



Execution overruns

Sporadic overruns may prevent τ_3 to run



Objectives

Investigate novel kernel methodologies to make operating systems more

- predictable (in terms of timing behavior)
- efficient (in terms of resource usage)
- robust (to tolerate overload conditions)
- easy to use (to simplify user interface)

Activity: Resource-Aware Operating Systems

Outcomes from Year 1

- **15 publications** from individual groups
- **14 joint publications**
- **4 workshops**
- **3 Tutorials**
- **4 joint projects** (ACTORS, INTERESTED, IRMOS, PREDATORS)
- **Industrial collaborations** with

  Microchip Technology, Evidence, Embedded Solutions, Windriver, Intecs, NXP

Main Technical Achievements

- A general purpose platform for small embedded systems
- Operating system support for multi-core systems
- RT-kernel support to the IEEE802.15.4/ZigBee protocol stack (Porto, Pisa)

General purpose platform for Embedded Systems

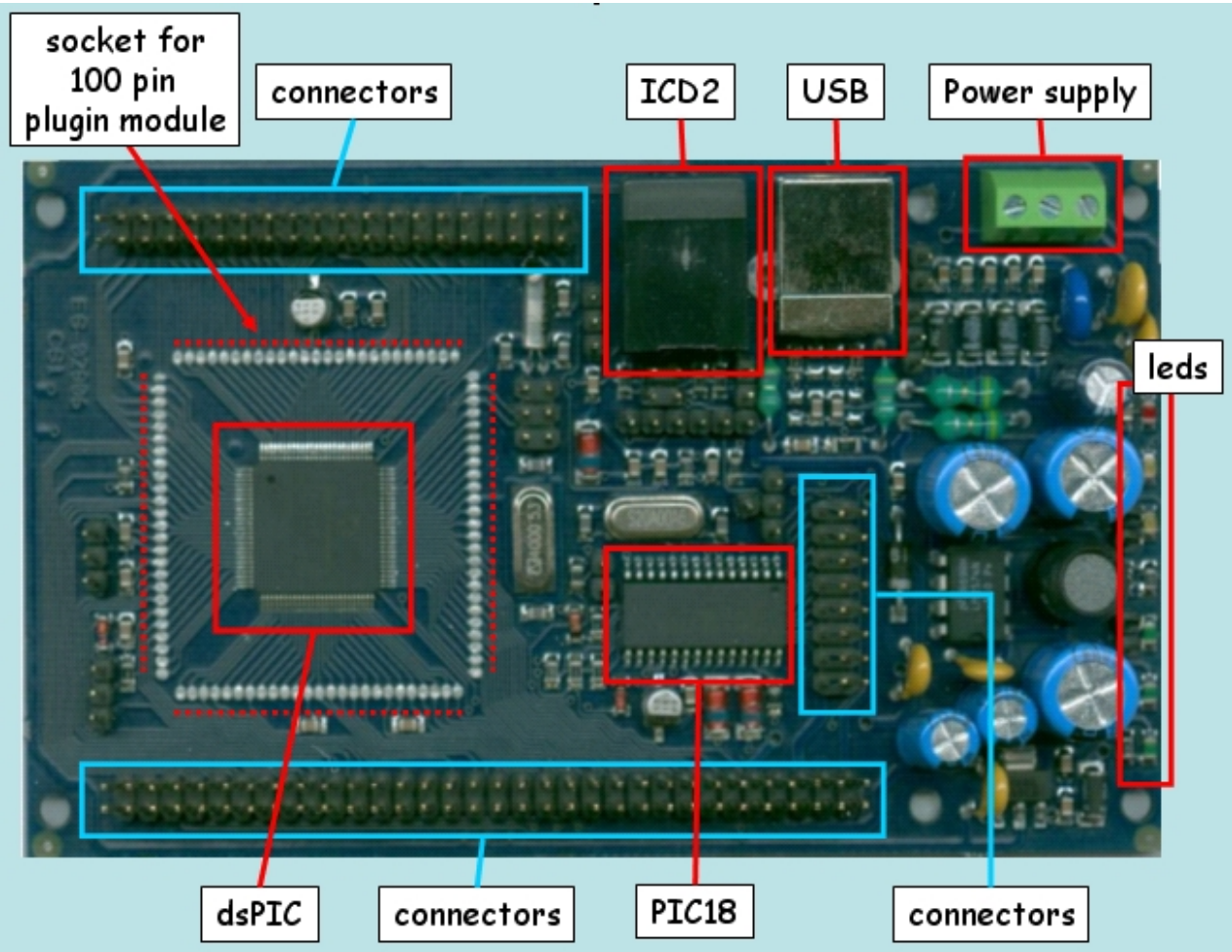
Partners: Pisa, Pavia, Evidence, Microchip Technology, Embedded Solutions

