



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

Transversal Activity Progress Report for Year 3

Transversal Activity:  
**Design for Adaptivity**

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*Policy Objective (abstract)*

An embedded hardware-software system is adaptive, if it can modify its behavior and/or architecture to changing conditions and requirements. Adaptivity is increasingly important as the complexity and autonomy of embedded systems increases. Adaptivity is a cross-cutting system characteristic that affects hardware and software as well as modeling, architecture, and run-time support. This deliverable summarizes the achievements of the activity during Y3 of ArtistDesign.

## Versions

| number | comment                                  | date                          |
|--------|--|-------------------------------|
| 1.0    | First version delivered to the reviewers | February 4 <sup>th</sup> 2010 |

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# 1. Overview

## 1.1 *High-Level Objectives*

An embedded hardware-software system is adaptive, if it can modify its behavior and/or architecture to changing requirements. Adaptivity is increasingly important as the complexity and autonomy of embedded systems increases. Adaptivity is required both off-line at design-time and on-line at run-time. Off-line adaptivity is required to handle changing system specifications and to support platform-based or product-family based development. On-line adaptivity is required to be able to dynamically respond to changing conditions and contexts and through this improve performance and resource utilization. The changes can involve different types of resource requirements, changing system objectives, and changing external conditions.

Adaptivity is a cross-cutting system characteristic that affects both hardware and software. At the software-level adaptivity is mainly concerned with flexible and adaptive resource scheduling, e.g., CPU time scheduling. At the hardware-level adaptivity includes both adaptation of operation modes, e.g., supply voltage and clock frequency, processor instruction sets, and dynamic management of hardware resources, e.g., processing elements and memory.

The cross-cutting nature of adaptivity implies that it affects all aspects of embedded system design. The high-level objective of this thematic activity is therefore to integrate the efforts and combine the competences related to adaptivity in embedded systems within the four thematic clusters. The main way of achieving this is to create suitable interfaces, meeting points, and research contacts between the partners. Another important objective for this activity is to define the ontology for adaptivity in embedded systems, i.e., the relationship between adaptivity, reconfigurability, flexibility, sustainability, and robustness, and the relationship between adaptivity and predictability.

Although partners from all the four thematic clusters are part of this activity, it is partners from the Operating Systems and Network cluster that dominate. Hence, the majority of the partners are working on issues related to adaptive resource management, including CPU scheduling and QoS management; adaptive networking, and operating and middleware support for adaptivity. The use of feedback and control-theoretical approaches in order to achieve adaptivity is also studied by several partners. However, the activity also contains partners with interests in modeling of adaptive processes and applications, hardware (run-time) reconfigurability, and timing analysis support for adaptability.

The joint research within the cluster can be divided into three areas:

- **Adaptive resource scheduling**

This area concerns adaptive scheduling in which schedules and task parameters are dynamically modified in order to prevent overload conditions and minimize some application-related cost function, e.g., control performance or energy consumption. The area includes mechanisms for achieving adaptivity both on a task level and on a system level, adaptive resource reservations, QoS management, and control-based mechanisms for achieving adaptivity. The area applies to a wide range of resource types, although the majority of the work will be focused on CPU and communication bandwidth

- **Hardware-based adaptivity**

This area concerns dynamic management of hardware resources (processing

elements, memory, communication interconnect) to meet dynamic resource requests from the software and to cater for different application domains both at design time and run time. It contains mechanisms for adaptation of hardware modes of operation.

Hardware-based adaptivity also includes modeling of adaptive processes and applications and hardware generation for such systems.

- **Adaptive networking**

This area includes different mechanisms for supporting adaptivity in communication networks, excluding on-chip networks. It includes dynamic ad hoc routing mechanisms in sensor network applications, adaptivity in network protocols at various levels to cater for dynamically changing application demands, and application-aware networking.

