Year 3 Review
Brussels, December 14th, 2007

Achievements and Perspectives:

Adaptive Real-Time

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

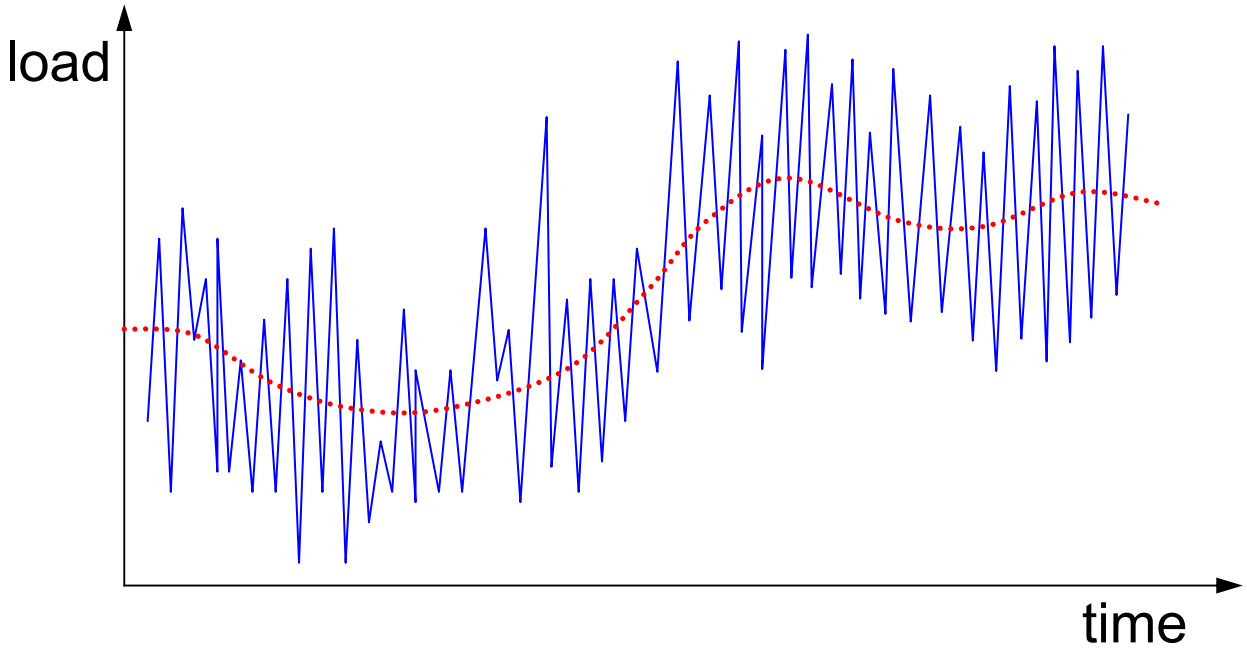
Outline of the Presentation

- **The ART cluster**
  - High-level objectives
  - Partners and activities
  - State of integration
- **Scientific Highlights**
  - Scheduling and RTOS platforms
  - Dynamic and Pervasive Networks
- **Future Work**
  - Plan for the next 12 months
  - Long term vision

The ART Cluster

Goal

Investigate novel methodologies to provide predictability and flexibility for embedded systems where resources requirements are inherently unstable and difficult to predict in advance.