- A microprocessor board (FLEX - by Evidence)
- An OSEK compliant RT kernel (ERIKA - by Evidence)
- A number of special boards for specific applications

Typical use:

- Fast prototyping
- Education

The FLEX board



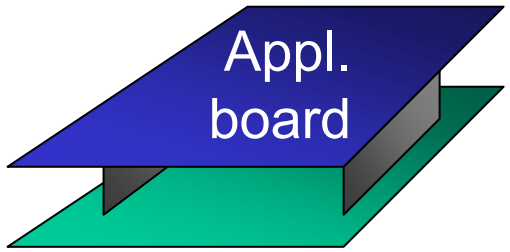
Dimensions: ***92 x 62 mm***

Weight: ***25 g***

The FLEX board

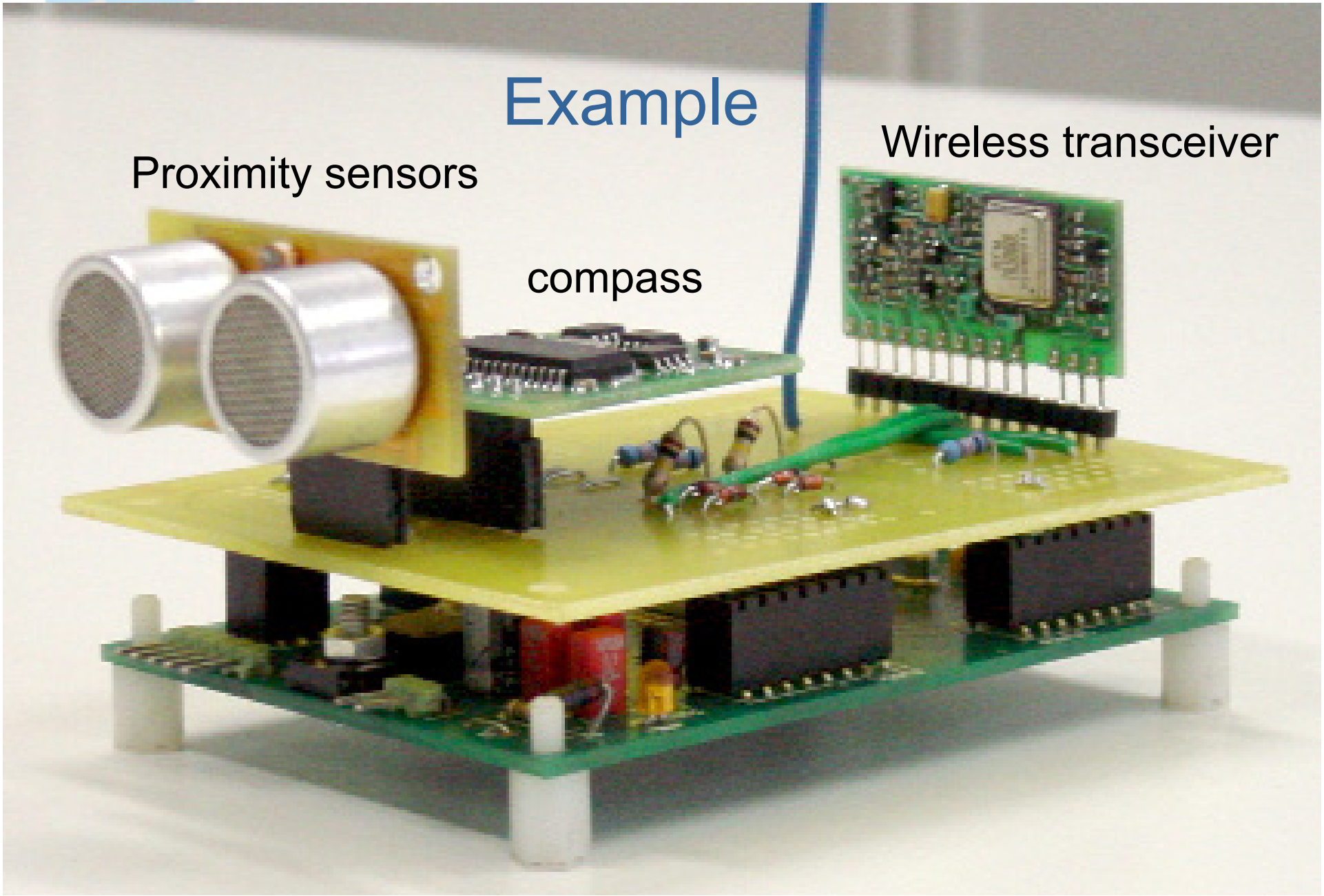
Main Features:

- On-board power regulation
- On the fly and remote programming
- Expandible with piggy-back connections
  - Wireless sensor network node
  - Servomotor controller
  - Inertial platform for flight control systems
  - Sound-localization module
  - Video interface module for visual tracking and distributed surveillance systems

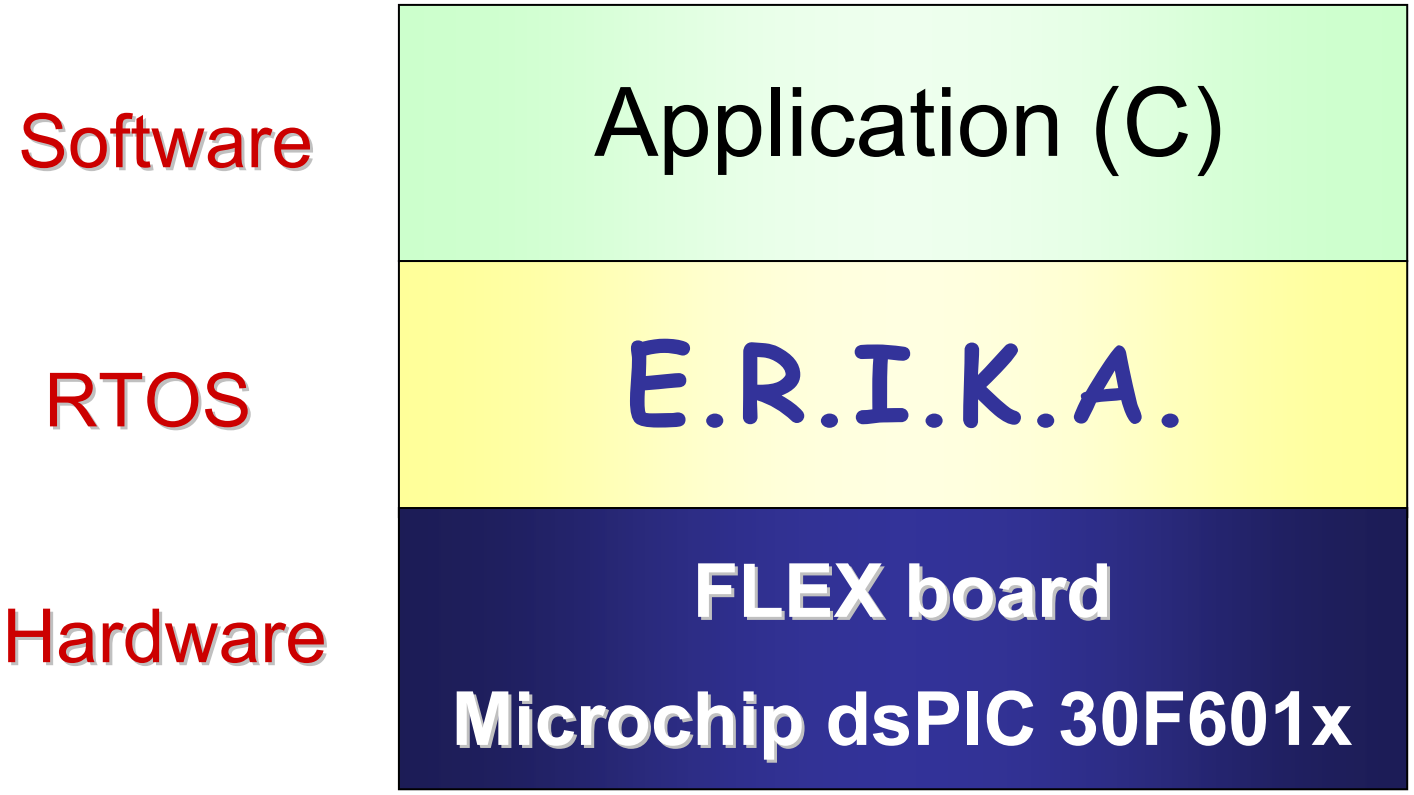


Flex board

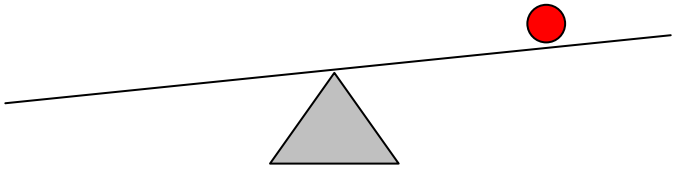
Example



Architecture

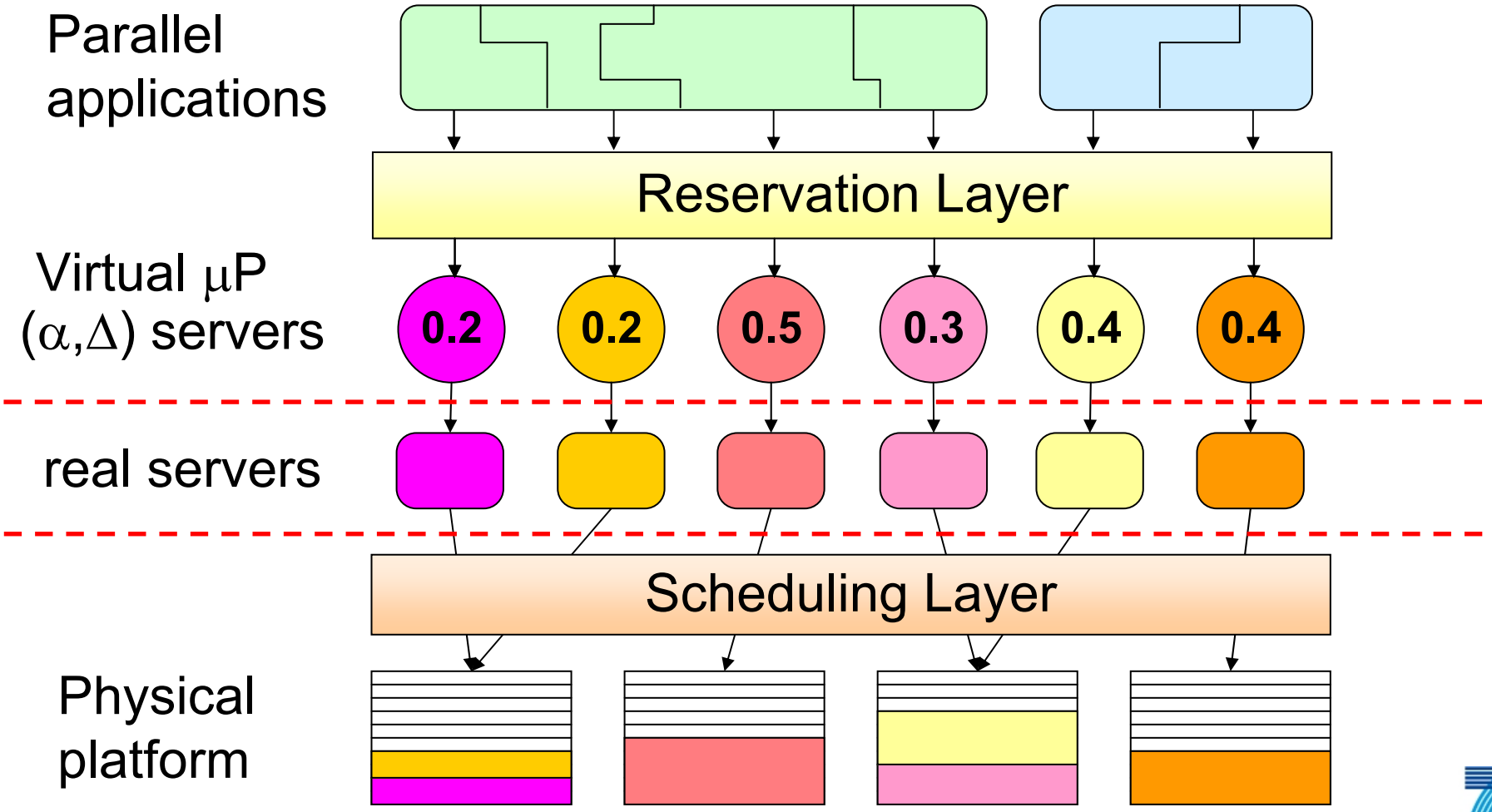


A sample RT application



Resource Reservations on multicore systems

Partners: Pisa, TUKL, Lund, Ericsson



Plan for Year 2

- Schedulability analysis of event-driven control systems (Pisa, Catalonia, Lund).
- Operating Systems support for multicore platforms (Pisa, TUKL, Lund, York, Cantabria).
- Evaluate the effects of scheduling and cache memories on task execution times (Pisa, Saarland, Dortmund, Bologna).
- RTOS support for quality-aware MPEG decoding (TUKL, NXP)

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Scheduling and Resource Management

