Year 3 (Jan-Dec 2010) D2-(0.2d)-Y3





IST-214373 ArtistDesign Network of Excellence on Design for Embedded Systems

Cluster Progress Report for Year 3

Cluster: Operating Systems and Networks

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Policy Objective (abstract)

The objective of this cluster is to build the fundamental basis of a new real-time software technology that can provide a more efficient and predictable support to the development of future embedded systems, characterized by high complexity dynamic behaviour and distributed organisation. To cover these issues, the cluster is organized into 3 activities:

- 1. JPRA Cluster: Resource-Aware Operating Systems
- 2. JPRA Cluster: Scheduling and Resource Management
- 3. JPRA Cluster: Real-Time Networks



Versions

number	comment	date
1.0	First version delivered to the reviewers	Feb 4 th 2011

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1. Overview

1.1 High-Level Objectives

The high level objective of this cluster is to build the fundamental basis of a new real-time software technology that can provide a more efficient and predictable support to the development of future embedded systems, characterized by high complexity dynamic behaviour and distributed organisation. In particular, the new software technology should:

- support scalability to facilitate the porting of control applications to different platforms;
- simplify the management of resources to control the growing complexity and distribution of embedded systems;
- take advantage of parallel processing platforms, such as multicores, in order to satisfy timing and adaptivity requirements;
- be light-weight to optimize the usage of scarce resources in tiny embedded computing devices;
- increase programming flexibility, for specifying functional and performance requirements to simplify test and verification;
- enable run-time reconfigurability and functionality updates to deal with the dynamics and ubiquitous nature of the supporting computing infrastructure;
- increase programming productivity, by raising the level of abstraction of the resource management services;
- increase system adaptivity to react to environmental changes, still providing a sufficient level of performance;
- be robust to tolerate transient and permanent overload conditions due to wrong design assumptions or unpredictable changes.

A means to achieve such a goal is to develop a research platform for real-time systems to share competencies, resources, and tools targeting at the development of applications, such as control systems, with performance and timing requirements. The use of a shared platform is essential for experimenting new real-time software technology, including novel scheduling algorithms, resource management techniques, communication paradigms, energy-aware policies and overload handling approaches to increase robustness and predictability. A shared platform also facilitates the transfer of research results to industry, as it allows teaching practical knowledge of concepts and techniques. In addition, several solutions can be developed and tested in parallel in different partner sites, allowing the evaluation of the most appropriate approach for specific applications.

Specific research topics addressed in this cluster are related to operating systems and networks, with particular emphasis on scheduling and resource management, including energy-aware strategies and exploitation of parallelism in multicores.

-- Changes wrt Y2 deliverable --

No changes with respect to Year 2.



1.2 Industrial Sectors

The industrial sectors that can benefit from adaptive real-time technology include Consumer Electronics, Industrial Automation, and Telecommunications.

Consumer Electronics (CE) products range from miniature cameras and MP3 players to advanced media servers and large displays. These systems are prone to intermittent overload conditions that could degrade the performance in an unpredictable fashion [Wus05, Loo03]. To address these problems, the cluster aimed at integrating the most recent research results achieved in the real-time community to build flexible as well as predictable real-time systems that can react to load changes and perform QoS adaptation in a controlled fashion.

In the area of Industrial Automation there is a trend to use distributed solutions for connecting the general plant actuators, sensors and the controllers. At the same time, there is an increase of demands for new options and improvements in the automation results, fetching more control of plant secondary data. The contribution of the cluster in this domain was to investigate how to achieve predictability and adaptivity in distributed systems.

Embedded systems for telecommunications applications are mainly targeted to the interfaces between communication technologies and to coding/decoding operations. They may be considered real-time as they have timeliness requirements for some of the critical operations they must perform. The work on resource reservation carried out in the cluster was of crucial importance to manage the increased complexity of the applications in this domain.

-- Changes wrt Y2 deliverable --

No changes with respect to Year 2.

1.3 Main Research Trends

Embedded systems are evolving towards applications that have more and more functionalities and adaptive behaviour to cope with a large set of environmental conditions and different user requirements. On one hand, the increasing complexity of the applications requires the use of multicore platforms capable of exploiting hardware parallelism to meet high-performance requirements and timing constraints. On the other hand, the rapid evolution of the hardware platforms requires new abstraction models to speed up application design and portability.

To efficiently operate in dynamic environments, a system must be adaptive; that is, it must be able to adjust its internal strategies in response to a change in the environment, to keep the system performance at a desired level. Implementing adaptive embedded systems requires new resource abstractions and specific support at different architecture levels.

Hardware platforms are evolving towards multicore architectures, which exploit parallelisms to improve performance while containing power consumption. New solutions combine heterogeneous processing elements (CPUs, GPUs, FPGA modules, etc.) to achieve higher performance. However, programming such a platforms is not trivial and a lot of effort is being devoted by the research community to build adequate abstractions that can simplify programming while exploiting the available parallelism as much as possible.

-- Changes wrt Y2 deliverable --

More emphasis on multicore platforms to increase performance and higher abstraction layers to speed up application design and portability.



2. State of the Integration in Europe

The research trends outlined in Section 1.3 are being addressed at different levels by several research groups and industrial companies.

2.1 Brief State of the Art

A lot of effort is being devoted by researches toward multiprocessor and multicore platforms. This section briefly summarizes the most recent results achieved in the last two years.

The real-time group at University of North Carolina is investigating new schedulability results for testing the schedulability of real time applications under different architecture scenarios and task models [1-8]. Several results in this groups have also been obtained with the collaboration of European researchers. The group at Polytechnic Institute of Porto started addressing multiprocessor scheduling with resource sharing [9, 10]. People at the Swiss Federal Institute of Technology of Zurich (ETH) are investigating the analysis of energy-aware scheduling on multiprocessor platforms [11-15]. At EPFL of Lausanne new algorithms are being developed for implementing efficient video coding standards on multicore platforms [16]. The group at University of York is working to extend the execution support of ADA processes on multiprocessor platforms [17-19]. The Retis Lab at the Scuola Superiore Sant'Anna of Pisa is working on implementing a virtual multi-processor abstraction layer to apply resource reservation in the Linux kernel [20-24].

Several ArtistDesign Partners are also involved in different European projects to develop methodologies and infrastructures for simplifying the use and the analysis of multicore platforms for specific applications domains of industrial interest.

For example, in the FRESCOR project (FP6/2005/IST/5-034026) [25], the main objective is to develop the enabling technology and infrastructure required to effectively use the most advanced techniques developed for real-time applications with flexible scheduling requirements, providing the necessary elements to target reconfigurable processing modules and reconfigurable distributed architectures. This is achieved by creating a contract model that specifies the application requirements, the resources that must be guaranteed and how the system can distribute spare resources to achieve the highest efficiency. This contract-based methodology requires, for each resource, an underlying implementation that is capable of enforcing the reservations implied by the different active contracts. The contracts is integrated with a component-based framework and provides the required level of abstraction to make the component model independent of the underlying implementation and hardware architecture. The framework is portable across different scheduling strategies and platforms. Because of the dynamic nature of the contracts and the independence that they provide among the different real-time components of the application, the methodology is well suited to address very dynamic systems, such as those based on reconfigurable architectures.

