Year Final Review
Brussels, December 12th, 2008

Achievements and Perspectives:

Adaptive Real-Time

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

Outline of the Presentation

- **High-level objectives**
- **Partners and activities**
- **Achievements**
- **What's next?**

Embedded Systems

QoS management

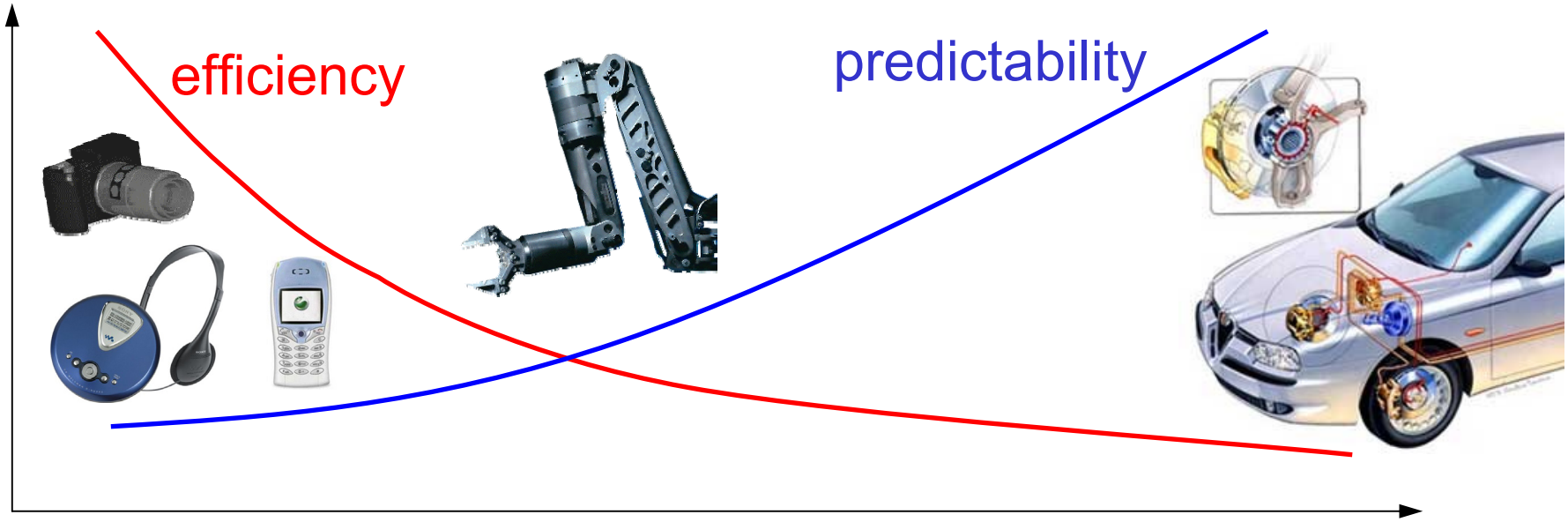
High performance

Off-line guarantee

soft **firm** **hard**

Criticality

System Requirements



QoS management | High performance | Off-line guarantee

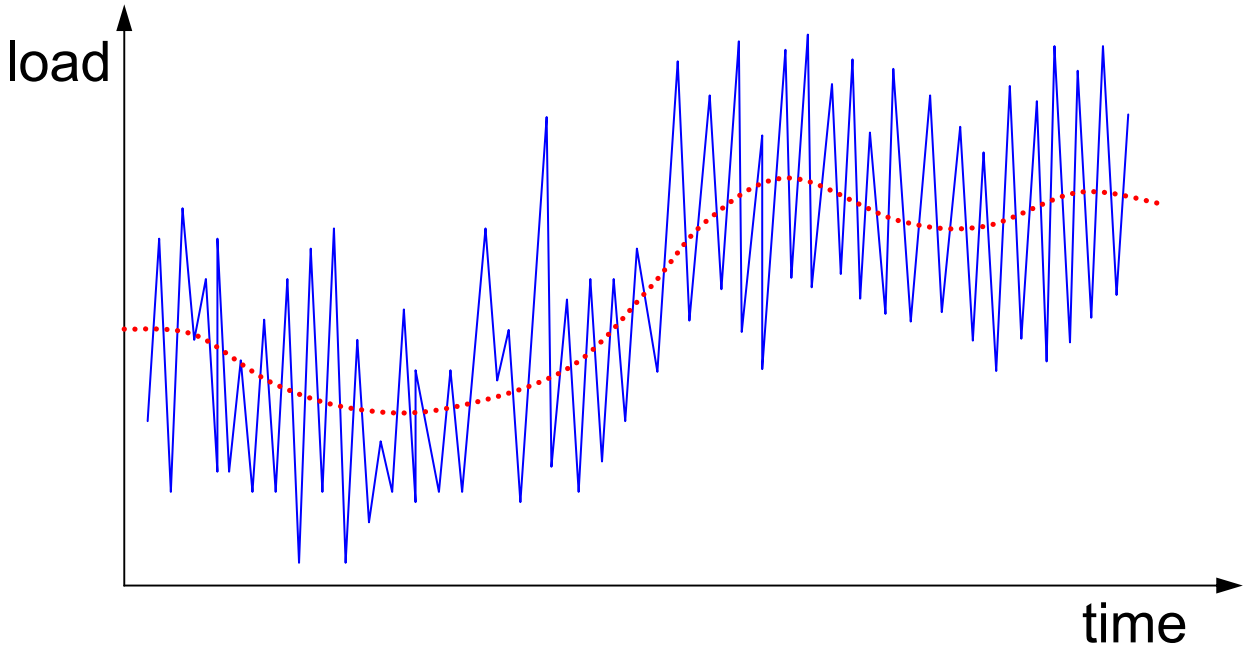
soft | **firm** | **hard**

Criticality

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.