QoS management

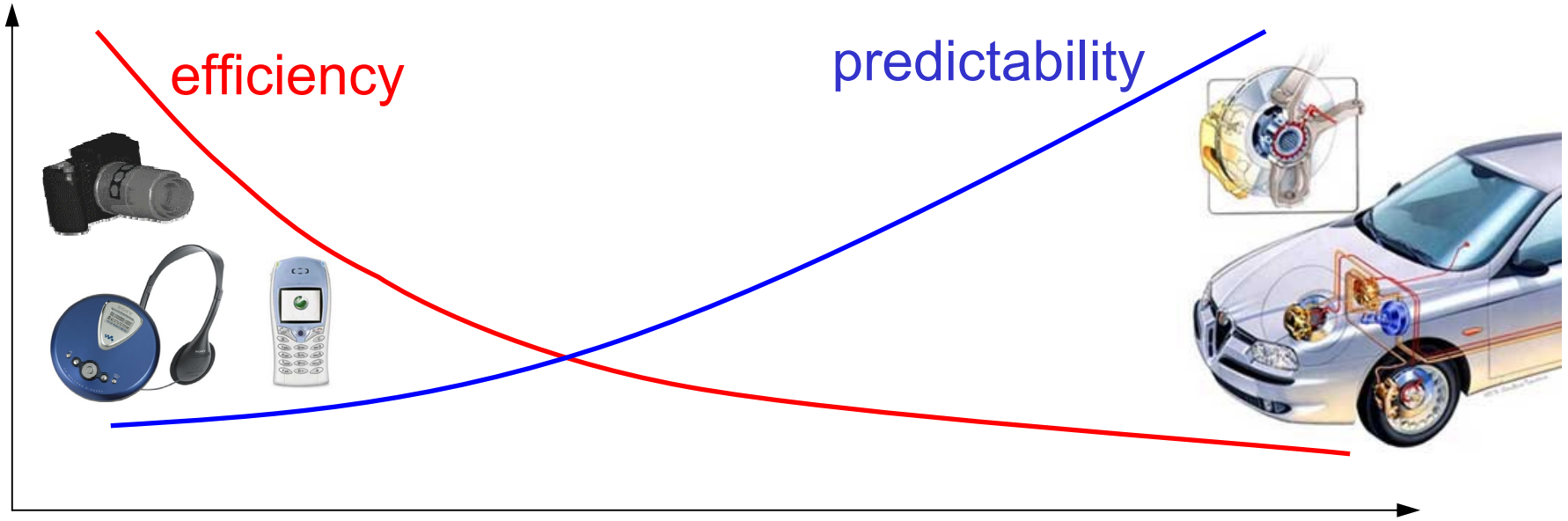
High performance

Off-line guarantee

soft **firm** **hard**

Criticality

System Requirements



QoS management High performance Off-line guarantee

soft **firm** **hard**

Criticality

Research areas

- **Operating Systems**
  - Predictability, Portability, Standards, ...
- **Resource Management Algorithms**
  - Scheduling, Mutual Exclusion, Power-aware algorithms, ...
- **Networks**
  - Protocols, Synchronization, Co-ordination, ...
- **Middleware**
  - Adaptativity, QoS Mangement, ...
- **Languages**
  - Expressiveness, Reliability, ...

ART partners	Role
Cluster Leader	
SSSA, Pisa:	RT scheduling and RT kernels
Core Partners	
Univ. of Aveiro:	networking, distributed applications
TU Kaiserslautern:	video streaming, scheduling
Univ. of Cantabria:	schedulability analysis and OS standards
Univ. of York:	real-time languages
UP Madrid:	QoS and resource management
PI Porto:	heterogeneous networks
Affiliated Partners	
Univ. of Pavia:	RT scheduling and resource management
Evidence:	kernels and tools for RT systems
UP Catalonia:	control methodologies for RT systems
Univ. of Catania:	distributed systems
UC3 Madrid:	QoS and resource management