The ACTORS project (Adaptivity and Control of Resources in Embedded Systems) [26] addresses design of resource-constrained software-intensive embedded systems with high requirements on adaptivity and efficiency. Three techniques are combined to achieve the goal: virtualization, feedback control, and data-flow programming models. Virtualization techniques, such as reservation-based scheduling, provide spatial and temporal separation of concerns and enforce dependability and predictability. Reservations can be composed, are easier to develop and test, and provide security support. Feedback control makes it possible to deal with uncertainties and variations in a controlled way and provides adaptivity to on-line changes in objectives, external conditions and use cases. By combining feedback control with resource reservations it is possible to handle incorrect reservations, reclaim and redistribute unused resources, and adjust to dynamic changes in resource requirements. Execution efficiency and



development efficiency require abstractions on a higher level than what is provided with C and threads/priorities. Data-flow models such as actor models provide the proper foundation for implementation of efficient, component based, and adaptive algorithms for both multimedia applications in consumer electronics and industrial control systems and signal processing applications. The project addresses three application domains: multimedia processing on cellular phone terminals, embedded control, and high-speed video processing for computer vision applications.

The PREDATOR (Design for predictability and efficiency) project [27] is concerned with embedded systems that are characterized by efficiency requirements on the one hand and critical constraints on the other. This combination of requirements typically occurs in application domains such as automotive, aeronautics, multi-media and industrial automation. The main objectives are to improve the design and development methods for safety-critical embedded systems, to develop tools that support these development methods, and to provide architectural platforms that exhibit the desired predictability properties.

The IRMOS (Interactive Realtime Multimedia Applications on Service Oriented Infrastructures) project [28] aims at enabling real-time interactions between people and applications over a Service Oriented Infrastructure, where processing, storage and networking needs to be combined and delivered with guaranteed levels of service.

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-- Changes wrt Y2 deliverable --

This section is completely new and contains the references to new research results and projects.

2.2 Main Aims for Integration and Building Excellence through ArtistDesign

Combining the results achieved by the various research groups is only possible by a tight interaction among the cluster participants. Hence, the aim of the integration through ArtistDesign is to facilitate communication among cluster members in order to:

- Improve the understanding of the key features to be added at different architecture levels (operating system, network, middleware, and language) to support adaptive realtime systems;
- Clarify the terminology to provide a common language for exchanging information between different cluster and research communities;
- Build a common operating system platform to perform experiments and develop tools that can be shared by the different research teams;
- Identify new research directions aimed at overcoming the problems encountered during the integration phase;
- Interact with industries to understand their problems and identify possible solutions;
- Form new consortia and make concrete project proposals to address specific research problems or develop critical applications of industrial interest.

-- Changes wrt Y2 deliverable --

No changes with respect to Year 2.



2.3 Other Research Teams

The cluster had several interactions with the following research teams:

- University of Illinois at Urbana Champagne (reference persons: Prof. Lui Sha, Prof. Tarek Abdelzaher, and Prof. Marco Caccamo) on wireless communication protocols for real-time distributed embedded systems.
- University of Virginia (reference persons: Prof. John Stankovic and Prof. Sang Son) on adaptive real-time systems for sensor networks.
- University of Lund (reference persons: Karl-Erik Arzen and Anton Cervin) on feedback control techniques for adaptive real-time systems.
- University of California at Berkeley (reference person: Alberto Sangiovanni Vincentelli) on the design of component-based operating systems.
- Philips Research Eindhoven (reference persons: Dr. Sjir van Loo) on resource management for consumer electronics.
- NXP (reference persons: Dr. Liesbeth Steffens) on resource management for consumer electronics.
- Ericsson Mobile Platforms (reference person: Dr. Johan Eker) on resource reservation and adaptive QoS management.
- Microchip Technology (reference person: Dr. Antonio Bersani) on real-time embedded platforms for monitoring and control.
- Carnegie-Mellon University (reference person: Prof. Raj Rajkumar) on wireless sensor networks, cooperative computing, and QoS adaptation.
- Seoul National University (reference persons: Dr. Jungkeun Park, Dr. Kanghee Kim), on distributed embedded systems and stochastic analysis of periodic task sets.
- Malardalen University, Sweden (reference person: Dr. Thomas Nolte), on integration of networked subsystems in resource constrained environments and on stochastic analysis of hybrid task sets.
- Saarland University, Germany (reference person: Prof. Reinhard Wilhelm), to investigate the use on limited preemptive scheduling to increase systems predictability.
- University of Dortmund, Germany (reference person: Prof. Peter Marwedel) on the use of real-time kernels for embedded applications.
- University of Bologna, Italy (reference person: Prof. Luca Benini), on a simulation environment for real-time multi-core systems.
- EPFL of Lausanne, Switzerland (reference person: Prof. Marco Mattavelli), on cacheaware scheduling algorithms that optimize memory usage in data-flow applications.
- Airbus, France (reference person: Dr. Benoit Triquet), on real-time operating systems for safety critical avionic applications.
- Bosch, Germany (reference person: Dr. Simon Kramer), on real-time operating mechanisms for increasing predictability and efficiency in automotive applications.
- Absint, Germany (reference person: Dr. Christoph Cullmann), on the use of timing analysis tools for optimally placing preemption points in the task code to reduce stack size and worst-case execution times.

-- Changes wrt Y2 deliverable --



New collaborations have started with Saarland University, University of Dortmund, University of Bologna, EPFL, Airbus, Bosch, and Absint.

2.4 Interaction of the Cluster with Other Communities

Interaction with the control community

A collaboration between the Scuola Superiore Sant'Anna Pisa and Lund has started on feedback control schemes to investigate how system adaptivity can be improved by integrating control theory and real-time scheduling. In particular, the use of feedback control techniques has been considered to make real-time embedded systems more reactive to environmental changes.

Another joint work involving people from Catalonia (affiliated to Lund) and Pisa has been carried out to investigate event-driven scheduling techniques for improving control performance while minimizing resource utilization.

Manel Velasco gave a tutorial in the CDC2010 workhop "Co-design of Control and Real-Time Computing: Perspectives, Techniques and Research Directions", on "Sampling in Event-driven Control Systems". This workshop brings together researchers working towards developing a unified theory that integrates process control and real-time computing.

URL: http://ee.nd.edu/faculty/vgupta/research/funding/gtcdc10 workshop.html

Interaction with the cluster on compilers and timing analysis

The collaboration with the cluster on compilers and timing analysis has been continued to work on techniques for reducing the variability of task execution times. Non-preemptive scheduling approaches have been investigated to reduce worst-case execution times of tasks.

Such a collaboration was started thanks to the ArtistDesign NoE. The two clusters started working together to develop a new approach consisting of a combination of several methods, including (a) design-space exploration on the hardware architecture level to identify good designs offering combinations of strong performance with good predictability, (b) appropriate kernel mechanisms for task and resource management that are predictable and analyzable, and (c) a synergistic development of models, design methods and matching analysis tools that extract precise system-behaviour properties.

Interaction with the consumer electronics industry

The ArtistDesign NoE enabled the collaboration with two major companies, Philips and Ericsson, acting in the domain of consumer electronics. After a tight interaction with the engineers responsible for the software development process, a number of industrial needs have been identified, to increase robustness and flexibility of new generation products.

The work on resource reservation carried out within the cluster was of crucial importance to manage the increased complexity of multimedia systems developed in this domain. Also, the expertize existing in the cluster on overload management was of high interest for these companies to cope with real-time systems with highly variable load.



Interaction with the electronics industry

The interaction of the cluster with Microchip Technology has been reinforced and a joint project was started to develop real-time embedded applications for education using 16-bit microcontrollers (as the dsPIC30 and the dsPIC33). In this context, the Scuola Superiore Sant'Anna, Evidence, and Microchip defined the characteristics of a small real-time embedded platform for sensory acquisition and motor control that can be used (in conjunction with a wireless card) as a node of a mobile wireless network. This unit, more powerful and flexible than a mote, was used to carry out experiments on sensor networks, embedded control, mobile robot teams and distributed control systems.