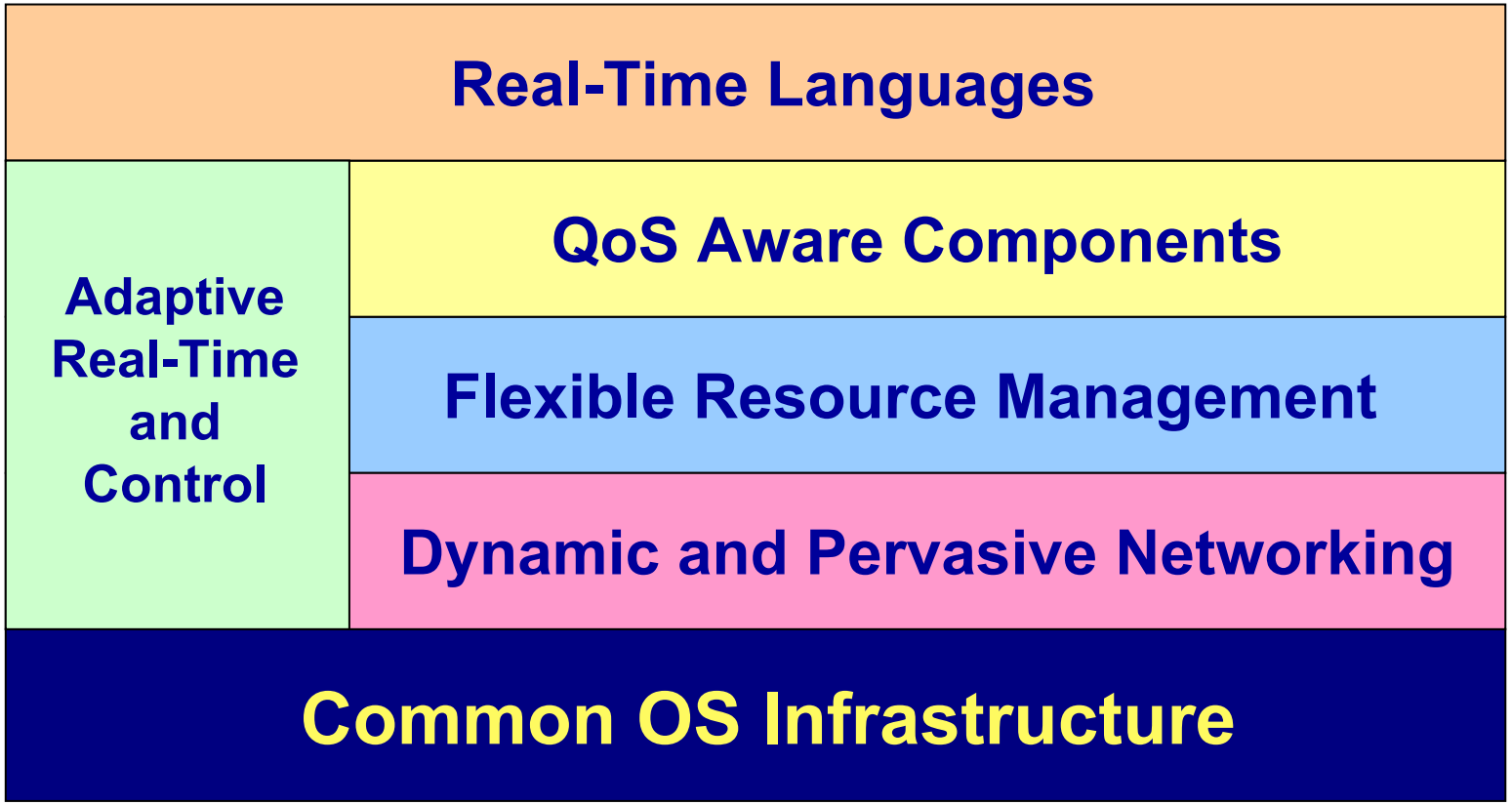


Research areas

- **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

Overview of the activities of the ART cluster



Year 3 Review
Brussels, December 14th, 2007

Achievements and Perspectives:

A Common Infrastructure for Adaptive Real-time Systems

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

Information Society Technologies

Achievements

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, …)

Achievements

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.