**-- Changes wrt Y2 deliverable --**

*No changes with respect to Year 2.*

## **1.2 Industrial Sectors**

The use of adaptive resource management is of particular interest for soft real-time applications, e.g., multimedia applications within consumer electronics systems and in telecommunications. Consumer electronics products range from miniature cameras and MP3 players to advanced media servers and large displays. Mainly driven by Moore's law, the evolution in the CE industry is very fast. Utilizing available hardware and software resources in an optimal fashion is crucial both to save costs and to keep the competitive edge. Moreover, multimedia systems exhibit a highly dynamic behavior, since task execution times are often dependent on input data that are difficult to predict. As a consequence, these systems are prone to intermittent overload conditions that could degrade the performance in an unpredictable fashion.

The introduction of multicore platforms also in embedded applications creates new design challenges. A particular problem compared to uniprocessor platforms is the WCET analysis. Due to the shared memory access WCET analysis runs the risk of being very conservative. This will most likely hamper the application of hard real-time techniques based on static analysis. Hence, the market for more dynamic or adaptive resource management based on feedback from the true resource utilization and/or the application quality-of-service can be expected to increase in the future.

Another challenge, not only for embedded systems, but for all computing systems is the increased variability in circuit delays and power consumption caused by quantum effects in sub-45 nm chips. This causes classical device estimation models to fail and creates a need for variability-aware designs in which monitors and "variability knobs" can be used to dynamically adjust operating points.

Also in industrial sectors where predictability is the main concern there is always a certain need for adaptivity. For example, companies like Boeing have expressed a need for active resource management and dynamic scheduling as well as to handle, during system execution, things that were not anticipated at design-time. The automotive industry also has expressed increasing needs to handle software upgrades in a robust way and flexible attachment of devices (e.g. PDA's, especially in the infotainment domain). In addition to resource management, this requires more stringent configuration management (be it on-line or support by off-line tools) that ensure that new configurations are compatible (both in a functional and non-functional sense).

A current trend is to use the word **autonomy** rather than **adaptivity** to describe these types of systems. Although the basic meaning is the same the word autonomous typically reflects an even higher degree of automation than what the word adaptivity does. For example, an embedded system that at run-time is able to switch between a limited number of pre-defined, and possibly pre-verified, configurations would typically be considered as adaptive but hardly as autonomous.

-- Changes wrt Y2 deliverable --

*Minor changes with respect to Year 2.*

### 1.3 Main Research Trends

Real-time systems constitute a notable share of today's embedded computers that needs special attention. The design of robust and fault-tolerant real-time systems is a highly active research area that has produced numerous approaches for evaluating and increasing system robustness against selected fault scenarios. These methodologies can be applied throughout the design process of an embedded system and yield systems that are highly robust against a selected set of disturbances in the field. Future embedded systems, however, will undergo an evolution in both hard- and software configuration during their lifetime. In the automotive industry, it is already common to update or add software components during the lifetime of a product, producing a variety of software configurations in the field. To ensure functional and temporal correctness of all possible configurations, OEMs have to maintain a complex versioning database and perform exhaustive testing to cover the whole configuration landscape. This already constitutes a problem today, which will grow into a major challenge in the future.

Designing embedded systems to be robust and fault-tolerant will not ultimately solve this problem, as the evolution an embedded system goes through during its lifetime cannot be foreseen at design time. Hence, embedded systems need to be adaptive to changing conditions, in the sense that they need to be able to meet given requirements including safety, security, and performance, in the presence of uncertainty in its external environment or internal execution platform. Adaptivity can be seen as a means for enforcing predictability in the presence of uncertainty.

The uncertainty can be viewed as the difference between the average and the worst-case behavior of a system and its environment. The trend in embedded system is towards drastically increasing uncertainty due to, e.g., execution platforms with increasingly sophisticated HW/SW architectures (layering, caches, multiple cores, speculative execution etc), increased connectivity with complex and non-deterministic external environments, increased amount of difficult-to analyze software, and increased variability with respect to use cases.

One technique for achieving adaptivity in particular in software-based systems is feedback. In many embedded systems worst-case designs are unfeasible for several reasons. One of these is the over-provisioning of resources that this typically implies. Other reasons are uncertainties associated with worst-case resource utilization estimates and on-line changes in objectives, external conditions and use cases. In a feedback-based resource management system, the allocation of resources is based on a comparison of the actual resource utilization by, e.g., a set of activities or tasks, with the desired resource utilization. The difference is then used for deciding how the resources should be allocated to the different activities. The decision mechanism constitutes the feedback controller in the scheduling scheme. Feedback control makes it possible to deal with uncertainties and variations in a controlled way.