Researchers of Catalonia (affiliated to Lund) organized several tracks in conferences organized by the IEEE Industrial Electronics Society, as reported below. In addition, J. M. Fuertes is Associate Editor of the Transactions on Industrial Informatics.

Interaction with the Open Source Automation Development Lab

Scuola Superiore Sant'Anna (SSSA) of Pisa joined the OSADL "Open Source Automation Development Lab", focusing on the use of open-source in the real-time and automation industry.

- SSSA organized training events about the IRMOS real-time scheduler, specifically:
 - a 1-hour training seminar co-located with General Assembly meetings of the IRMOS Project at the University of Southampton;
 - a 2-hour training seminar during the WATERS 2010 workshop, co-located with the ECRTS 2010, in Bruxelles;
 - a 3-hours training seminar during the 12th Real-Time Linux Workshop (RTLWS 2010), in Nairobi (Kenya), at the University of Strathmore;

-- Changes wrt Y2 deliverable --

This section is completely new. Additional collaborations were established with the communities of embedded control systems, compiler and timing analysis, and consumer electronics. Joint papers have been written on resource reservations, cache-aware scheduling, and multicore systems.



3. Overall Assessment and Vision for the Cluster

3.1 Assessment for Year 3

All research activities in the cluster have progressed substantially within the third year. The fruitful collaboration among the cluster participants is demonstrated by the relevant number of joint publications, projects and events organized within the cluster. The following list briefly summarize some of the major achievements for year 3. Details and more information can be found in the three activity reports by the cluster.

UNIBO-PISA continued to collaborate on predictability and modularity of MPSoC for Real-Time applications. The interaction has been realized by the integrating tools developed by the partners: the Erika RTOS from SSSA has been extensively used on the MPARM platform developed by UNIBO.

USAAR, PISA, Dortmund, AbsInt. Also supported be the PREDATOR project, these partners collaborated to improve the estimation of worst-case execution times considering cache-aware scheduling and WCET-aware compilers.

EVIDENCE-PISA. A great effort has been done to introduce resource reservation and deadline-based scheduling (EDF) in the Linux operating system, so enabling the implementation of advanced resource reservations techniques.

LUND-TUKL-PISA. Also supported by the ACTORS project, these partners collaborated to develop a design framework for partitioning real-time applications on multicore heterogeneous systems, with the objective of guaranteeing optimal usage of the available resources.

PISA-UPC tightly worked together to define a laboratory platform and experiment to be integrated in the education of embedded control system engineers. The experiment consists in the control of a dynamical system on a platform supported by the Erika real-time kernel. The set up has been tested on a graduate course jointly organized in Pisa on June 14-18, 2010.

ULUND-PISA continued to collaborate on event-based control systems. In this third year, the work has focused on network scheduling of event-based controllers.

Aveiro, UnivPorto and Malardalen worked on a reconfigurable hierarchical scheduling framework within an enhanced Ethernet switch that allows an efficient use of bandwidth, enforcing temporal and spatial isolation.

York, Cantabria, Porto, Madrid, Valencia collaborated for providing a language support for programming schedulable systems. This year the work has focused on getting support for multiprocessors into the next versions of Ada and the Real-Time Specification for Java. These have now effectively been agreed and will enter into the standards at their next releases.

TUKL, CSEM, Philips, Pisa, York, Porto, Prague. Contributed on the development of timeliness in Wireless Sensor Networks. The teams at TUKL, CSEM and Philips proposed a generalized notion of timeliness which suits the characteristics of WSN, based on the requirements in the EU IST project WASP.

Mallorca, UnivPorto, Catalonia, IFP addresses the problem of robustness and timeliness in Controller Area Networks.

Cantabria, Madrid: UPM and UC3M, Bilbao, UnivPorto collaborated for providing real-time support to middleware and composability. A set of timing analysis tools has been integrated with a toolset for MDE. In addition, a new approach has been explored to integrate the real-time end-to-end flow model with the automatic generation of Ravenscar-compliant source code in distribution middleware.

ALL PARTNERS contributed to a major activity (coordinated by YORK) for building a taxonomy of resources, considering multi-resource platforms and including the use of banded notions of time and hierarchical structures.



Madrid, Pisa, Aveiro, UnivPorto, Malardalen, NXP, TUKL worked on protocol optimizations for embedded real-time communications. The validation showed performance improvements in comparison to currently used infrastructures. The performance has been reported to a journal in an article which now in accepted status.

Catania, Pisa, Evidence have been involved in intelligent transportation systems, automatic traffic monitoring and road surveillance. Various sensors have been used to estimate traffic parameters. Catania proposed a wireless sensor network architecture based on computer vision techniques for automatic scene analysis and interpretation.

-- The above is new text, not present in the Y2 deliverable --

3.2 Overall Assessment since the start of the ArtistDesign NoE

The work produced by the cluster since the start of the NoE is excellent. The major benefit of the ArtistDesign NoE was to act as a large research forum, where groups with different expertise had the possibility to interact and collaborate for addressing challenging research problems in the complex domain of embedded systems. Such a collaborative work produced the following significant results:

- <u>Challenging research issues</u>. Different collaborations took place within the cluster that allowed exploiting complementary expertize available among the partners to address complex problems and propose interesting solutions. This can be assessed by the large number of joint papers produced by the cluster members. Some of the most relevant results achieved so far include:
 - The implementation of a real-time scheduler in the Linux kernel, with a support for resource reservation;
 - The support for multi-core platforms in terms of schedulability analysis, resource reservation, and automatic partitioning of parallel applications;
 - A more predictable communication support for Wireless Sensor Networks, for the exchange of soft real-time messages;
 - The development of a comprehensive taxonomy for the resources currently used in embedded real-time systems.
- <u>European projects</u>. Several European projects started thanks to the integration activities triggered by ArtistDesign. Examples are SOOS, MORE, INTERESTED, FlexWARE, MADES, and iLAND.
- Bridge bewten Industry and Academia. Several contacts with the industry have been established within ArtistDesign, which contributed to reduce the huge gap existing between the theoretical work carried out in the university and the applications developed by the companies. A significant effort has been made by the cluster to precisely define a common language between industry and academia.
- <u>Education</u>. A number of graduate courses, workshops and training laboratory activities have been organized to disseminate the knowledge of the cluster to graduate and PhD students.

-- The above is new text, not present in the Y2 deliverable --



3.3 Indicators for Integration

During year 3, interactions between partners can be measured as follows:

- 53 joint publications (16 in Activity 1, 16 in Activity 2, and 21 in Activity 3) in international journals and proceedings related to real-time and embedded computing systems; The plan was 10 Joint publications/year.
- 7 Keynote speeches by team leaders of the cluster.
- Joint organization of 14 workshops, tutorials, special sessions in international highly recognized conferences (the target was 3 workshops/year for discussing new trends and solutions on operating systems and networks):
 - 1. Conference: IEEE ETFA, Bilbao, Spain September 14-17, 2010
 - 2. WARM Workshop, Stockholm, Sweden April 12th, 2010.
 - 3. Workshop: on Real-Time Networks, Brussels, Belgium June 30, 2009
 - 4. Workshop: SOCNE 2010, Perth, Australia April, 2010
 - 5. Workshop: WARM 2010, Stockholm, Sweden April 12, 2010
 - 6. Workshop in DATE 2010, Dresden, Germany, March 12, 2010.
 - 7. Workshop on Real-Time Systems Open Problems, at ECRTS 2010.
 - 8. Special Track in INDIN 2010, Osaka, Japan –13-16 July, 2010
 - 9. Special Session in IECON 2010, Phoenix, USA 7-10 November, 2010
 - 10. Special Session in ICIT 2010, Viña del Mar, Chile 10-12 December, 2010
 - 11. Special Session in HSI 2010, Rzeszow, Poland 13-15 May, 2010
 - 12. Special Session 1 in ETFA 2010, Bilbao, Spain September 13-16, 2010.
 - 13. Special Session 2 in ETFA 2010, Bilbao, Spain September 13-16, 2010.
 - 14. ARTEMIS Summit, Gent, Belgium October 26-27, 2010.
- Organization of joint educational activities on real-time operating systems and networks, like training courses, summer schools, or student competitions;
 - Graduate Course on Real-Time Calculus, Pisa, Italy, March 22-23, 2010.
 - Graduate Course on Real-Time Networks, Pisa, Italy April 26-30, 2010.
 - Graduate Course on Embedded Control Systems, Pisa, Italy, June 7-11, 2010.
 - Graduate Course on RT Kernels for Microcontrollers, Pisa, Italy, June 14-18, 2010.
 - Summer School on RT Embedded Systems, Rabat, Morocco 20-22 Dec., 2010.
 - Summer School in Rabat, Morocco 11-16 July, 2010.
- Creation of a repository for relevant publications, algorithms, and libraries related to realtime operating systems.
- Integration of tools existing at the partner sites:
 - Erika kernel (Pisa-Evidence) and MPARM Simulator (UNIBO)
 - Tool for partitioning real-time applications on multicore platforms (Pisa)
 - Integration of the RTSIM scheduling simulator (Pisa) in NS2.
- Mobility, including PhD student and faculty exchanges:
 - 15 exchanges (see Section 4.2)
- Impact on industrial practice in the area of real-time scheduling:
 - Use of resource reservation by Ericsson (ACTORS project)
 - Use of limited preemptive systems by Airbus and Bosch (PREDATOR project)
 - Use of multi-core kernel for automotive applications by Magneti Marelli (Evidence).

-- Changes wrt Y2 deliverable --

No changes with respect to Year 2.



3.4 Long-Term Vision

The long-term vision of the cluster is to build a significant amount of knowledge on problems, methodologies, techniques, and tools for embedded systems with highly dynamic behaviour, so that it can be disseminated in the industry and in the academia to educate next generation engineers to make embedded systems more robust, more efficient, more flexible, and more predictable than what is possible today.

There are strong indications that adaptive real-time techniques will continue to be important for the embedded systems community. Scheduling and resource management must allow a higher flexibility to handle future applications, which are going to be more dynamic in terms of resource requirements.

The current industrial trend of developing multi-core platforms is introducing a higher degree of complexity that is pushing the research community towards new approaches and methodologies. In fact, the traditional programming model used so far in uniprocessor platforms is quite inadequate for systems consisting of multiple cores and needs to be completely revisited.

To reduce design times and simplify portability of applications on top of different architectures, the trend is to abstract the physical platform resources with a set of virtual resources, which can be managed independently of the physical resources.

Energy-aware and temperature-aware strategies are also becoming very relevant at different architecture levels to prolong battery lifetime and reduce chip damages due to high temperatures, respectively.

-- Changes wrt Y2 deliverable --

More emphasis on multicore platforms, virtualization, energy consumption, and adaptive behaviour.



4. Dissemination

The cluster has been quite active in disseminating the research results achieved in the context of the ArtistDesign network of excellence, as an overall strategy for reaching other research/academic/industrial communities with related interests.

4.1 Conferences and Workshops

Several scientific papers have been published and a number of workshops, and conferences have been organized by the cluster to spread the acquired knowledge in the scientific community. The conferences and workshops in which the cluster has been involved include:

- RTAS 2010 IEEE Real-Time and Embedded Technology and Applications Symposium, Stockholm, April 13-16, 2010. URL: http://www.rtas.org/
- RTSS 2010 IEEE Real-Time Systems Symposium, San Diego (CA), November 30th, 2010.
 URL: http://www.rtss.org/
- ECRTS 2010 Euromicro Conference on Real-Time Systems, Brussels, Belgium, July 7-9, 2010. URL: http://ecrts.eit.uni-kl.de/ecrts10
- ETFA 2010 IEEE International Conference on Emerging Technologies and Factory Automation, September 13-16, 2010, Bilbao, Spain. URL: <u>http://www.etfa2010.org/</u>
- RTCSA 2010 IEEE International Conference on Embedded and Real-Time Computing Systems and Applications, Macau, China, August 23-25, 2010. URL: <u>http://conference.cs.cityu.edu.hk/rtcsa2010/</u>
- RTNS 2010 18th International Conference on Real-Time and Network Systems, Toulouse, France, November 4-5, 2010. URL: <u>http://www.irit.fr/rtns2010/</u>
- OSPERT 2010 Sixth International Workshop on Operating Systems Platforms for Embedded Real-Time Applications, Brussels, Belgium, July 6th, 2010. URL: <u>http://www.artist-embedded.org/artist/Overview,1909.html</u>
- WCET 2010 Tenth International Workshop on Worst-Case Execution Time Analysis, Brussels, Belgium, July 6th, 2010. URL: <u>http://www.artist-embedded.org/artist/WCET-2010,1848.html</u>
- RTN 2010 Ninth International Workshop on Real-Time Networks, Brussels, Belgium, July 6th, 2010.
 URL: http://rtn2010.das.ufsc.br/
- WATERS 2010 1st International Workshop on Analysis Tools and Methodologies for Embedded and Real-time Systems, Brussels, Belgium, July 6th, 2010. URL: <u>http://retis.sssup.it/waters2010/</u>
- RTSOPS 2010: 1st International Real-Time Scheduling Open Problems Seminar, Brussels, Belgium, July 6th, 2010. URL: http://www.cs.wayne.edu/~fishern/Meetings/rtsops2010/
- Industrial Workshop and Exhibition, Stockholm, April 12, 2010. URL: <u>http://www.mrtc.mdh.se/CPSweek/industrialWS/</u>



- First International Workshop on Energy-Aware Design and Analysis of Cyber-Physical Systems, Stockholm, April 12, 2010. URL: <u>http://mypage.siu.edu/harinir/CPSWorkshop/index.htm</u>
- WARM 2010 First Workshop on Adaptive Resource Management, Stockholm, April 12, 2010. URL: http://www.artist-embedded.org/artist/New-article,2075.html
- CRTS 2010 3rd Workshop on Compositional Theory and Technology for Real-Time Embedded Systems, San Diego (CA), November 30th, 2010. URL. http://retis.sssup.it/crts2010/
- SOCNE 2010 5th IEEE International Workshop on Service Oriented Architectures in Converging Networked Environments (SOCNE) 2010, Perth, Australia, April 2010. URL: <u>http://www.socne.org/</u>
- CPSWEEK 2010 The 4th Cyber-Physical Systems Week, Stockholm, April 12 16, 2010 URL: <u>http://www.cpsweek2010.se/</u>
- DATE 2010 Design, Automation & Test in Europe, Dresden, Germany, March 8-12, 2010.
 URL: http://www.date-conference.com/date10/
- HSCC2010: 13th ACM International Conference on Hybrid Systems: Computation and control, Stockholm, April 12-16, 2010. URL: <u>http://hscc10.it.uu.se/</u>
- MED 2010: 18th Mediterranean Conference on Control and Automation. Marrakech, Morocco, June 23-25, 2010. URL: <u>http://www.med10.org/</u>
- NecSys2010: 2nd IFAC Workshop on Distributed Estimation and Control in Networked Systems, Annecy, France, 13-14 September, 2010. URL: <u>http://necsys2010.inrialpes.fr/</u>
- IECON2010: 36th Annual Conference of the IEEE Industrial Electronics Society, Glendale, AZ, USA, 7-10 November 2010. URL: <u>http://iecon2010.njit.edu/index2.html</u>
- Topic on Real-Time and Dependable Systems Principles and Practice, at the 13th Design, Automation and Test in Europe (DATE 2010), chaired by Luis Almeida.
- Track on Distributed, Embedded Networked Control in 8th IEEE International Conference on Industrial Informatics (INDIN2010) (chaired by: Josep M. Fuertes, Mo-Yuen Chow and Jose Lastra).
- Special Session on Networked-Based Control Systems in 36th Annual Conference of the IEEE Industrial Electronics Society (IECON 2010) (chaired by: Josep M. Fuertes, Mo-Yuen Chow, and NBCS TC).
- Special Session on Networked-Based Control Systems in IEEE International Conference on Industrial Technology (ICIT2010) (chaired by: Josep M. Fuertes, Mo-Yuen Chow, and NBCS TC).
- AMS Track in IEEE IES International Conference on Emerging Technologies and Factory Automation (ETFA2010) (chaired by: J. Fuertes)



