

Year 3 Review
Brussels, February 24th, 2011

Cluster

Achievements and Perspectives:

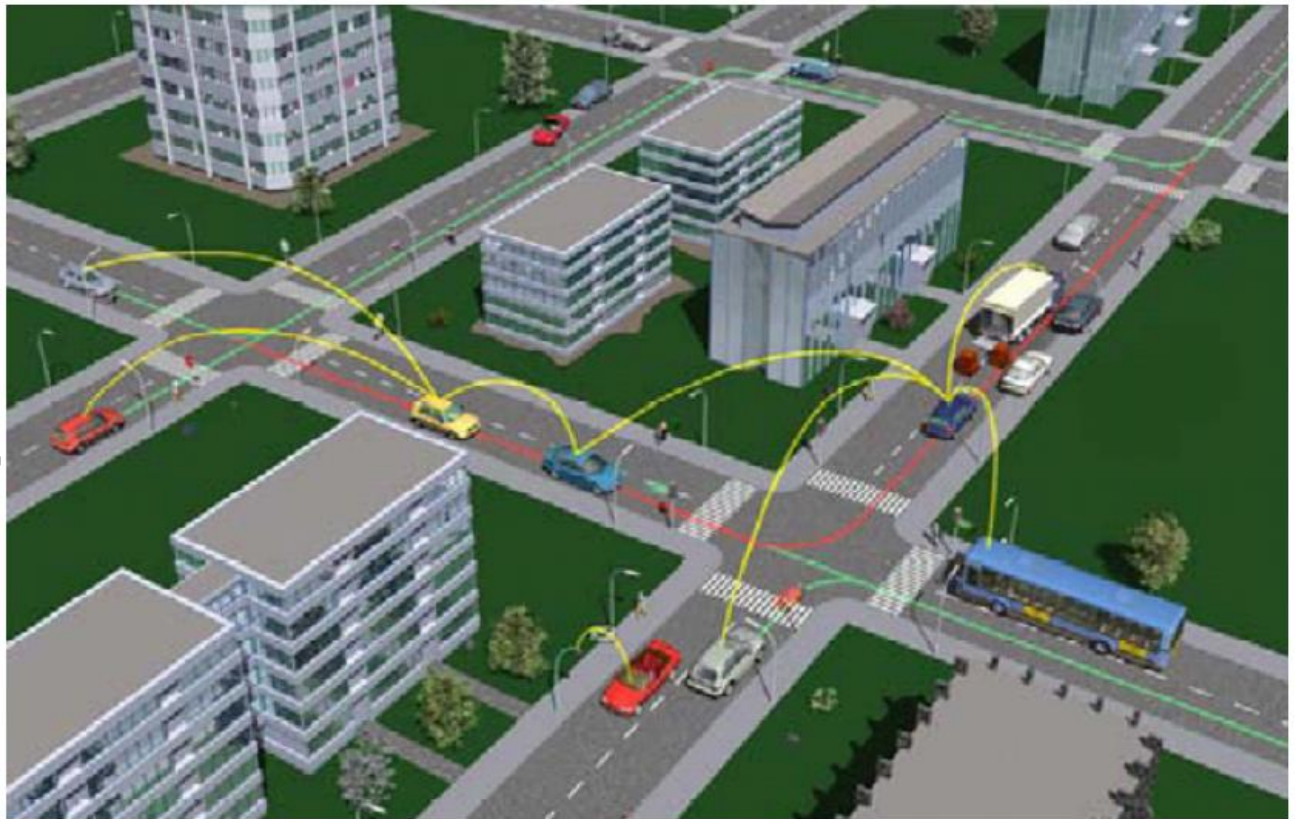
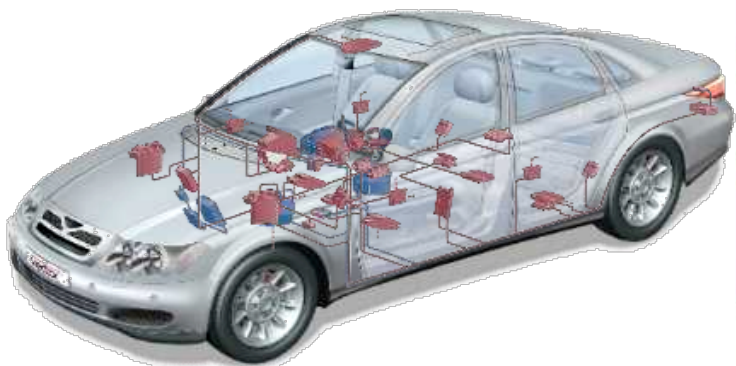
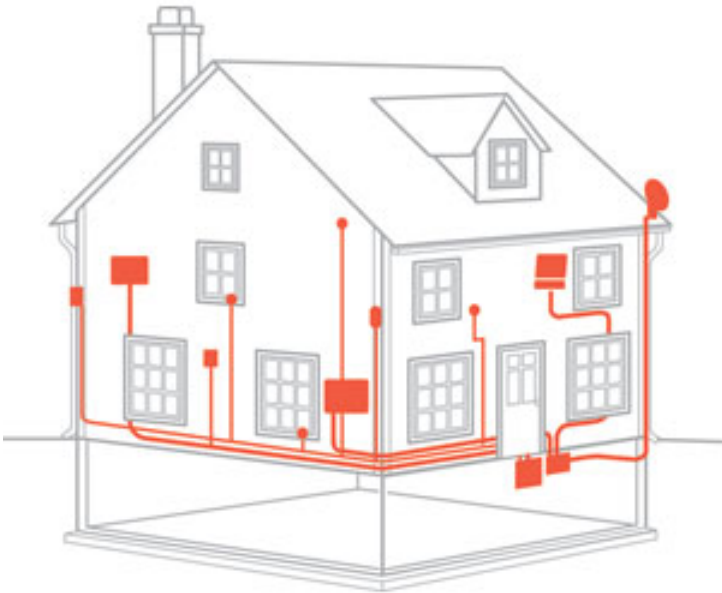
Operating Systems and Networks