Feedback scheduling is primarily suited for soft real-time applications and adaptive real-time applications, where missing one or more deadlines does not jeopardize correct system behavior, but only causes performance degradation. For this type of systems, the goal is typically to meet some Quality of Service requirement. The adaptive class of real-time systems is a suitable description for a many practical applications. This includes different types of multimedia applications, but also many control and signal processing applications. An important research trend here is how to best model embedded computing system from a control perspective. Different model formalisms can be considered, from pure discrete event based models to fluid continuous-time approximative models.

The research trends related to adaptivity in embedded systems are numerous since adaptivity is crosscutting. In hardware-based oriented embedded systems there are work performed on modeling and hardware generation for adaptive processes and applications. Emerging architectures such as partially reconfigurable, either fine-grained or coarse-grained, FPGAs provide a huge potential for adaptivity in the area of embedded systems. Since many system functions are only executed at particular points of time they can share an adaptive component with other system functions, which can significantly reduce the design costs. However, adaptivity adds another dimension of complexity into system design since the system behavior changes during the course of adaptation. This imposes additional requirements on the design process, in particular system verification.

In the software-oriented part of embedded systems there is also a considerable work on computational models that allow for adaptivity, how adaptivity can be provided in component-based architectures, adaptive task models for scheduling, program language constructs supporting adaptivity, and run-time support for adaptive resource management from operating systems, middleware, and communication networks. The resources in the latter case typically include clock cycles, memory, communication bandwidth, and energy, but could in general also include other resources which are allocated dynamically.

**-- Changes wrt Y2 deliverable --**

*No changes with respect to Year 2.*



## 2. State of the Integration in Europe

### 2.1 *Brief State of the Art*

Since adaptivity affects all layers of system development and all the thematic areas in ArtistDesign it is quite difficult to provide a brief technical state of the art description. Here, we have focused on the industrial state of the art. For a description of the state of the art in research we refer to the respective thematic cluster reports.

Adaptive resource management is primarily of interest in consumer electronics, industrial automation, and telecommunications. Mobile cellular terminals today are getting more and more advanced and their source code consists of 5-15 million lines of, typically C, code involving a large number of parallel activities. For these applications, the use of adaptive resource management would allow to safely mix real-time and non real-time processes. The majority of the activities are related to multimedia streaming, where multiple video and audio streams are common. It is not uncommon to have a desired system utilization that is well beyond 100 %. Designing the system for the worst-case scenario is not economically justified. Hence, adaptivity is needed in order to be able to dynamically tradeoff the quality of the activities.

In telecommunication companies, the main current interest seems to be in exploring the use of the Linux OS and its real-time extensions. QoS mechanisms, virtualization and reservation-based scheduling, multi- and many-core platforms, and data-flow based programming models are also attracting substantial interest.

In the area of Industrial Automation, the continuous increment in processing power and memory capacity in local processors gives the opportunity to add new tasks into them, increasing system complexity in terms of supervision, diagnostics, presentation, communication, etc. Adaptive task scheduling that preserves the real-time constraints is a possible way to handle such situations and manage the complexity of the application.

Reconfigurable hardware systems are a technique that for a long time has not been able to compete either with software-based systems or with ASIC-based solutions. However, there are signs that that is about to change, especially for applications where the gains in performance over software-based system and the faster development cycle compared to ASICs are important.

The multi/many-core trend also narrows the gap between software and hardware-based implementation techniques. In both cases good models are needed for exploiting parallelism, both in the programming models and languages used and in the compilers and analysis tools. Ideally, it should be possible to execute the same application either on a FPGA with a high-level of parallelism or on a, e.g., quad-core, platform without having to change anything in the source.