Activity leader: Alan Burns
University of York
York, UK

Objectives

- **Provide Policies**
  - For effective resource usage
- **Provide Analysis**
  - For predicting system behaviour
  - Simulation, scheduling analysis, measurement, model checking
- **Provide Models**
  - For composing systems
  - Time triggered and event-triggered work flow
  - For static and dynamic usage patterns

Challenges

- To move from single processor platforms to multiprocessor, multi-core, FPGA, etc.
- To integrate various resources and abstract views of the overall system
  - Integrate policies
  - Integrate analysis
  - Integrate models
- Static and Dynamic, peer-to-peer and hierarchical

Approaches

- The use of search techniques to investigate architectural tradeoffs
- The definition and use of virtual resources (VRes)
- The use of reservations and contracts for allocating VRes
- The use of coordination languages to integrate different resource types
- Exploit new platform capabilities (SoC, NoC, FPGA)
- The application of self-adapting (feedback) resource allocation
- The recognition and use of various time scales over which resources are scheduled

Year 1 Achievements

- 15 or more specific work topics, 40 or more publications, 3 workshops, 16 or more funded projects
- Contract-based resource management to cater for CPUs, memory, disc, FPGAs, wired and wireless networks.
- Metadata-based task concurrency management
- Analysis for implicit deadline sporadic tasks on multicore systems
- Allocation techniques for workload management using search, also new models such as the gravitational model
- Shared resource management for precedence constrained tasks with capacity sharing and stealing
- Optimal period selection and scheduling for embedded controllers
- Event-based scheduling for control

Plans for Year 2

- Continue productive exchange of ideas across the project, and the wide diversity of work on scheduling
- Construct a taxonomy of resource management that will
  - Be a useful information source
  - Address multi-resource management
  - Address the integration of policies, analysis and models