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

Outline of the Presentation

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

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 cope with 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)
 Univ. of Porto
 TU Kaiserslautern
 Univ. of Cantabria
 Univ. of York
 Univ. of Lund
 PI Porto
 IMEC

RT scheduling and RT kernels
 networking, distributed applications
 video streaming, off-line scheduling
 schedulability analysis and OS standards
 fixed priority scheduling
 real-time and control issues
 heterogeneous networks
 Low power and memory management

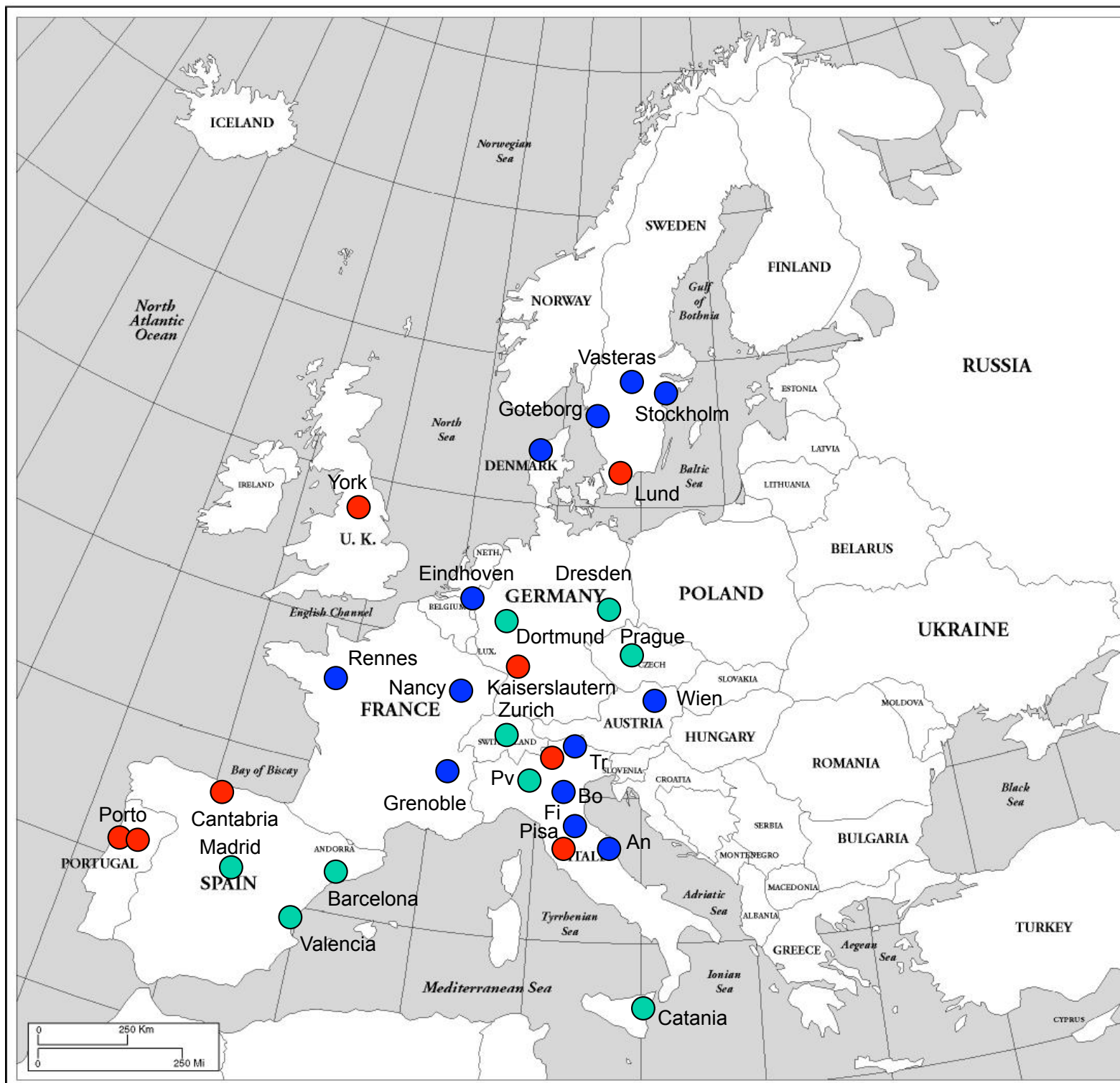
Affiliated Partners

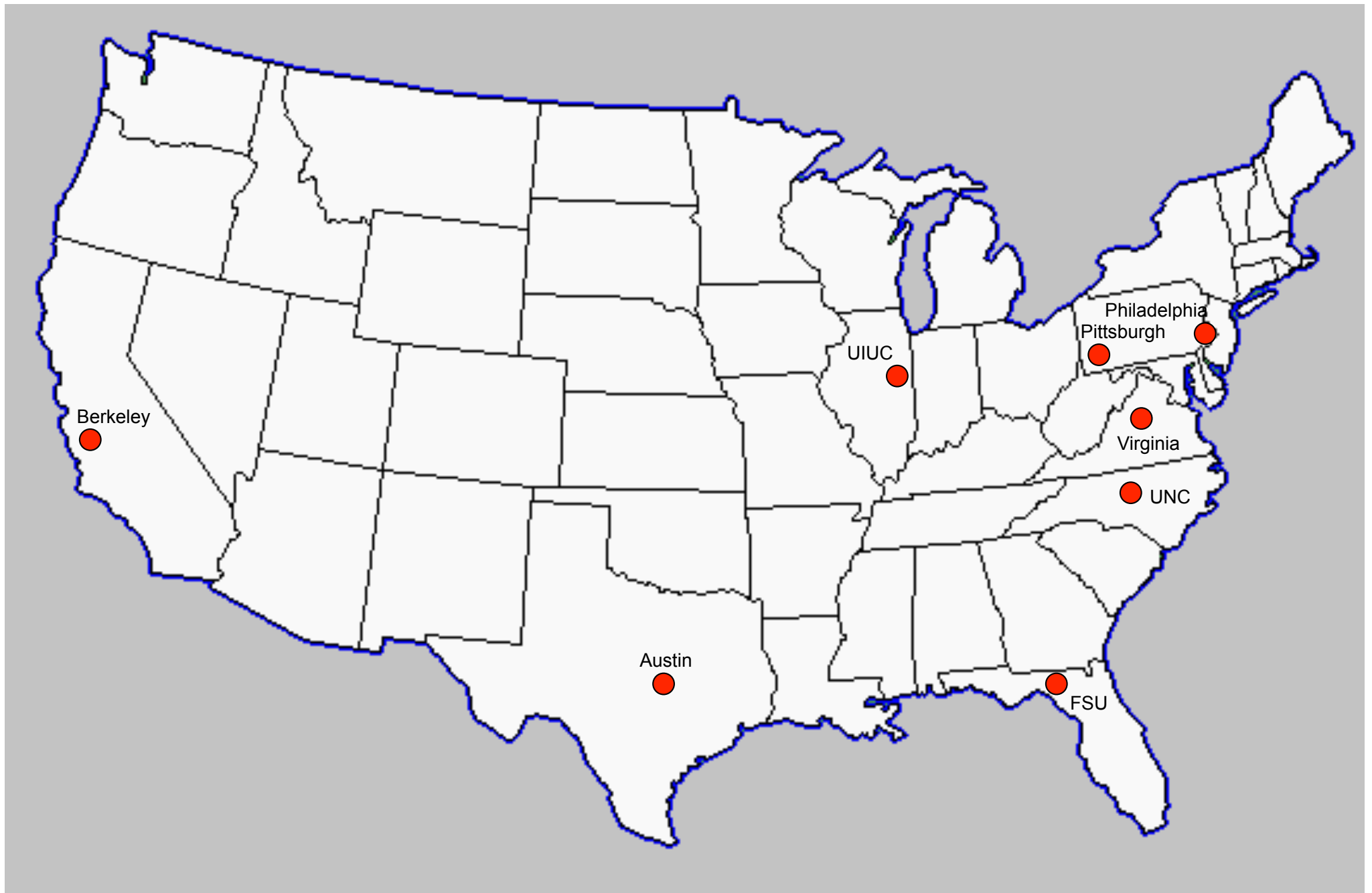
Windriver
 Microchip Technology
 NXP
 Evidence
 UP Catalonia
 Univ. of Catania
 Univ. of Dresden
 Univ. of Madrid
 Univ. of Pavia
 Univ. of Valencia
 EPFL Lausanne
 Univ. of Balearic Islands