**-- Changes wrt Y2 deliverable --**

*No changes with respect to Year 2.*



## 2.2 Main Aims for Integration and Building Excellence through ArtistDesign

Adaptivity is a concern which cuts vertically across all levels of abstraction in embedded systems design, spanning from high-level requirements to implementation details on specific platforms. It therefore needs to be carried out in a synergistic manner, and is therefore the subject of a transversal activity involving all clusters of the NoE. In Artist2 adaptivity-related issues were spread out among different activities in different clusters. The main purpose of this activity is to integrate research teams working on different aspects of adaptivity in embedded systems design.

### -- Changes wrt Y2 deliverable --

*No changes with respect to Year 2.*

## 2.3 Other Research Teams

The main teams in Europe on software-related adaptivity in embedded systems are part of ArtistDesign and this activity. In the more hardware-related area some of the leading teams in Europe belong to ArtistDesign but not all. The ones that are outside ArtistDesign mostly are part of the HiPEAC NoE ([http://www.hipeac.net/members\\_new](http://www.hipeac.net/members_new)) which has separate clusters on reconfigurable computing, adaptive compilation and multi-core architectures. However several of the ArtistDesign partners also belong to HiPEAC, e.g., IMEC, CEA, Aachen, TU Braunschweig, UDortmund, and UBologna. Hardware-based adaptivity is also the focus of the ANDRES project (<http://andres.offis.de/>) in which OFFIS, TU Vienna, KTH, UCantabria and Thales participate. The same situation holds for the sensor network field. Several very strong European groups are not part of ArtistDesign, e.g., TU Berlin and SICS. The sensor network and cooperating object NoE in FP7 that runs in parallel with ArtistDesign is CONET (<http://www.cooperating-objects.eu/>). Organic computing systems which adapts dynamically to the current conditions of its environment through self-organization, self-configuration, self-optimization etc is the topic of the priority program 1183 funded by the German Science Foundation (DFG) ([www.organic-computing.de/spp](http://www.organic-computing.de/spp)). Here several German teams participate.

Within US there is large amount of research on different aspects of adaptivity in embedded systems and on the use of control in embedded systems. Most of the software-based parts of this currently go under the label cyber-physical systems, an area where NSF recently has started a new program. Strong research groups in the US include UIUC (Abdelzaher, Sha), Virginia (Son, Stankovic), CMU (Rajkumar), UNC (Baruah, Anderson). There are also interest in related topics from several control groups in the US, e.g., Berkeley (Sasthy), UIUC (Dullerud, Basar), Caltech (Murray, Doyle), CMU (Krogh) just to name a few.

### -- Changes wrt Y2 deliverable --

*No changes with respect to Year 2.*

## **2.4 Interaction and Building Excellence between Partners**

The interaction and work within this activity consist of individual and joint research projects (see Chapter 3), jointly organized meetings and workshops (see Chapter 3 and 5), and jointly organized educational events (Chapter 3)

### **-- Changes wrt Y2 deliverable --**

*The same as Y2, except for the Wiki work that has been discontinued. The actual interactions and excellence building are described in Sections 3 and 5.*

## **2.5 Interaction of the Transversal Activity with Other Communities**

The partners of the activity interact with a several other research communities. These include the high-performance computing community, the sensor network community, and the control community at large and in particular the networked control community. The partners also interact with different industry branches, e.g., the automotive industry, e.g., through the network created by the DySCAS project, the microelectronics industry (through interactions with STMicroelectronics and NXP), the telecom industry (through Ericsson). The partners also have strong links to several US groups, e.g. UIUC, UNC and UVA, with Tarek Abdelzaher, Lui Sha and Sanjoy Baruah as affiliated international partners to ArtistDesign.

The partners also interact with the partners of the European projects that they participate in which do not belong to ArtistDesign. These projects include ACTORS, HiPEAC, PREDATOR, COMBEST, MOSART, ANDRES, REALITY, CHAT, FlexWARE, GUARANTEE, RT-Model, CHESS, and MOSART.

### **-- Changes wrt Y2 deliverable --**

*No changes with respect to Year 2*

### 3. Summary of Activity Progress

The following summarizes the technical activities that are part of this activity. Certain parts have been omitted due to the fact that they already are reported in the deliverables from the thematic clusters. It has been our attempt to reduce any overlap to the minimum. However, since all deliverables are generated in parallel it is still possible that there is a certain overlap.