4.2 Courses and Seminars

• Graduate Course on Real-Time Calculus Scuola Superiore Sant'Anna, Pisa, Italy – March 22-23, 2010

<u>Objectives</u>: The course covered aspects of system level performance analysis of distributed embedded systems, approaches to system-level performance analysis, requirements in terms of accuracy, scalability, composability and modularity, performance evaluation and mapping of distributed algorithms; analysis of memory access and I\O interaction on shared busses in multi-core systems.

<u>Organizers:</u> Giorgio Buttazzo (Scuola Superiore Sant'Anna), Lothar Thiele (ETH Zurich, Switzerland).

Graduate Course on Real-Time Networks

Scuola Superiore Sant'Anna, Pisa, Italy – April 27-30, 2010

<u>Objectives</u>: This course presented an introduction to computer networks from a real-time systems perspective. The lectures included an initial presentation of general concepts in networks, physical and data link layers, medium access control, traffic scheduling and its relationship with medium access control, schedulability analysis, wireless communication protocols, and holistic design of distributed systems.

<u>Organizers:</u> Giorgio Buttazzo (Scuola Superiore Sant'Anna), Luis Almeida (Univeristy of Porto, Portugal).

Graduate Course on Real-Time Control Systems

Scuola Superiore Sant'Anna, Pisa, Italy – June 7-11, 2010

<u>Objectives</u>: The objective of the course was to introduce classical control notions applied to real-time computing systems. Topics included: discrete time systems, period selection, delayed models, variability on periods and delays, controllability, observability and performance of discrete time controllers, optimal discrete controllers, real-time computing of control systems, event driven systems, lab practice with the Flex board and some electronic devices.

<u>Organizers:</u> Giorgio Buttazzo (Scuola Superiore Sant'Anna), Pau Marti (Technical University of Catalonia, Barcelona, Spain), Manel Velasco (Technical University of Catalonia, Barcelona, Spain).

• ARTIST Graduate School on Real-Time Kernels for Microcontrollers Scuola Superiore Sant'Anna, Pisa, Italy – June 14-18, 2010

<u>Objectives</u>: The course was aimed at providing the fundamentals concepts of real-time computing systems, including scheduling, resource management and timing analysis; introducing the OSEK/VDX standards, taking as a reference implementation the Erika Enterprise kernel; showing how to apply such concepts in practice, with examples based on the Flex platform and the Microchip dsPIC DSC microcontrollers; teaching participants how to develop simple control applications using Erika Enterprise with code generation from functional models.

<u>Organizers:</u> Giorgio Buttazzo (Scuola Superiore Sant'Anna), Pau Marti (Technical University of Catalonia, Barcelona, Spain), Ettore Ricciardi (ISTI-CNR, Pisa).

URL: http://www.artist-embedded.org/artist/Overview,2037.html



4.3 Participation in Standards

Some cluster members are actively involved in the following standardization activities:

• UML Profile QoS and Fault Tolerance

URL: http://www.artist-embedded.org/artist/UML-Profile-QoS-and-Fault.html Member: Miguel A. de Miguel, UP Madrid.

• Ada

URL: http://www.artist-embedded.org/artist/UML-Profile-QoS-and-Fault.html Member: Alan Burns, Univ. of York.

• POSIX 1003

In 2010, the POSIX.13 and POSIX.1d standards were reaffirmed. In addition, the process to revise these standards has been started. The scope of the revision is to align both standards with the current version of the POSIX.1 system services (2010 edition). Michael González is participating as a member of the working group, and is also the technical editor for both standards.

URL: http://www.artist-embedded.org/artist/POSIX-IEEE-1003.html

Member: Michael Gonzalez Harbour, Univ. of Cantabria.

• MPEG Multimedia Middleware (M3W)

URL: http://www.artist-embedded.org/artist/MPEG-Multimedia-Middleware-M3W.html Member: Alejandro Alonso, UP Madrid.

- Lucia Lo Bello, from Univ. of Catania (affiliated to Pisa) is involved in standardization activities as Member of the International Electrotecnical Commission (IEC), Technical Committee SC65C, as member of Working Group 16, dealing with Wireless Industrial communication networks. Working Group 17, dealing with Coexistence in Wireless Industrial communication networks.
- Standardization effort was undertaken by the Scuola Superiore Sant'Anna of Pisa for including a new deadline-based reservation scheduler into the mainline Linux kernel. To achieve this goal, some core kernel developers, such as Thomas Gleixner (responsible for the i386 support) and Paul McKenney (responsible for the Read-Copy-Update synchronisation machinery into Linux), have been invited to fruitful technical meetings about the real-time support in the Linux kernel.

-- The above is new material, not present in the Y2 deliverable --



5. Cluster Participants

-- Changes in the Cluster Participants w.r.t. Y1 deliverable --

Team leaders of IMEC and UC3-Madrid were updated. Prof. Marco Caccamo was added in the list of affiliated international partners. The profile of Lucia Lo Bello of the Catania affiliate was updated.

5.1 Core Partners

Cluster Leader Activity Leader for "Resource-Aware Operating Systems"		
	Prof. Giorgio Buttazzo Scuola Superiore Sant'Anna (SSSA), Pisa (Italy) URL: <u>http://feanor.sssup.it/~giorgio/</u>	
Technical role(s) within ArtistDesign	Coordinating the cluster on Operating Systems and Network and the activity entitled "Resource-Aware Operating Systems". Providing support on real-time scheduling, operating systems, resource management, overload handling, energy aware algorithms, and quality-of-service strategies.	
Research interests	Real-time operating systems, dynamic scheduling algorithms, quality of service control, multimedia systems, advanced robotics applications, and neural networks.	
Role in leading conferences/journals/etc in the area	 Editor-in-Chief of the Journal of Real-Time Systems (Springer). Associate Editor of the Journal of Embedded Computing (Cambridge International Science Publishing). Executive Board Member of the Euromicro Conference on Real- Time Systems. Program Chair of RTSS'01, ECRTS'03, EMSOFT'04, HSCC'07. General Chair of RTSS'02, EMSOFT'04, ECRTS'07. Reviewer for Real-Time Systems, IEEE Transactions on Computers, ACM Transactions on Embedded Computing. Program committee member of most real-time related conferences. 	
Notable past projects	"FIRST: Flexible Integrated Real-time Systems Technology", IST-2001-32467 (2002-2005) investigated advanced scheduling for	



	handling applications with various real-time requirements.
	"OCERA: Open Components for Embedded Real-time Applications", IST-2001-35102 (2002-2005) integrated advanced real-time mechanisms in open-source kernels.
	"FABRIC: Federated Applications Based on Real_time Interacting Components", IST-2001-37167 (2002-2003) investigated QoS management methods for home networks.
	"ARTIST: Advanced Real-Time Systems", IST-2001-34820 (2002-2005) investigated adaptive real-time systems for QoS management.
	"TRACS - Flexible Real-Time Architecture for Traffic Control Systems", ESPRIT III project No. 6373 (1992-1995) investigated real-time techniques for vessel control systems.
Awards	Best paper Award at the 10 th Int. Conference on Real-Time and Embedded Computing Systems and Applications (RTCSA 2004), Gothenburg, Sweden, August 2004. Paper: "The Jitter Margin and Its Application in the Design of Real-Time Control Systems".
	Award for the best paper and presentation at the ANIPLA Workshop on Operating Systems for Industrial Control Applications, Milan, November 18, 1999.
	HUSPI Award given by Honeywell for the best journal publication on robotic systems, November 1987.
Further Information	Senior Member of IEEE