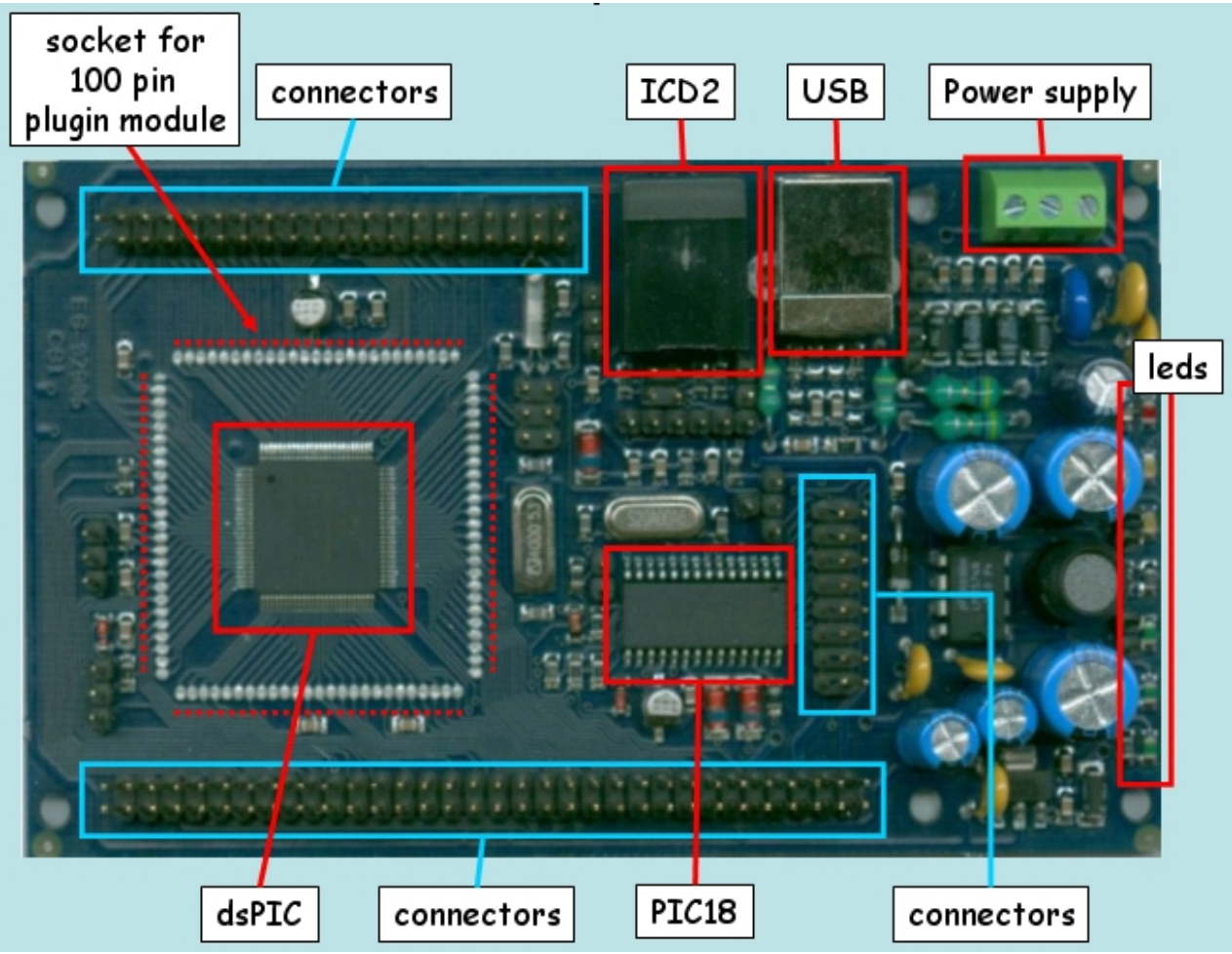
Achievements

An Educational kit for Embedded Systems

In collaboration with Microchip Technology, Evidence, and Embedded Solutions, we developed:

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

The FLEX board



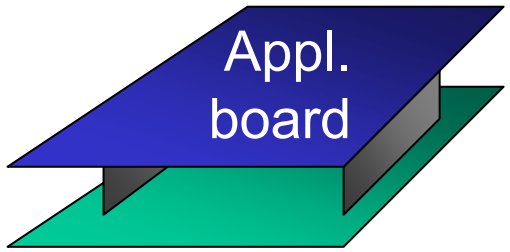
Dimensions: ***92 x 62 mm***

Weight: ***25 g***

The FLEX board

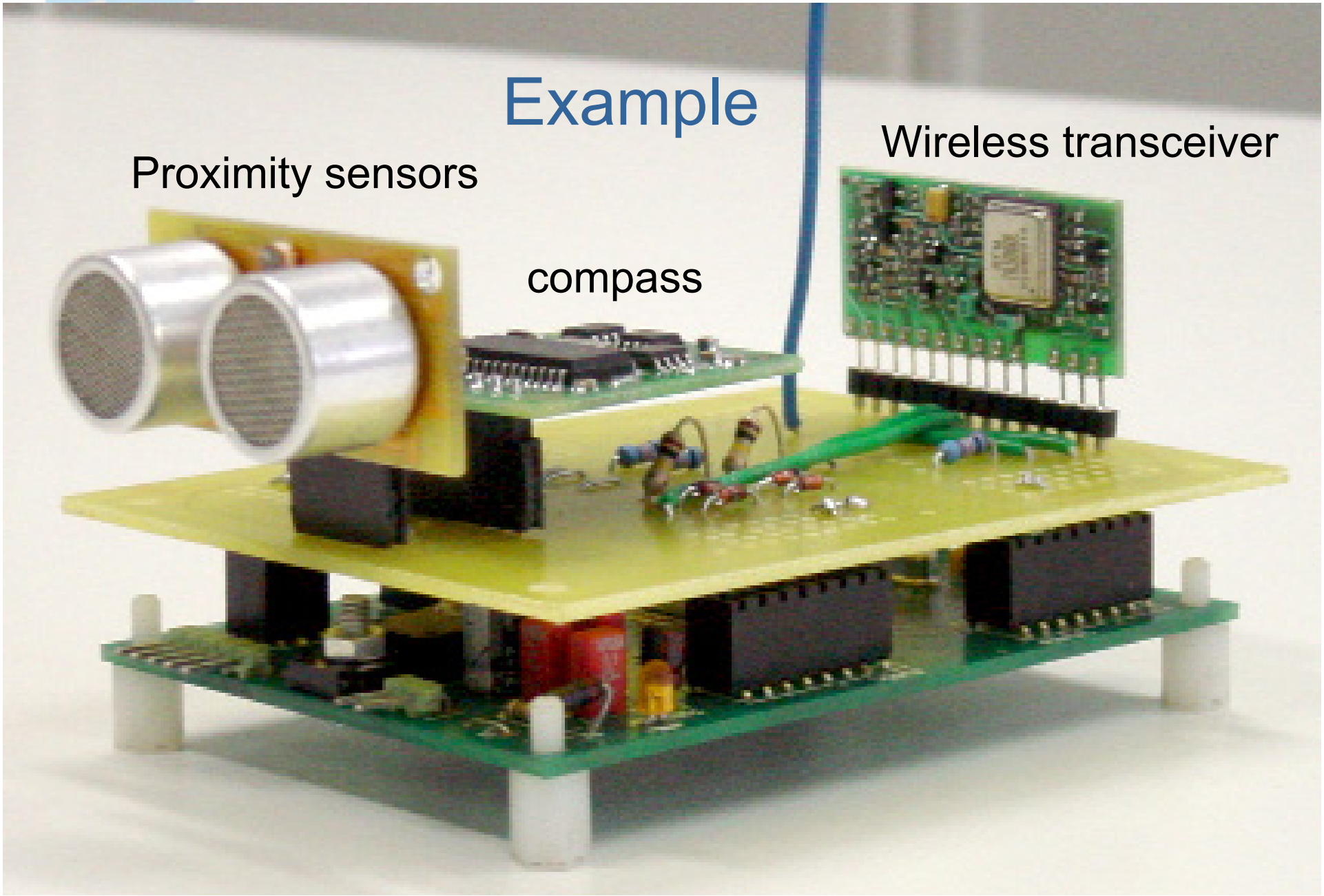
Main Features:

- 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

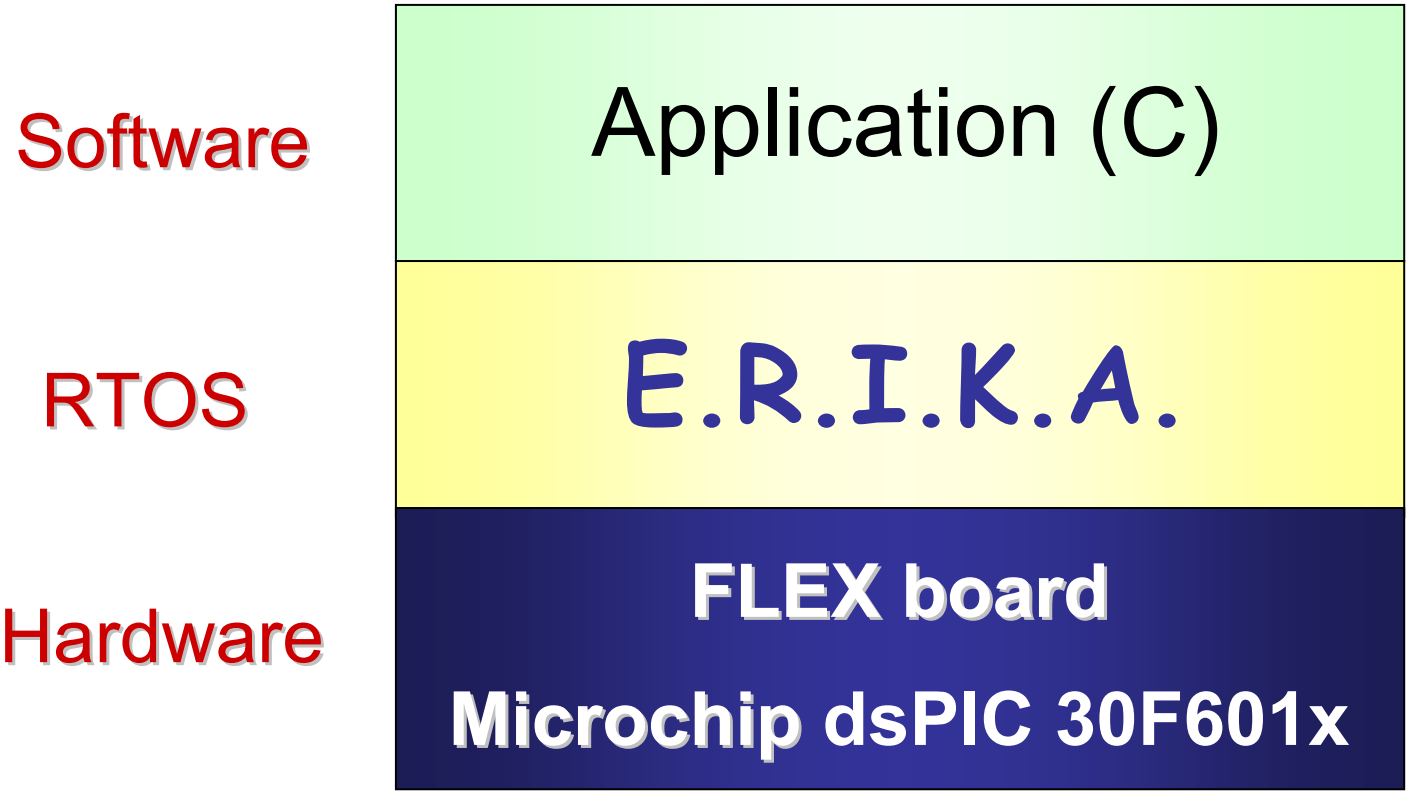


Flex board

Example



Architecture



E.R.I.K.A.

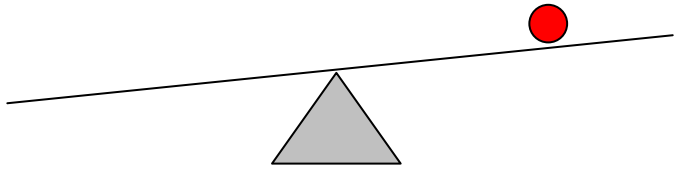
http://erika.sssup.it

In collaboration with

Key features

- Support for several microcontrollers
  (Microchip dsPic, Atmel AVR, ARM7, H8, …)
- Support for multi-processors (Altera Nios-II)
- Small footprint (from 700 bytes to 2 Kbytes)
- High time resolution
- Advanced scheduling (RM, EDF, Priority Inheritance)
- OSEK compliance

A sample RT application



Towards production of educational control kits

The ball & beam device is under production by

- Scuola Superiore Sant'Anna (RT software)
- Evidence (RTOS support)
- Embedded Solutions (Board design and testing)
- WRC (Mechanical design and control)
- Star Engineering (Mechanical design)
- Microchip Technology (Hardware components)

Dynamic and Pervasive Networks

Activity Leader: Eduardo Tovar (Porto)

Main research focus

- Guaranteeing QoS properties (e.g. timeliness and energy-efficiency) in dynamic and resource-constrained Networked Embedded Systems.