It should be emphasized that in the majority of the cases the actual research work described below has only marginally been funded by ArtistDesign. In most cases the funding comes from other national or European projects. The role of ArtistDesign is to provide the networking “glue” between these activities.

#### 3.1 Technical Achievements

Here the technical achievements of the partners, both jointly and individually, during Year 3 are summarized. Although the distinction is often difficult an attempt has been made to structure the achievements in three groups: adaptive resource scheduling, adaptive networking, and hardware adaptation. In the first and largest group we also include work on modelling and analysis relevant to adaptation.

##### 3.1.1 Adaptive Resource Scheduling

##### **Adaptive and feedback-based resource management (SSSA, ULUND, TUKL, Evidence, Ericsson)**

Several of the partners from the OS and Networks cluster work together in the STREP project ACTORS coordinated by Ericsson. ACTORS addresses design of resource-constrained software-intensive embedded systems with high requirements on adaptivity and efficiency. Three techniques are combined: virtualization, feedback control, and data-flow programming models. In ACTORS applications are expressed in the CAL actor based data-flow language. Different design space exploration tools are applied to the data flow models for profiling, tracing, partitioning, and model transformations. A very efficient multi-core run-time system for execution of CAL models has been developed. The target platform in ACTORS is Linux. Support for virtualization is provided by the new Linux scheduling class SCHED\_EDF/SCHED\_DEADLINE that supports hard constant bandwidth servers. This scheduling class is currently on its way into the Linux mainline kernel. The resource management is provided by a C++ based resource manager that dynamically selects application service levels and server parameters, based on sensor measurements of the amount of consumed budget for each server and the obtained QoS from the applications using feedback and feedforward control. The approach is being applied to three demonstrators, a control demonstrator, a wireless media demonstrator, and an image processing demonstrator.

Web site: <http://www.actors-project.eu/>

As a spin-off of ACTORS ULUND and Ericsson are working on porting the ACTORS resource manager to Android using ST-Ericsson's development platform. ULUND has also combined the resource manager with processor thermal management applied to mobile robotics.

##### **Adaptive resource management for uncertain execution platforms (ULUND, Ericsson)**

In parallel with the ACTORS project ULUND and Ericsson are also collaborating on adaptive resource management for uncertain execution platforms. The problem of resource management in a system of a-priori unknown software components executing on nondeterministic hardware is considered. The approach uses on-line parameter estimation to

address uncertainties and combines this with a convex optimization-based control scheme able to handle overload situations. An algorithm to solve the optimization in real-time has been developed. An implementation of the approach has been experimentally compared with a static analysis scheme using worst case a-priori estimates. It is demonstrated that the presented approach outperforms the static scheme in situations with uncertainty and that the advantage increases as uncertainty grows.

Another problem that has been investigated is the problem of modeling and controlling resources in a system with interaction between hardware and software components. A model encompassing both hardware and software dynamics has been developed together with an on-line estimation scheme in order to reduce dependence on a-priori information. A control structure has been presented in order to control performance under constrained resource situations and to reduce effects of estimation errors and disturbances. The approach has been applied to a conversational video case and evaluated through simulations.

### **Feedback control of computing systems (ULUND)**

The work performed by ULUND on feedback control of web servers reported in Y2 continues. This year the work has led to one publication and a new Swedish VR project on the topic has been approved.

### **Theory of distributed performance analysis (TU Braunschweig)**

TU Braunschweig has continued to investigate the possibility of bounding the execution time of system-level analysis. This research yielded a novel polynomial-time WCRT approximation for static priority preemptive systems. The bound for global system analysis has been formulated, but not yet published.

As a second aspect, timing implications of mode-changes in presence of communicating tasks in real-time systems were investigated. Here, a lack of suitable analysis algorithms has been identified.