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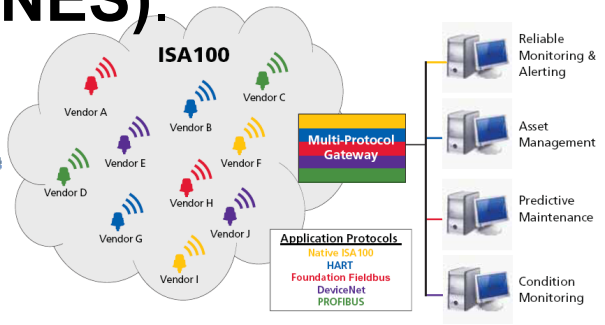
Real-Time Networks

Activity leader: *Luis Almeida*
Univ. of Aveiro / Univ. of Porto
Portugal

The increasing trend for
networked embedded systems (NES).

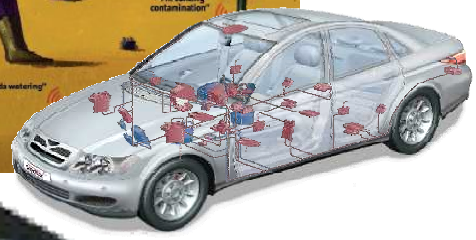


Wireless communication everywhere

Wireless Sensor Networks

Data aggregation and

Timeliness aspects



Flexibility and robustness in NES

Activity: Real-Time Networks

Technical results from Year 1

- **Wireless Sensor Networks**
  - *Worst-case analysis and dimensioning* **(Porto, Prague, Catania, York)**
  - *QoS add-ons to IEEE802.15.4/ZigBee* **(Porto, Catania)**
  - *RT-kernel support to the IEEE802.15.4/ZigBee protocol stack* **(Porto, Pisa)**
  - *Scalable data aggregation* **(Porto, Vienna)**
- **Flexibility and robustness in NES**
  - *RT-network support for middleware and composability* **(Aveiro, Madrid, Cantabria, Mälardalen)**
  - *Mobility and cooperation in IEEE802.11* **(Aveiro)**
  - *Star topologies: Dependability analysis of ReCANcentrate and development of an Ethernet FTT-switch* **(Mallorca, Aveiro)**
  - *Evaluation of DC powerline communications* **(Pavia, Aveiro, Mälardalen)**

Activity: Real-Time Networks

Summary of outcomes from Year 1

- **17 publications** from individual groups (1 best paper award - ETFA)
- **12 joint publications** (1 best work in progress paper award - WFCS)
- **6 workshops** (RTN, CPS-CA, APRES, 2*DC-Powerline, OSN)
- **6 seminars** in diverse places (2 keynotes – CPS-CA, RTNS)
- Participation in the **TinyOS Net2 Working Group** (*Open-ZB stack*) and contributions to the **IEEE802.15.4 and ZigBee standards** (*dimensioning of cluster-tree WSNs*)
- **6 joint projects** FP7-STREP (FlexWARE, ADAMS), ARTEMIS (iLAND, EMMON), ITEA2 (SYLEX, EVOLVE), all with strong industrial participation
- **Industrial collaborations** with

  Critical Software (P), ISA (P), Visual Tools (E), Magneti-Marelli (I), Yamar (IR), STMicroelectronics (I), National Semiconductors (USA), NXP (NL)

Activity: Real-Time Networks

Plans for Y2

- To produce a **taxonomy** of: *(continuation of previous year)*

  WSNs and MANETs for time-sensitive applications

  Flexibility in Networked Embedded Systems

- **Summer school** on Real-Time Networks with industrial participation
- Continue the sequence of **network related workshops** co-located with major events in the Real-Time and Embedded communities
- Further networked embedded systems **educational tools**

  Refinement of CiberMouse tools (MANETs) / more tools for WSNs

- Contributions to **communication protocols**, their application and analysis

  On-going RT-related efforts in WSNs, MANETs, DC powerline, star topologies...