General Achievements

- Important scientific and technological contributions in these areas
- Joint publications at high quality conferences and journals
- Design, analysis, modelling and dimensioning tools, some open-source
- Joint organization of successful workshops, keynotes and seminars
- European-level projects and NoEs in related fields triggered by ARTIST2 DPN achievements

Dynamic and Pervasive Networks

Activity Leader: Eduardo Tovar (Porto)

Selection of Achievements

- Engineering IEEE 802.15.4 and ZigBee Cluster-Tree wireless sensor networks with QoS concerns (Porto, Prague and Catania)
- Time/energy efficient data aggregation mechanisms based on dominance-based MAC protocols (Porto, Vienna)
- Reliability enhancements in CAN and Ethernet (Aveiro, Madrid, Mallorca, Cantabria)
- RTN'08 (ECRTS) and CPS-CA'08 (DCOSS) workshops organization
- IEEE 802.15.4/ZigBee toolset (Porto, Pisa, Prague):
  - http://www.open-ZB.net - 60000 visits, 3000 downloads
  - New TinyOS 802.15.4 and ZigBee Working Groups
  - Migration to the ERIKA real-time operating system

Flexible Scheduling Technologies

Activity Leader: Michael González Harbour (Cantabria)

Objective

- Provide predictability and adaptivity to systems where resource requirements are inherently unstable and difficult to predict, by using adaptive resource reservations.

History

- The activity was carried out in years 1 & 2.
- It was merged for years 3 & 4 with the “Resource-Aware Adaptive Resource Management for Consumer Electronics” activity into the “Flexible Resource Management for Real-time Systems” activity

Flexible Scheduling Technologies

Activity Leader: Michael González Harbour (Cantabria)

Achievements (Cantabria, York, Kaiserslautern, Pisa, Madrid, Aveiro, Porto, Pavia, Evidence, Catania) => FRESCOR - FP6

- Requirements for integrated resource scheduling framework
- Architectural model of the resource scheduling framework, based on contracts and integrating multiple resources
- Design of a QoS resource manager performing adaptive management of the contract-based framework
- New theoretical developments: Server-based scheduling, network scheduling, energy aware scheduling
- Two workshops
- Dissemination through 34 publications, 4 keynotes

QoS-Aware Components

Activity Leader: Alejandro Alonso (UP Madrid)

Objective

- The goal of this activity is to bring together expertizes in component-based design to allow a smooth integration of software from different vendors, guaranteeing both predictability and quality to end-users.

Achievements (Madrid, Cantabria, Aveiro, Thales, INRIA)

a. Characterisation of services

b. QoS in Component-Based Approaches

c. Consolidation of the MARTE standard

d. Specification of QoS properties using UML profiles

e. Important results were obtained regarding *fault-tolerance* and *adaptability* in the **INFLEXION** project (Adaptable and Flexible Execution Infrastructure)

Real-Time Languages

Activity Leader: Alan Burns (York)

Objective

- Understand how programming languages can be enriched to express timing constraints and non-functional requirements, and how such an information can be used to detect inconsistencies before runtime.

Achievements – A survey of languages

- A survey of programming languages for embedded and real-time systems was produced, considering over 20 programming languages. All languages covered in the survey are supported by tools (typically compilers) which generate executable code for the designated hardware platform.

Real-Time Languages

Activity Leader: Alan Burns (York)

Achievements - Standards

- ISO standard for Ada, to increase its expressive power in order to support adaptive systems.
- Real-time specification for Java (RTSJ)
- Real-time profiles for the POSIX OS standard.

Real-Time Languages

Activity Leader: Alan Burns (York)

Achievements – Specifics in 2008

- Language survey (York plus a large number of other ARTIST partners)
- Development of Real-Time Utilities for Ada 2005 (Cantabria, Porto, UP Madrid, York)
- Implementation of Ada 2005 (Cantabria)
- Ada 2005 real-time mechanisms (UP Madrid, York)
- Real-Time Java Community Building (UC3M, Verimag, York)

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

In summary

- New research projects have been triggered
  - FRESCOR, ACTORS, PREDATOR, INTERESTED, …
- RTOS platforms are available to the community
- Repository has been created for
  - documentation, algorithms, RTOS software, tools, applications, …
- Collaboration with the industry and leading groups has been reinforced.

What's next?

- Collaborations will continue through ArtistDesign
- Research will continue through established collaborations and related joint projects
- RTOS platforms will be used and maintained by the community.
- Repository will be a useful source for students and researcher to speed up the initial phase
- Collaboration with the industry and leading groups has been reinforced.
- Educational activities (e.g. ARTIST2 summer school)