ART Cluster Activities

JPIA Platforms

- A common infrastructure for adaptive RT systems

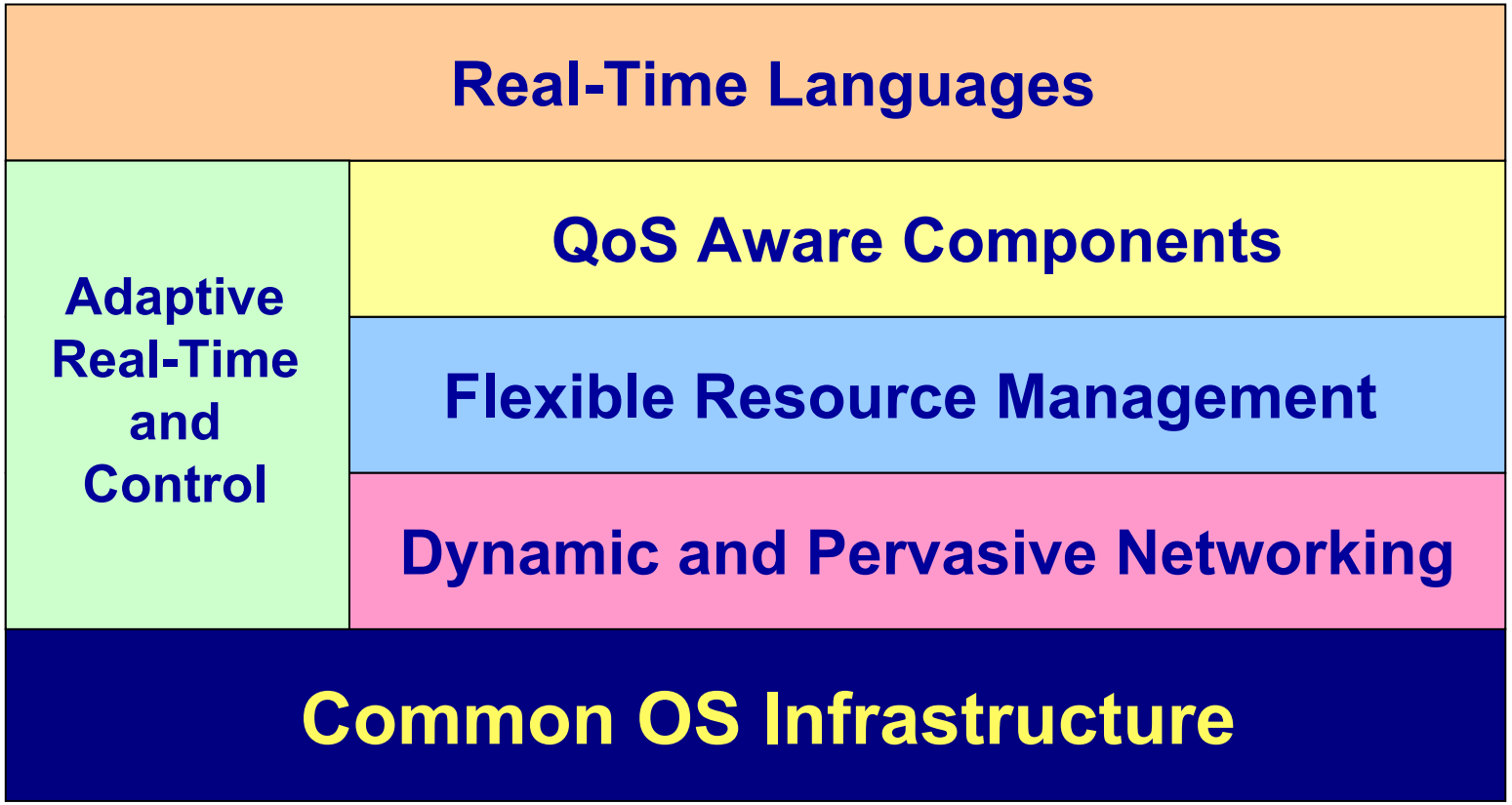
JPRA NoE Integration

- Adaptive real-time, HRT and Control
- QoS Aware Components

JPRA Cluster Integration

- Flexible Resource Management for Consumer Electronics
- Dynamic and Pervasive Networking
- Real-Time Languages

Overview of the activities of the ART cluster



State of integration

International Collaborations

- Univ. of Illinois at Urbana Champaing
  - Lui Sha (RT control and scheduling)
- Univ. of North Carolina at Chapel Hill
  - Sanjoy Baruah (Multiprocessor scheduling)
- Univ. of Virginia
  - John Stankovic (RT scheduling, sensor networks)
- Carnegie Mellon University
  - Raj. Rajkumar, John Lehoczky (Resource Reservation)
- National Taiwan University
  - Tei-Wei Kuo (Resource management)
- Indian Institute of Technology Madras
  - Krithi Ramamritham (Real-time data management)