Team Leader Activity Leader for "Scheduling and Resource Management"		
	Professor Alan Burns University of York, UK URL: <u>www.cs.york.ac.uk/~burns</u>	
Technical role(s) within ArtistDesign	Undertakes research in real-time systems scheduling, particularly for flexible systems. Also concerned with the development of programming languages for this domain.	
Research interests	Scheduling, languages, modelling and formal logics.	
Role in leading conferences/journals/etc in the area	Previous Chair of the IEEE Technical Committee on Real-Time Systems. Edited special issue of ACM Transactions on Embedded Systems (on education).	
Notable past projects	DIRC – Dependability Interdisciplinary Research Collabroations – A large, UK, 6-year, multisite project looking at dependability of	



computer-based systems. Burns was a PI and manged the work on temporal aspects of dependability.
FIRST – EU funded project concerninf flexibile scheduling
FRESCOR – EU follow on project to FIRST

Team Leader		
	Prof. Gerhard Fohler	
	Technical Univeristy of Kaiserslautern (TUKL)	
(Color)	URL: <u>www.eit.uni-kl.de/fohler</u>	
Technical role(s) within ArtistDesign	The role of TUKL is to investigate resource management policies for controlling the quality of service in multimedia applications. The team is leading the activity on Adaptive Resource Management for Consumer Electronics and is involved in the development and analisys of algorithms for video streaming applications. A further focus is on flexible scheduling, with the aim of integrating offline and online approaches.	
Research interests	Real-time scheduling, integration of offline and online scheduling, QoS management, video streaming and media processing.	
Role in leading	Chairman, technical committee on real-time systems, Euromicro	
conferences/journals/etc in the area	Member of executive board technical committees on, IEEE real-time systems, IE embedded systems	
	Area editor real-time, Journal of System Architecture, Elsevier	
	Program chair, IEEE Real-Time Systems Symposium, 2006	
	Program chair, subtrack real-time systems, DATE 2005-2007	
	Program committee member of most real-time related conferences	
Notable past projects	FRESCOR - Framework for Real-time Embedded Systems based on COntRacts, EU IST STREP	
	WASP - Wirelessly Accessible Sensor Populations, EU IST IP	
	BETSY - BEing on Time Saves energY continuous multimedia experience with low battery power, EU IST STREP	
	FIRST - Flexible Integrated Real-Time System Technology, EU IST STREP	
	FABRIC: "Federated Applications Based on Real_time Interacting Components", IST-2001-37167 (2002-2003) investigated QoS management methods for home networks.	



Team Leader		
	Prof. Michael González Harbour	
	Universidad de Cantabria http://www.ctr.unican.es	
Technical role(s) within ArtistDesign	The role of University of Cantabria is to provide support for schedulability analysis of embedded distributed systems with real- time requirements. The Group has also developed methodologies and tools for software engineering of real-time systems in which a mixture of soft and hard deadlines can be found and as such is leading the activity on Flexible Scheduling Technologies. The group is also actively participating in the development of the Real-time POSIX operating systems standards, and is active in real-time languages, (Ada) and therefore contributing to the platform being used in the Real-Time Languages activity. One important goal of the Group has always been to test the results of basic research in practical applications. As a consequence, the Group has contacts with industrial companies in the field of industrial automation.	
Research interests	Real-Time Schedulability Analysis, Real-Time Operating Systems, Real-Time Languages, Real-Time networks	
Role in leading conferences/journals/etc in the area	Program chair of ECRTS 07, Program Co-Chair of the International Conference on Reliable Software Technologies 2006, Program Committee Member of RTAS, RTSS, ECRTS, and various Workshops on real-time systems.	
Notable past projects	FRESCOR, Framework for Real-time Embedded Systems based on COntRacts. The FRESCOR project is aimed at developing a framework that integrates advanced flexible scheduling techniques directly into an embedded systems design methodology, covering all the levels involved in the implementation, from the OS primitives, through the middleware, up to the application level (www.frescor.org)	

Team Leader Activity Leader for "Real-Time Networks"	
	Prof. Luis Almeida University of Porto URL: <u>http://www.fe.up.pt/~lda/</u>



Technical role(s) within ArtistDesign	Leader of the team from the University of Porto.
Research interests	Real-time communication (traffic scheduling, protocols,)
	Flexible architectures for distributed embedded systems
Role in leading conferences/journals/etc in the area	Usually participates in the Organizing and /or Program Committees of conferences in the fields of Real-Time Systems (e.g., RTSS, ECRTS, RTAS) and industrial communications (e.g., WFCS, ETFA, FET). Has chaired several workshops (e.g., RTN, WTR, WiP sessions). Reviewer for several related journals (e.g., IEEE TII, TIE, TC, ACM TECS, Kluwer JRTS)
Notable past projects	ARTIST2 (FP6 NoE) – team leader
	ARTIST (FP5 accompaning measure) – team leader.
	CAMBADA – Cooperative Autonomous roBots with Advanced Distributed Architecture (participant).
	http://www.ieeta.pt/atri/cambada/
	DISCO, DIStributed embeddable systems for COntrol applications (participant).
	http://www.ieeta.pt/lse/DISCO_web.pdf
	CIDER, Communication Infrastructure for Dependable and Evolvable Real-time systems (team leader).
	http://www.hurray.isep.ipp.pt/activities/cider/
Awards	Best Paper Award in ETFA 2008
	Best Work-in-Progress Paper Award in WFCS 2008
	Best Paper Award in ANIPLA 2006
	Best Paper Award in WFCS 2004
	Best Paper Award in SICICA 2000