RT operating systems
 Embedded applications
 QoS management in multimedia systems
 kernels and tools for RT systems
 control methodologies for RT systems
 distributed systems
 Microkernel architectures
 QoS and resource management
 RT applications and kernels
 Real-time and control issues
 Network protocols and distributed systems
 Dependable RT distributed systems

Geographical distribution of the cluster partners

- Core partners
- Affiliates
- Others





Additional International Partners

- **University of Illinois at Urbana-Champaign**
Contacts: Lui Sha, Tarek Abdelzaher, Marco Caccamo
Topics: Sensor networks, RT scheduling and control
- **University of Virginia**
Contacts: John Stankovic, Sang Son
Topics: Sensor networks and RT data management
- **University of North Carolina at Chapel Hill**
Contacts: Sanjoy Baruah, James Anderson, Kevin Jeffay
Topics: Multi-processor scheduling, multimedia systems
- **Carnegie Mellon University**
Contacts: Ragunathan Rajkumar, John Lehoczky
Topics: Resource reservations, QoS management
- **University of Pittsburgh**
Contacts: Daniel Mossé,
Topics: Energy-Aware Scheduling

Cluster activities

Real-Time Networks

Scheduling and Resource Management

Resource Aware Operating Systems

Workshops and Conferences

Events initiated and steered by the cluster

- **OSPERT**: Workshop on Op. Sys. Platforms for Emb. RT applications
- **RTN**: Int. Workshop on RT Networks
- **APRES**: Int. Workshop on Adaptive and Reconfigurable Systems

Events strategically steered by the cluster

- **ECRTS**: Euromicro Conference on Real-Time Systems
- **RTSS**: IEEE Real-Time Systems Symposium
- **RTAS**: IEEE RT and Embedded Tech. and Appl. Symposium
- **ETFA**: IEEE Int. Conf. on Emerging Tech. and Fact. Automation
- **HSCC**: ACM Int. Conf. on Hybrid Systems: Computation and Control
- **CRTS**: Int. Wks. on Compos. Theory and Tech. for RT Emb. Systems

Major conferences have **Special Issues** on the International Journal of **Real-Time Systems** (Springer)