State of integration

Industrial Collaborations

- Philips - QoS management for multimedia sys.
- Ericsson / Marconi - RT systems for telecommunications
- NXP - Power-aware methodologies
- Microchip Technology - RTOS for embedded control appl.s
- Magneti Marelli - Schedulability tools for automotive sys.
- STM - RTOS for multicore architectures
- Schneider-Electric/COMAU - RTOS for industrial control
- Several SMEs

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Achievements and Perspectives:

A Common Infrastructure for Adaptive Real-time Systems

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

Information Society Technologies

Scientific Highlights

RTOS platform

- We provided a shared RTOS platform (SHARK) for experimenting new RT software technologies on real control applications:
  - novel scheduling algorithms
  - resource management techniques
  - energy-aware policies
  - overload handling techniques for robustness and predictability
- We showed how to extend current OSs to support RT appl^{s} with dynamic behavior (Impact on POSIX, OSEK, …)

Scientific Highlights

Approach

1. Select a flexible, modular, open-source RT kernel ⇒

2. Kernel installation on partner sites and personnel training

3. Support partners in developing RT applications and new kernel mechanisms

4. Repository of RT applications and algorithms for task scheduling and resource management.

Scientific Highlights

Achievements in Year 3

1. New release: SHARK 1.5.4 (Nov. 22, 2007)

- A few bugs fixed
- It now runs within a **virtual machine**, so speeding up the development of new applications.
- Successfully tested under **VirtualBox** and **QEMU**

Scientific Highlights

Achievements in Year 3

2. Real-Time applications

- Ball balancing (Pisa)
- Inverted pendulum (Univ. of Catalonia)
- Mobile robots (Univ. of Aveiro)
- Video processing appls. (TULK)
- Traffic smoothing algorithms (Univ. of Catania)
- Feedback scheduling (Univ. of Catalonia)
- Porting HOLA-QoS algorithms (UPM)
- ...

Scientific Highlights

Achievements in Year 3

3. Organized Events

- 11 Keynotes
- 7 Workshops
- 8 Courses
- 1 Tutorial
- 1 CyberRobot Competition
- 97 papers
- 18 joint papers