### **In-system sensitivity analysis for real-time systems (TU Braunschweig)**

During the last year, a distributed approach for the analysis of sensitivity against jitter variations has been developed. The algorithm allows for a completely distributed implementation on top of the distributed analysis engine developed in the scope of the EPOC program. In order to evaluate the performance of such distributed algorithms a software tool for simulation and pseudo-random generation of system models has been developed.

### **Change impact analysis (UYork)**

In the work of UYork change impact analysis has been performed on a real embedded system to gauge the impact of changes on a system. Statistical techniques are used to build a model of a systems behaviour and then commonly expected changes injected. The aim is to predict whether the changes will lead to the system failing to meet its timing requirements. A key driver in the work is to achieve the prediction with a given statistical confidence.

### **Parametric WCET analysis (MDH)**

The work on parametric WCET analysis, initiated with USaar, has continued in 2010 with implementation work. The improved method that was developed last year (see Y2 deliverable)

is now being implemented in the WCET analysis prototype tool SWEET. A working version is expected early 2011. For details, see the Timing Analysis activity report.

### **Runtime management of cache-related preemption delay (IPPorto)**

The increase processing power of modern embedded systems tends to lead to a combination of system parts with different criticality in a single system. Furthermore another trend is to modify the system post deployment. This may be motivated, for example, by system upgrades or system extensions. A common way to protect critical applications from those with lesser criticality, which may have unknown properties, is to employ temporal isolation methods like the ARINC-351 based systems. However, while the scheduling impact of that separation is well researched, the indirect impact of the execution of other applications in terms of lost cache content has not received such attention. CISTER researchers from IPPorto have investigated how such cache-related preemption delays in such an environment can be considered ensuring real-time guarantees as well as fairness of the distribution of the cost of the preemption.

Weblink:

<http://www.cister.isep.ipp.pt/docs/runtime+crpd+management+for+rate%2Dbased+scheduling/546/download/>

### **Fault tolerance in adaptive cooperative systems (IPPorto)**

IPPorto has continued the development of the CooperatES framework, focusing on fault tolerance issues. It is imperative to accept that failures can and will occur, even in meticulously designed systems, and design proper measures to counter those failures. The conducted work was motivated by the need to develop a flexible and cost-effective fault tolerance solution with a significant lower overhead compared to a strict active redundancy-based approach. The term cost-effective implies that they want to achieve a high error coverage with the minimum amount of redundancy. Due to its low resource consumption, passive replication is appealing for embedded real-time systems that cannot afford the cost of maintaining active replicas and need not assure hard real-time performance. The work proposes low runtime complexity heuristics to (i) dynamically determine which components to replicate based on their significance to the system as a whole; (ii) determine a number of replicas proportional to the components' significance degree; and (iii) select the location of those replicas based on collected information about the nodes availability as the system progresses.

Weblink:

<http://www.cister.isep.ipp.pt/docs/flexible+and+dynamic+replication+control+for+interdependen+t+distributed+real-time+embedded+systems/577/download/>

### **Dynamic behavior of embedded systems (IMEC, NTUA)**

In this context Imec has developed run-time task assignment strategies that optimally exploit the available resources and achieve an increase in the system throughput. The approach was demonstrated on a Barco video processing platform with heterogeneous processors: NVidiaQuadro FX3700 and dual Intel quadcore Xeon processors. The tasks considered were AVC (H.264) encoding tasks where the motion estimation component was either CUDA-accelerated (on GPU) or not (CPU).

The next step to load balancing at device level is load balancing at the network level, where processing resources are shared among devices in the network. Experimental work at IMEC has shown how migrating video processing tasks from the lighter end-device to more powerful servers can be performed seamlessly. This load balancing succeeds in adapting to changes in

workload requirements and resource availability while maintaining the desired quality of service.

### **Adaptive control of MPEG-4 decoding (TUKL, ULUND)**

Decoding MPEG-4 streams in resource constrained system faces the challenges of matching varying resource demand (due to MPEG-4 encoding) to varying resource availability (due to varying network bandwidth or CPU availability). Adaptation has to meet the demand of high resource utilization and avoiding issues such as oscillation between over and under utilization of resources, which can bring the system to a state with low resource utilization.