- **152 publications** from individual groups (A1: 38, A2: 87, A3: 27)
- **53 joint publications** (A1: 16, A2: 16, A3: 21)
- **7 Keynote speeches**
- **14 Workshops/Tutorials**
- **6 Educational activities** (summer schools and graduate courses)
- **3 tool-integration activities**
- **15 student exchanges**
- **6 joint projects** (ACTORS, IRMOS, PREDATOR, FRESCOR, WASP, ILAND)

➤ **Industrial collaborations**

Avionics: *Airbus, Embraer*

Automotive: *Bosch, Magneti Marelli, TTTech*

Railway systems: *Ansaldo*

Robotics: *ENSA (Equipos Nucleares)*

Video surveillance: *Visual Tools*

Healthcare: *Trialog, CAEN*

Consumer electronics: *Ericsson, Philips, NXP*

RTOS producers: *Wind River, Evidence, CISCO*

Platforms: *ARM, Microchip Technology*

Embedded systems: *Intecs, Embedded Solutions*

➤ Industrial impact:

- Resource reservation is used by **Ericsson** (ACTORS project)
- Limited preemption by **Airbus** and **Bosch** (PREDATOR project)
- ERIKA kernel will be used by **Merloni** for washing machines.
- ERIKA multi-core kernel considered by **Magneti Marelli** for automotive applications
- FTT-SE Ethernet protocol is used by **Trialog** (iLAND project)
- MARTE OS is used by **Equipos Nucleares**

Year 3 Review
Brussels, February 24th, 2011

Achievements and Perspectives:

Resource-Aware Operating Systems

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

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)

Main Technical Achievements (1)

Deadline Scheduling on Linux (*Pisa, Evidence*)

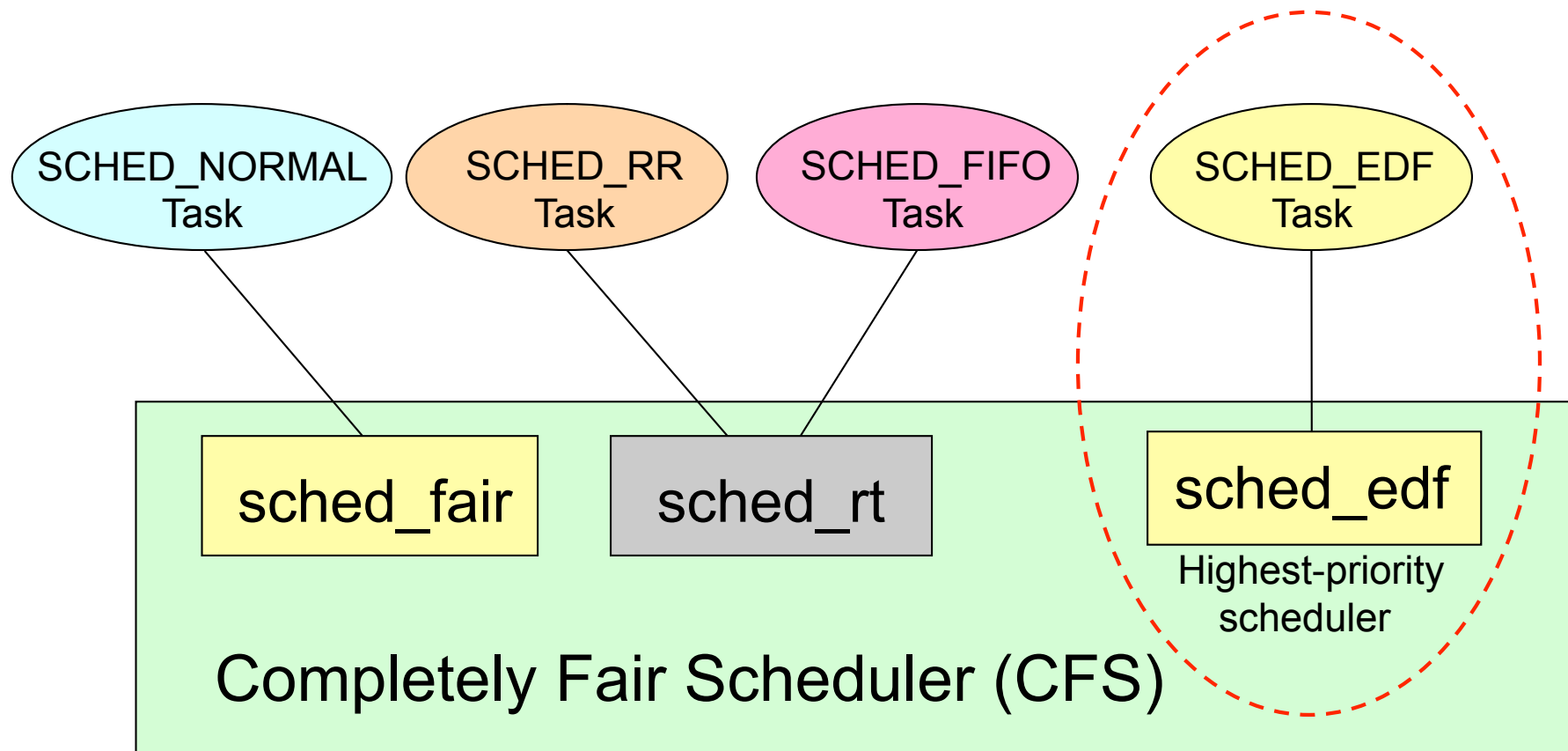
The Linux kernel has been extended to support:

- Earliest Deadline First (EDF) scheduling of periodic tasks (POSIX compliant scheduling class)
- Resource Reservations and Bandwidth Control, through a Constant Bandwidth Server (CBS).

These mechanisms are going to be integrated into the main line distribution!! **LIVE DEMO**

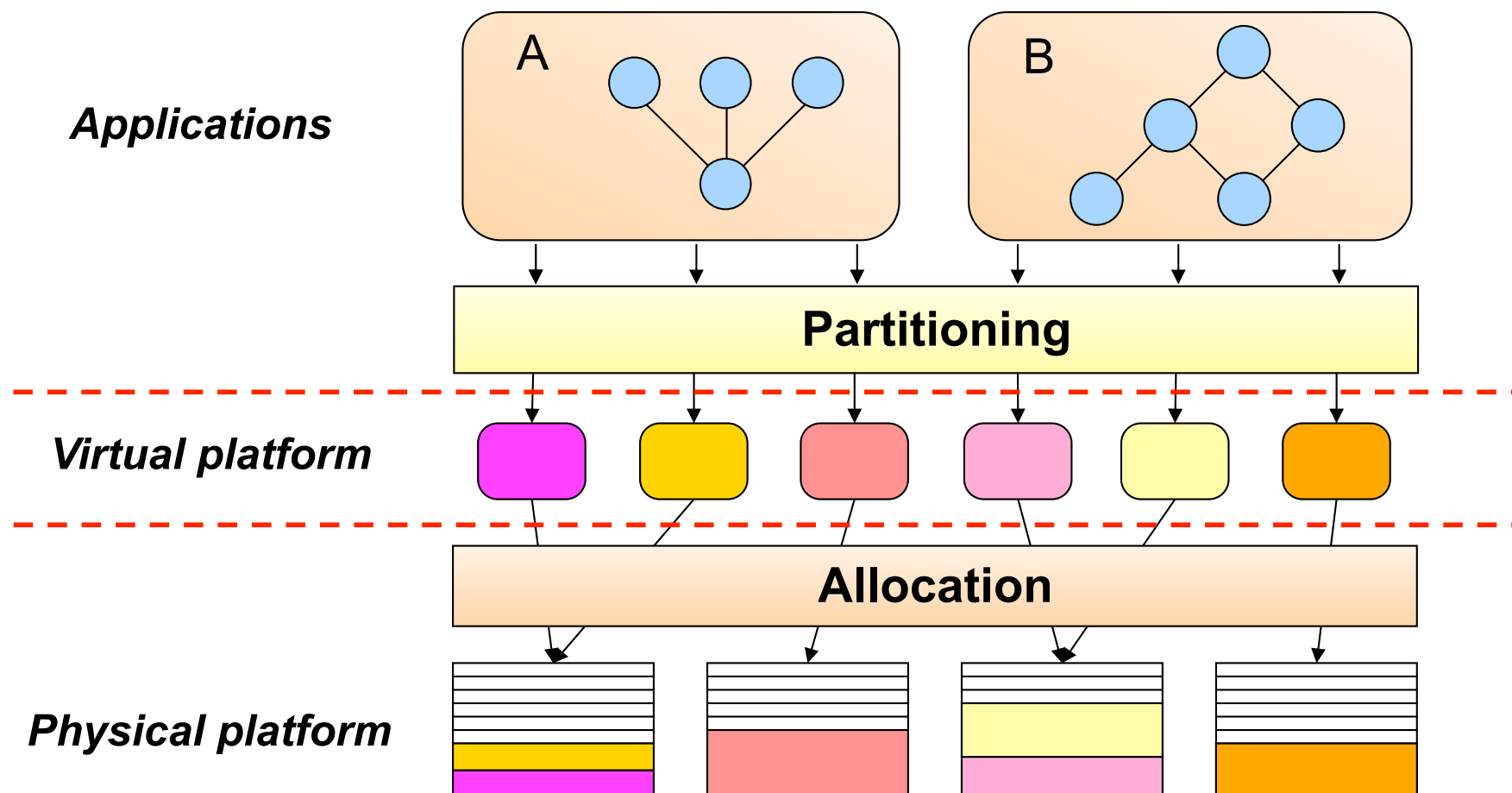
Main Technical Achievements (1)