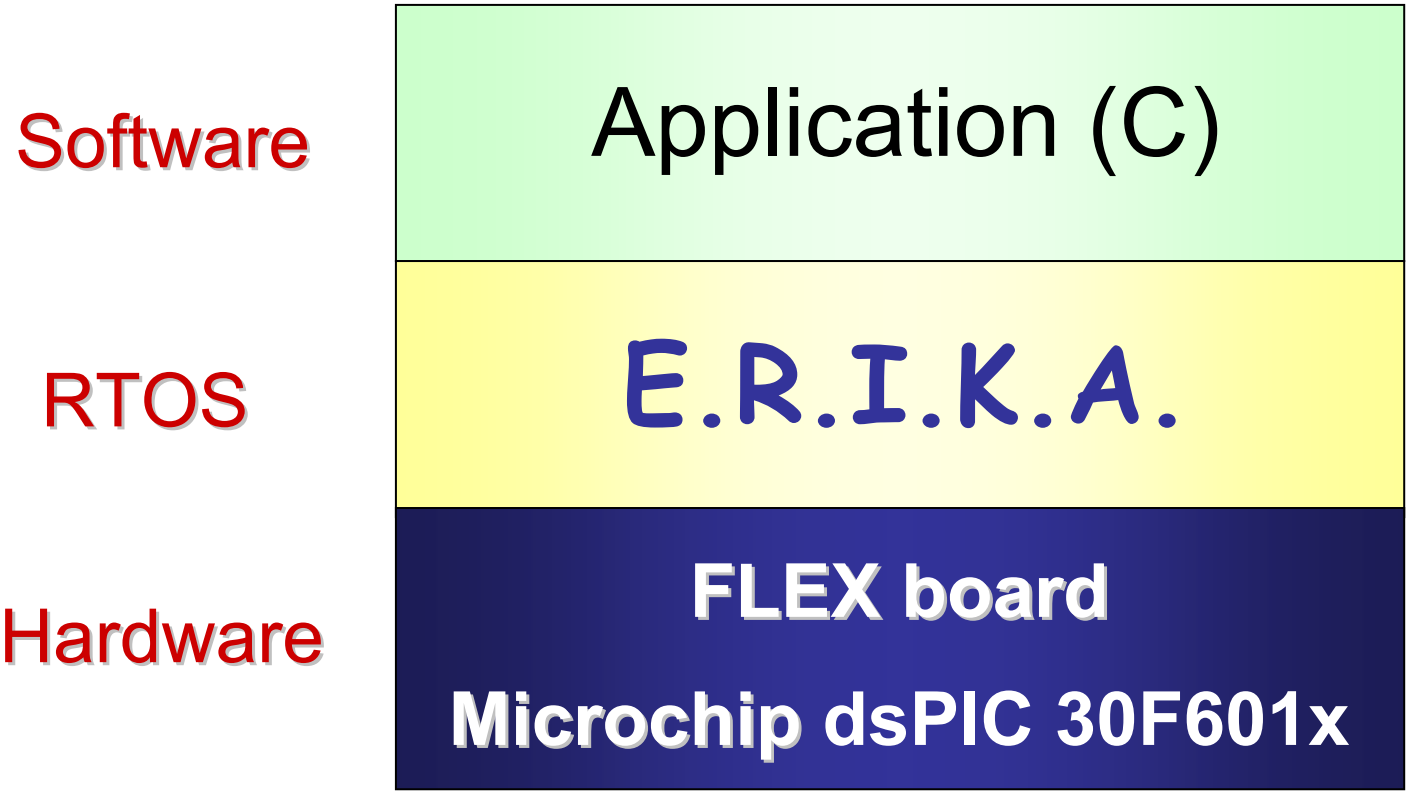
Scientific Highlights

Achievements in Year 3