Team Leader	
	Prof. Eduardo Tovar Polytechnic Institute of Porto (ISEP-IPP), Porto (Portugal) URL: <u>http://www.hurray.isep.ipp.pt/asp/show_people.asp?id=1</u>
Technical role(s) within ArtistDesign	The role of ISEP-IPP team is to investigate distributed embedded systems, with a particular focus on communication protocols for WSN and MANETs. The team is leading the activity on Real-Time Networks and involved in flexible scheduling technologies, resource management policies and QoS-aware collaborative computing. The



	team has also a strong commitment in Real-Time Languages.
Research interests	Real-time systems, wireless sensor networks, multiprocessor platforms, communication networks, factory automation and system integration.
Role in leading conferences/journals/etc	Executive Board Member of the Euromicro Technical Committee on Real-Time Systems.
in the area	Program Chair ECRTS'05, RTN'02, WDES'06.
	General Chair of WFCS'00, ECRTS'03.
	Program committee member in several editions of ERCTS, RTSS, RTAS, RTCSA, ICDCS, SRDS, WFCS, ETFA, EMSOFT and other IEEE, ACM and Euromicro events on real-time systems, embedded systems and factory communication systems.
	Reviewer for Real-Time Systems, IEEE Transactions on Computers, ACM Transactions on Embedded Computing, IEEE Transactions on Industrial Informatics.
Notable past projects	"REMPLI: Real-time Energy Management via Power-lines and Internet", NNE5-2001-00825 (2003-2006) investigated advanced scheduling and protocols for power-line communication systems (PLC).
	"R-Fieldbus: High Performance Wireless Fieldbus in Industrial Multimedia-Related Environment", IST-1999-11316 (2001-2003), integrated advanced real-time mechanisms in hybrid wired/wireless fieldbus neworks. Mobility protocols and end-to-end deadlines
	"CABERNET: Network of Excellence in Distributed Computing Systems Architectures", IST-2000-25088 (2001-2003).
	"CIDER: Communication Infrastructure for Dependable Evolvable Real-time systems", POSI/1999/CHS/33139 (2001-2003), Portuguese Science Foundation project on real-time communication networks.
Further Information	Senior Member of IEEE



Team Leader Activity Leader for "Design for Adaptivity"		
	Professor Karl-Erik Årzén Lund University URL: http://www.control.lth.se/user/karlerik/	
Technical role(s) within ArtistDesign	Leader for the Transversal activity "Design for Adaptivity". Team leader for Lund University. Participates in the OS and Networks cluster	
Research interests	Embedded control, real-time systems, adaptive resource management, veedback applied to computer systems	
Role in leading conferences/journals/etc in the area	CoChair 4th Intl. Workshop on Feedback Control Implementation and Design in Computing Systems & Networks (FeBID 2009)	
Notable past projects	RUNES, ARTIST2, ACTORS (ongoing)	
Awards	The Dr Guido Carlo-Stella award in manufacturing automation from the World Batch Forum in 2006 for achievements in manufacturing automation and information structuring	

Team Leader	
	Prof. Dr. Maja D'hondt
	IMEC vzw.
	http://www.imec.be
Technical role(s) within ArtistDesign	Representing IMEC Smart Systems and Energy Technology division in: -Cluster: SW Synthesis, Code Generation and Timing Analysis -Cluster: Operating Systems and Networks -Cluster: Hardware Platforms and MPSoC Design -Intercluster activity: Design for Adaptivity
	-Intercluster activity: Integration Driven by Industrial Applications



Research interests	Maja D'Hondt received her Master and Ph.D degrees in Computer Science from the Vrije Universiteit Brussel in Belgium in 1998 and 2004 respectively. Since 2008 she leads a team of (senior) researchers and PhD students working on run-time resource management middleware for embedded systems.
Role in leading conferences/journals/etc in the area	Maja D'Hondt has published in International Journals and Conferences. She has sat on several program committees of international conferences. She played an active role in the organization of international conferences as workshop and tutorial chair.
Notable past projects	ResponsibleforScalopesARTEMISproject(http://www.scalopes.eu/),OptiMMAIWTproject(www.imec.be/OptiMMA),andStadiumIWTproject(distrinet.cs.kuleuven.be/projects/stadium/).IWTIWTIWT



5.2 Affiliated Industrial Partners

Team Leader	
	Dr. Paolo Gai (Ph.D.)
	Evidence srl (Italy)
	URL: <u>http://feanor.sssup.it/~pj/</u>
Technical role(s) within ArtistDesign	Support for the SHaRK kernel maintenance, consulting on POSIX and OSEK standards, real-time kernels, design and analysis tools.
Research interests	Real-time scheduling, operating systems, design and analysis tools.
Notable past projects	FIRST: Flexible Integrated Real-time Systems Technology, IST-2001-32467 (2002-2005) investigated advanced scheduling for handling applications with various real-time requirements.
	OCERA: Open Components for Embedded Real-time Applications, IST-2001-35102 (2002-2005) integrated advanced real-time mechanisms in open-source kernels.
	ARTIST: Advanced Real-Time Systems. (<u>http://www.artist-embedded.org</u>)

5.3 Affiliated Academic Partners

Team Leader	
	Prof. Marisol García-Valls Universidad Carlos III de Madrid URL: <u>http://www.it.uc3m.es/mvalls</u>
Technical role(s) within ArtistDesign	UC3M leader on Adaptive resource management for CE"
Research interests	Distributed systems: real-time middleware and communications. QoS-based resource management and multimedia. Scheduling. Real-time languages (real-time lava Ada)



Role in leading conferences/journals/etc in the area	Participation in the Programme Committee of conferences such as ETFA, ICESS, EstiMedia.
	Reviewer of a number of Journals: Trans. Industrial Informatics, Trans. Industrial Electronics, Real Time Systems Journal, Concurrency Practice and Experience, etc.
Notable past projects	iLAND (Technical coordinator/leader): mlddLewAre for deterministic dynamically reconfigurable NetworkeD embedded systems (ARTEMIS-JU 100026). From 2009 to 2012
	DDS Gateway for web services.
	ARTISTDesign, ARTIST2
	ARTIST: Advanced Real-Time Systems. URL: http://www.artist-embedded.org

Activity Leader for "Qos-aware components"	
	Prof. Alejandro Alonso
	Universidad Politécnica de Madrid.
	URL: <u>http://www.dit.upm.es/aalonso</u>
Technical role(s) within	Activity Leader for "Qos-aware components"
ArtistDesign	UPM leader on Adaptive resource management for CE"
Research interests	Design of real-time systems, programming languages, scheduling, distributed systems and quality of service
Role in leading conferences/journals/etc in the area	Participation in the Programme Committee of conferences such as Euromicro Real-Time Systems, International Conference on Reliable Software Technologies.
Notable past projects	MORE: Network-centric Middleware for GrOup communication and Resource Sharing across Heterogeneous Embedded Systems
	HIJA: High-Integrity Java Applications. The goal is to develop a new Java-based middleware platform fo the creation of Architecture-Neutral, high-integrity, distributed Real-Time Systems (ANRTS)
	ROBOCOP and Space4U. Development of component framework for embedded devices. It includes support for QoS and resource management.
	TRECOM: Techniques for the development of advanced distributed real-time systems for safety and business critical systems.



Team Leader	
	Prof. Hermann Härtig Dresden University of Technolgy URL: <u>http://os.inf.tu-dresden.de/~haertig/</u>
Technical role(s) within ArtistDesign	Virtualisation, microkernels, real-time operating systems.
Research interests	Real-time operating systems for the support of applications with Quality of Service requirements. Scheduling and file system support for bounded response time.
Role in leading conferences/journals/etc in the area	Program Committee member Reviewer
Notable past projects	Fiasco, L⁴Linux, L4Env

Team Leader	
	Name: Alfons Affiliation: Universidad Politécnica de Valencia, Spain URL: http://www.gii.upv.es/personal/alfons/
Technical role(s) within ArtistDesign	Real-time control on embedded platforms
Research interests	Virtualisation, hypervisor, real-time operating system, dynamic memory management
Role in leading conferences/journals/etc in the area	Program Committee member
	Reviewer
Notable past projects	ARTIST2: Network of Excellence on Embedded Systems Design. U.E. IST Programme - IST 004527. 2004-08
	FRESCOR: Framework for Real-time Embedded Systems based on COntRacts FRESCOR. U.E. IST Programme - IST 034026. 2006-