Deadline Scheduling on Linux (*Pisa, Evidence*)



Main Technical Achievements (2)

Partitioning applications on multi-core platforms



Summer School

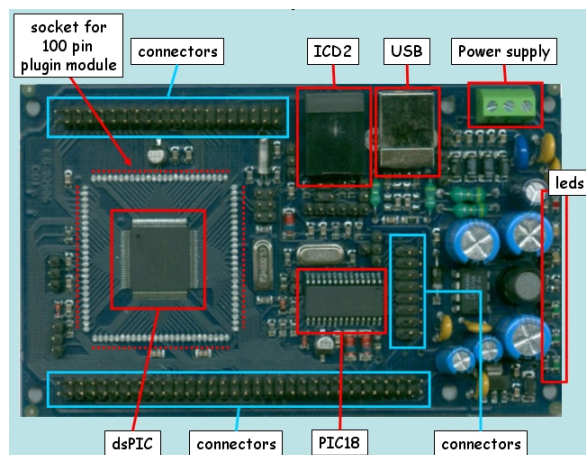
Graduate Course on Embedded Control Systems: Theory and Practice

Scuola Superiore Sant'Anna, Pisa, Italy – June 14-18, 2010

- Giorgio Buttazzo - Scuola Superiore Sant'Anna, Italy
- Pau Martí – University of Catalonia, Spain
- Manel Velasco – University of Catalonia, Spain

Educational Platform for Embedded Control Systems

Pisa, Pavia, Evidence, Microchip Technology, Embedded Solutions



- Fast prototyping RT control applications
- Facing RT scheduling issues
- Handling resource management
- Used in graduate courses



Activity: Resource-Aware Operating Systems

- **38 publications** from individual groups
- **16 joint publications**
- **2 Keynote speeches**
- **3 Workshops/Tutorials**
- **2 Educational activities**
- **3 Tool-integration activities**
- **5 student exchanges**

Plan for Year 4

- Continue the development of software modules to support real-time control applications on the [educational kit](#).
- Investigate hierarchical scheduling to support [composability of heterogeneous platforms](#).
- Consider the effect of [shared resources](#) and non-preemptive regions in resource reservations.
- Evaluate [partitioning](#) algorithms [on multi-core platforms](#), and investigate the allocation of dynamic applications with highly variable resource requirements.

Year 3 Review
Brussels, February 24th, 2011

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

Problems Tackled in 2010

- ❖ Extend the taxonomy
- ❖ Extend the use of contract-based scheduling
- ❖ Produce effective scheduling and placement algorithms for multiprocessor systems
- ❖ Determine an effective way to undertake architectural tradeoffs
- ❖ Define adaptive resource management
- ❖ Extend sensitivity analysis
- ❖ Resource management software in programming languages

Overall Assessment and Vision

- ❖ Remains a very active area in EU
- ❖ 29 technical achievements in deliverables
- ❖ 103 papers – many joint authored or result of collaborations
- ❖ Wiki has been used to collect results, but has not itself fostered deeper integration
 - Transfer to Wikipedia in 2011?
 - Or look to continue existing wiki after ArtistDesign?