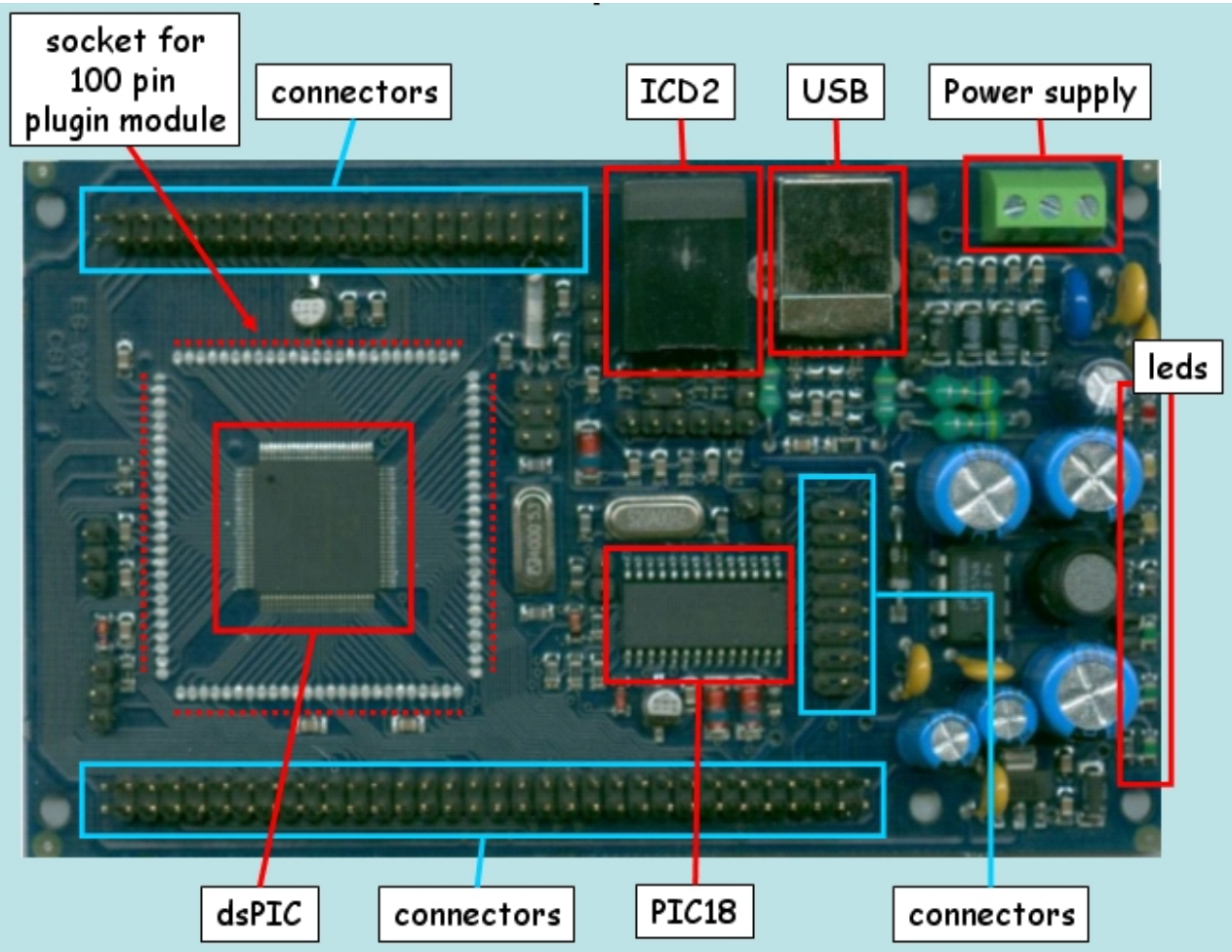
4. Collaboration with Microchip Technology