2009
THREAD: Integral support for embedded, distributed open real-time systems Spanish Ministry of Education, Science and Technology - TIC2005-08665-C03. 2005-2008
SENSE: Smart Embedded Network of Sensing Entities. U.E. IST Programme - IST 033279. 2006-2009
TECOM: Trusted Embedded Computing. Programme ITEA-2 and PROFIT (M. Industria, Spanish Governement). 2007-2010
OCERA: Open Components for Embedded Real-Time Applications. U.E. IST Programme (IST 35102). 2002-05

Team Leader	
	Prof. Jean-Dominique Decotignie
	Ecole Polytechnique Fédérale de Lausanne (Switzerland)
	URL: http://lamspeople.epfl.ch/decotignie/
Technical role(s) within ArtistDesign	
Research interests	
Role in leading conferences/journals/etc in the area	
Notable past projects	

Team Leader	
	Prof. Lucia Lo Bello
	University of Catania (Italy) – Affiliated to SSSA, Pisa
	URL: <u>http://www.diit.unict.it/users/llobello/</u>
Technical role(s) within ArtistDesign	Support for the SHaRK kernel maintenance. Implementation of industrial multimedia system using SHARK. Execution time measurement. Stochastic analysis of soft real-time tasks in the context of priority-driven soft real-time systems. Calculation of stochastic response time profiles of tasks that are hierarchically scheduled using server based techniques.



	Support for real-time communication in distributed embedded systems, with particular reference to networked embedded systems used in factory communication and in automotive environments. Real-time communication over wireless networks: modeling, timing analysis, transmission scheduling, topology management, coexistence assessments, to support soft real-time traffic over IEEE 802.11, 802.15.4 and Bluetooth networks. Design issues and protocols for wireless sensor networks and networked embedded systems.
Research interests	Wireless networks and sensor networks, factory communication, real-time scheduling, overload handling, real-time industrial embedded systems, networked embedded systems, energy-aware protocols, automotive communications.
Role in leading conferences/journals/etc in the area	Program Chair of SOCNE 2010, HSI'09, ETFA 08, ETFA 05. WIP Chair of ETFA 09, SIES 07, ETFA 06. General Chair of ECRTS 04.
	On the PC of many editions of ECRTS, RTSS, RTAS, WFCS, ETFA, RTN, FET, RTNS, WTR. Reviewer for several international journals, included the Real-Time Systems Journal, IEEE/IES Transactions on Industrial Informatics, IEEE Transactions on Industrial Electronics, ACM Transactions on Embedded Systems, IEEE Transactions on Education. On the Editorial Board of the Journal of Real-time Image Processing, Springer, Germany.
Notable past projects	Italian National projects PRIN 04 entitled "Study and development of a real-time land control and monitoring system for fire prevention", COFIN 01 entitled "High-Performance Processing for Applications with High-Intensity Computational Requirements and Real-Time Constraints, both funded by the Italian Ministry of University and Research European project ESPRIT 26951 "NOAH - Network Oriented
Further Information	Responsible for the University of Catania of the flexWARE Project, Flexible Wireless Automation in Real-Time Environments, www.flexware.at, a STREP Project funded by the European Commission within the 7 FP. Involved in standardization activities as Member of the International Electrotecnical Commission (IEC), Technical Committee SC65C, as member of Working Group 16, dealing with Wireless Industrial
	communication networks. Working Group 17, dealing with Coexistence in Wireless Industrial communication networks. Working Group 11, Real-Time Industrial Ethernet (RTE). Senior member of the IEEE since June 2009. Recipient of the IEEE Industrial Electronics Society 2008 Early Career Award.



Team Leader	
	Dr. Pau Martí Technical University of Catalonia, Barcelona, Spain URL: <u>http://www.upcnet.es/~pmc16/</u>
Technical role(s) within ArtistDesign	Real-time systems and control systems co-design
Research interests	Real-time and control systems, overload handling, jitter analsyis and compensation, control theory.
Role in leading conferences/journals/etc in the area	Program committee member of major real-time and control conferences. Reviewer for the Real-Time Systems Journal.

Team Leader	
Contraction of the second seco	Prof. Ivo De Lotto Robotic Lab, University of Pavia, Italy <u>http://www.unipv.it/ingegneria/servizi/scheda.php?mat=000300</u>
Technical role(s) within ArtistDesign	Provide support for the development of real-time control applications in the domain of robotics and automation.
Research interests	Sensory systems, robotics applications, wireless communication, energy-aware computing.
Role in leading conferences/journals/etc in the area	Program committee member of major conferences on robotics. Reviewer of International journals on robotics. Member of the evaluation committee for national projects.
Awards / Decorations	Gold Medal of Italian Ministry of Education (1988)

Team Leader	
	Prof. Marisol García-Valls
	URL: <u>http://www.it.uc3m.es/mvalls</u>
Technical role(s) within ArtistDesign	UC3M leader on Adaptive resource management for CE"



Research interests	Distributed embedded systems, design and modelling of real-time systems, real-time programming languages, quality of service
Role in leading conferences/journals/etc in the area	Member of the Programme Committee of conferences such as ARCS 06, EstiMedia 04-06, JTRES 03-04, EUC 05, EMSOFT 03-04 Reviewer of the Real-Time Systems Journal
Notable past projects	ARTIST: Advanced Real-Time Systems. URL: <u>http://www.artist-embedded.org</u> MUSE: MUIti Service Access Everywhere

Team Leader	
	Prof. Julian Proenza University of the Balearic Islands URL: <u>http://dmi.uib.es/research/SRV/jpa_ppl_en.htm</u>
Technical role(s) within ArtistDesign	Team leader of affiliated partner. Indirect participation in the Cluster, with the core team University of Porto.
Research interests	Dependable and Real-Time Systems, in particular, on fault-tolerant distributed systems, clock synchronization and field-bus networks, like CAN (Controller Area Network).
Role in leading conferences/journals/etc	Chair of several workshops in his fields of interest. Participation in several Organizing and Program Committees of related events.

Team Leader	
	Prof. Paulo Pedreiras University of Aveiro URL: <u>http://www.ieeta.pt/~pedreiras</u>
Technical role(s) within ArtistDesign	Team leader of affiliated partner. Indirect participation in the Cluster, with the core team University of Porto
Research interests	Distributed Real-Time Systems, in particular, real-time communication protocols and operating systems, low level QoS management.
Role in leading conferences/journals/etc in the area	Participation in several Organizing and Program Committees of related events for several years.



5.4 Affiliated International Partners

	Professor Lui Sha, University of Illinois at Urbana-Champaign http://www.cs.uiuc.edu/directory/directory.php?name=sha
Technical role(s) within ArtistDesign	Technical expert.
Research interests	Distributed real-time computing systems, dynamic real-time architecture, QoS driven resource management and security and fault tolerance in networked embedded systems.

	Professor Tarek Abdelzaher, University of Illinois at Urbana- Champaign http://www.cs.uiuc.edu/homes/zaher/
Technical role(s) within ArtistDesign	Technical expert
Research interests	Operating systems, networking, sensor networks, distributed systems, and embedded real-time systems.

	Professor Marco Caccamo, University of Illinois at Urbana- Champaign http://pertsserver.cs.uiuc.edu/~mcaccamo/
Technical role(s) within ArtistDesign	Technical expert
Research interests	Real-time systems, real-time scheduling and resource management, wireless real-time networks, and quality of service control in next generation digital infrastructures.



	Professor Sanjoy Baruah, University of North Carolina at Chapel Hill http://www.cs.unc.edu/~baruah/
Technical role(s) within ArtistDesign	Technical expert.
Research interests	Schedulability analysis and multiprocessor systems.

6. Internal Reviewers for this Deliverable

- **Sanjoy Baruah** (University of North Carolina at Chapel Hill)
- Marco Caccamo (University of Illinois at Urbana Champaign)