A highlight – task splitting

- ❖ Two themes to scheduling multiprocessor and multicore platforms
 - Statically allocation: bin packing + single processor scheduling
 - Dynamic allocation: potentially more effective, new theory needed, overheads are an issue
- ❖ Discussions between Porto, York, CMU, Pisa, UNC and others opened up a middle way
 - Most tasks are statically allocated, $N-1$ are split between processors (for N CPUs)

C=D Algorithm

- ❖ One task splitting scheme for EDF scheduling has a task split so that first part has $C=D$
 - The second part then has maximum time to execute on second processor
- ❖ Often 100% utilisation is achievable (when overheads are ignored)
 - But overheads are potentially low
- ❖ General performance is very good
- ❖ People in Paris (INRIA) have performing a comparison with other schemes – results are good!
- ❖ Pisa is currently implementing on their Linux platform

Plans for Year 4

- Consolidate information on the wiki
- Continue to work on the issues and problems identified in previous years
- Resource-aware communication middleware
- QoS aware scheduling in real-time Java and other programming languages
- More attention to power and energy issues
- More attention to distributed issues
- Mixed criticality systems

Year 3 Review
Brussels, February 24th, 2011

Real-Time Networks

*Activity leader: Luis Almeida
University of Porto
Portugal*

Objectives

- **Managing complexity in networked embedded systems**
 - QoS adaptation and graceful degradation
 - higher integration

- **Towards *(real-time) wireless everywhere***
 - WSN, MANETs, cooperating embedded systems
 - Reduce communication–related energy consumption

- **Networking technology outreach**
 - courses, seminars, schools, standards, joint R&D projects

Challenges

➤ (Real-time) wireless everywhere (WSN)

➤ Synchronisation and routing

- High real-time

➤ Management of resources

- Long lifetime, high scalability and data aggregation

**Timeliness and energy in
Wireless Sensor Networks**

➤ Managing complexity (NES)

➤ QoS adaptation and graceful degradation

- Resilience to node failures, topology changes, adaptation to changing requirements, other reconfigurations

➤ Networking support to applications

- Provide real-time and complex services
 - » Efficient temporal partitioning and dynamic, end-to-end resource reservation

**Flexibility, robustness
and efficiency in NES**

Highlights from Year 3

❖ Timeliness and energy in WSN

- TDMA MAC with **energy-aware elastic scheduling**
- Continued support for **OpenZB**

❖ Flexibility, robustness and efficiency in NES

- Functional composition for **real-time service-oriented** middleware
- Providing flexible **virtualisation** in **Ethernet** switches

❖ Specific application domains

- DDS and ICE based **video transmission** with RT and QoS support
- Wired/wireless integration in **industrial networks** with chain protocols
- Distributed computer vision in **Intelligent Transportation Systems**

Summary of outcomes from Year 3

- **27 publications** from individual groups (4 in journals + 3 thesis)
- **21 joint publications** (5 in journals + 1 thesis)
- **4 workshops/confs** (RTN, SOCNE, WARM, ICESS)
- **8 special sessions/tracks** (ETFA, HSI, ICIT, INDIN, IECON)
- **4 tutorials/seminars** (3 in schools, 1 in specific event)
- Continued participation in the **TinyOS Net2 Working Group** (*OpenZB stack*)
- **6 joint international projects** FP6/7-STREP (FlexWARE, MADES, WASP), ARTEMIS (iLAND, EMMON, INDEXYS), all with strong industrial participation plus **3 joint national** (HARTES-P, CANbids-E, IPERMOB-I)
- **Industrial collaborations** with
Critical Software (P), Visual Tools (E), Trialog (F), Magneti-Marelli (I), Evidence (I), STMicroelectronics (I), NXP (NL), EADS (D), Softeam (F), Xi/Open (UK), TXT E-solutions (I),

Plans for Y4

- Continue with the **taxonomy** on **real-time WSNs and MANETs**
 - organize specific meeting
- **Summer school** on RT Networks and/or participation in other similar schools.
- Continue the sequence of **networking related workshops** co-located with major events in the Real-Time and Embedded communities (RTN, APRES...)
- Contributions to **communication protocols and middleware**, their application and analysis

***WSN:** RT and energy, data aggregation and scalability, mobility...*

***NES:** RT support to distribution middlewares,
support for dynamic adaptation / reconfiguration,
composability ...*

Towards a real-time connected world