- Develop a general purpose board for embedded systems (**FLEX board** - by Evidence)
- Provide RTOS technology with OSEK compatibility (**ERIKA RTOS** - by Evidence)
- Develop a number of special purpose boards with related applications

Architecture



The FLEX board



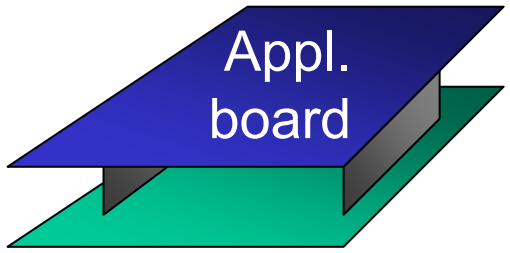
Dimensions: ***92 x 62 mm***

Weight: ***25 g***

The FLEX board

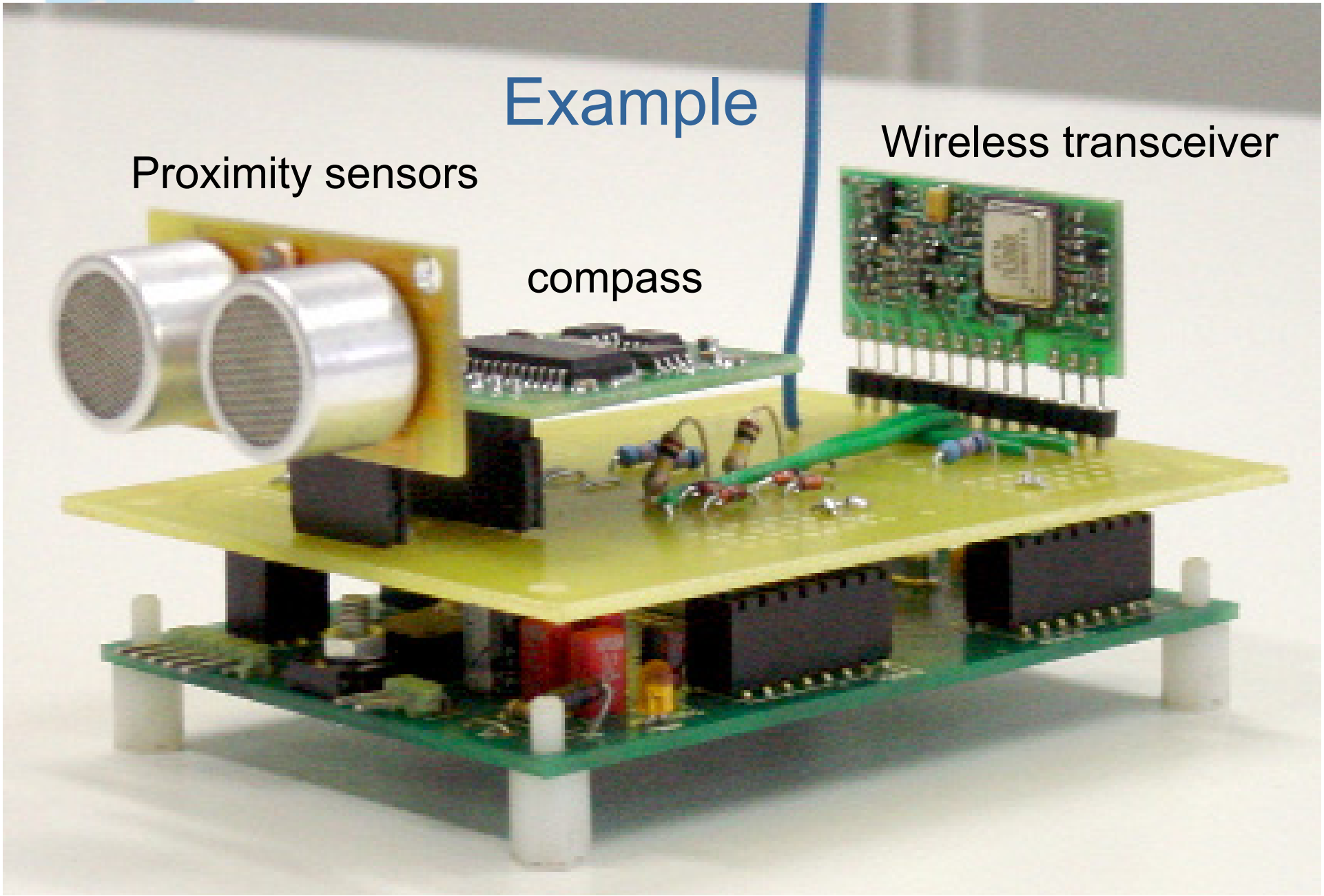
Main Features:

- 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



E.R.I.K.A.

http://erika.sssup.it

In collaboration with

Key features

- Support for several microcontrollers
  (Microchip dsPic, Atmel AVR, …)
- Support for multi-processors (Altera Nios-II)
- Small footprint (from 700 bytes to 2 Kbytes)
- High time resolution
- Advanced scheduling (Rate Monotonic, EDF, Priority Inheritance)
- OSEK compliance

Future work: Plan for Year 4

1. Contribute to the development of a **Mini FLEX** board for distributed RT applications (e.g., sensor networks, living assistance, mobile robot coordination, active surveillance).

   Pisa, Pavia, Evidence, Microchip Technology, Embedded Solutions

2. Investigate **component-based RTOS**, defining features and problems to be solved to decouple kernel mechanisms between them and from the application.

   Pisa, Cantabria, TUKL, Aveiro, Madrid

3. Extend current RTOSs to **multicore devices**, with the objective of making optimal usage of the available CPUs, as well as minimizing power consumption.

   Porto, Aveiro, Catania, Pisa, York

Future work: Long term vision

- Support **scalability** to facilitate porting on different platforms;
  Pisa, Pavia, York, Evidence
- Investigate **energy-aware res. manag.** to prolong lifetime;
  Pisa, Pavia, Aveiro, Madrid
- Increase **programming flexibility** to simplify testing;
  York, Cantabria, Madrid, Porto
- Increase system **adaptivity** to react to environmental changes, still providing a sufficient level of performance;
  Pisa, Pavia, Aveiro, Lund, Madrid, Catalonia, Cantabria, TUKL
- Investigate **robust algorithms** to tolerate transient and permanent overloads conditions due to wrong design assumptions or unpredictable changes.
  Pisa, Aveiro, Catalonia, TUKL

Flexible Resource Management

Activity Leader: Michael Gonzalez (Cantabria)

Objective

- Develop an efficient resource manager to perform adaptive QoS control of time sensitive applications with dynamic characteristics

Achievements

- Architectural model of the flexible scheduling framework (Cantabria, TULK, SSSA, Aveiro)
- Integrated CPU scheduling and cache management (TUKL, NXP)
- Hierarchical scheduling (Pisa, York)
- Design of a quality of service manager (Pisa, TUKL, Madrid, Cantabria)

Flexible Resource Management

Plans for Year 4

- Conclude the analysis of application requirements of adaptive applications.
- Develop algorithms for the integration of CPU scheduling and cache management and analyse their effectiveness on actual boards.
- Provide a framework that allows to choose the appropriate scheduling methods for individual activities in different resources.

Real-Time Languages

Activity Leader: Alan Burns (York)

Objective

- Support RT functionality via language constructs rather than OS calls to simplify testing and programming of complex applications.

Achievements

- Development of Real-Time Utilities for Ada 2005 for both the full language and the Ravenscar sub-set for high-integrity systems.
- Ada 2005 run-time has been implemented on MARTE OS.
- Extensions to the Real-Time Specification for Java (RTSJ), including work in the Expert Group responsible for the Standard
- Investigation into extended dynamic memory management within RTSJ

Real-Time Languages

Plans for Year 4

- Continue to work on design pattern for Ada 2005, to include resource control algorithms and scheduling schemes.
- Publish, via the ARTIST web site, these patterns.
- Further development of the RTSJ (Real-Time Specification for Java) standard and dynamic memory management techniques, and the building up a user community.
- Produce a white paper (on the web) reviewing the current status of language developments – to include Ada 2005, RTSJ, Java, the Synchronous languages, C and C++ (with POSIX), SCOOP and Hume.

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Achievements and Perspectives

Dynamic and Pervasive Networks

Activity leader : Eduardo Tovar
Institute Polytechnic Porto

Attending here : Björn Andersson and Mário Alves
Institute Polytechnic Porto


The Economist
Meet Britain's next prime minister
Will Africa ever get it right?
In praise of Yeltsin
The world's biggest banking battle
Australia's water crisis
APRIL 28TH–MAY 4TH 2007
www.economist.com
When everything connects
A 14-page special report on the coming wireless revolution
"We're ripe, pick us!"
"I'm here, Mummy. N 51 30. 24 W 0 08. 19"
"Time for walkies"
"You left me here"
"I'm all out of milk"
"Blood pressure too high"
"Accident ahead"
"We're 50% off"
"I'm sensing contamination"
"Send me energy"
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There is an increasing trend for networked embedded systems.

Energy efficiency

Real-Time

Interaction with Physical Environment

Reconfigurability

There is an increasing trend for networked embedded systems.

Collaborations/Interactions Between Partners

Produced by the Cartographic Research Lab
University of Alabama

Sensor Networks

Collaborations/Interactions Between Partners

Produced by the Cartographic Research Lab
University of Alabama

Reconfigurability

Collaborations/Interactions Between Partners

Produced by the Cartographic Research Lab
University of Alabama

COTS Technology

Results (highlights)

Best paper award ECRTS07.

Engineering ZigBee cluster-tree networks.

Results (highlights)

Best paper award ECRTS07.

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⇒We produce excellent results.

Results (highlights)

Organized the NeRes07 workshop.

Organized the RTN07 workshop.

Results (highlights)

Organized the NeRes07 workshop.

Organized the RTN07 workshop.

⇒We integrate excellence.

Results (highlights)

Open-ZB toolset:

- **1000 downloads.**
- **19000 visits in one year.**
- **Only non-American partner in TinyOS Network working group.**

UIUC and CMU uses WiDom.

Results (highlights)

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UIUC and CMU uses WiDom.

⇒We have impact outside the activity.

Results (highlights)

Triggered new research efforts within the DPN activity.

e.g. Pisa and York are doing WSN.

Conclusion

The Dynamic and Pervasive Networking activity has:

1. **been producing excellent results;**
2. **integrated results;**
3. **had impact.**

Thanks for your time!