During Year 3 a controller has been extended with additional stream adaptation methods based on subframe level elements for a wide range of granularities. The previous work on MPEG-2 has been started to be extended to MPEG-4.

### **Improving real-time BIP (Verimag).**

During year 2 of COMBEST, a model-based implementation method for real-time applications in BIP has been developed. This method relies on two models of the application. The abstract model is based on timed automata. It takes into account platform-independent timing constraints expressing user requirements. The actions of the abstract model are assumed to be timeless. It has also been introduced the notion of physical model, which describes the behavior of the abstract model when it is executed on a target platform. It is obtained from the abstract model by assigning execution times to its actions. Under some time-robustness assumption for WCET, the Real-Time Engine implementing this method respects the semantics of the abstract model. This method has been improved in two directions.

The real-time scheduling policy used by the Real-Time Engine has been improved. This policy is based on earliest deadline first (EDF). The Real-Time Engine associates to each enabled interaction a timing constraint (i.e. a time interval and an urgency type: lazy, delayable or eager) computed from the timing constraints associated to the corresponding transitions of the atomic components. Interactions are chosen according to the deadlines computed from their timing constraint. The problem with this approach is that deadlines are computed considering only transitions that can be executed at the next step, i.e. using a single step planning horizon mechanism. The scheduling policy improvement is based on using the following principle: if an interaction I1 precedes another interaction I2 and I2 has a deadline D2, then I1 should be also completed before D2. This principle has been applied both at the level of transitions (inside atomic components) and at the level of interactions. A prototype that performs the backward propagation of timing constraints for each the timed automaton (i.e. for each atomic component) has been implemented. Work is also performed on algorithms for timing constraints propagation between those atomic components.

The notion of environment ports in BIP models has been also introduced. They allow a clean description and implementation of the interactions of a BIP model with its execution environment. The execution environment can be for instance the physical environment, the hardware platform, or another software application running on the platform but not written in BIP. An environment port is implicitly associated to events coming from the environment. Transitions of an atomic component labeled by an environment port require the presence of an event to be executed. In the proposed implementation of the Real-Time Engine, the Event Handler is responsible for updating the status of environment ports depending on the presence of events. The update of the events is achieved by Drivers that are the interfaces between the Engine and the environment. Waiting for new events can be implemented in the Drivers using techniques such as active waits, processes signals, or interruptions. Experimental results on a robot application implemented in BIP show that using environment ports drastically increases



the reactivity of the application with respect to its environment. Moreover, the CPU usage has been also reduced due to the fact that active waits in the model have been replaced by simple transitions involving environment ports.

A necessary condition for implementability is time-safety, that is, any (timed) execution sequence of the physical model is also an execution sequence of the abstract model. Time-safety simply means that the platform is fast enough to meet the timing requirements. As execution times of actions are not known exactly, time-safety is checked for worst-case execution times of actions by making an assumption of time-robustness: time-safety is preserved when increasing speed of the execution platform.

Verimag has shown that as a rule, physical models are not time-robust and show that time-determinism is a sufficient condition for time-robustness. For given real-time software and execution platform corresponding to a time-robust model, the Execution Engine coordinates the execution of the application software so as to meet its timing constraints. Furthermore, in case of non-robustness, the Execution Engine can detect violations of time-safety and stop execution. Verimag has also implemented the Execution Engine for BIP programs with real-time constraints. The implementation method has been validated for an adaptive MPEG video encoder. Experimental results reveal the existence of timing anomalies seriously degrading performance for increasing platform execution speed.

### **Adaptation in service-oriented architectures (UPM)**

Service Oriented Architectures (SOA) provides a number of advantages for current applications, such as making it easier applications deployment and service discovery. In this type of applications, it is common the co-existence of applications with and without safety and time requirements. UPM is working towards techniques for adapting the service request handling behaviour to the specific requirements of the services. The approach taken is to use CPU contracts to ensure some computation time for dealing with services with special requirements. This framework runs on top of a modified version of the Linux kernel that provides CPU budgets. During this period of time, this framework has been extended for supporting multi-core hardware. In addition, the basic principles of this approach are being used in the project GUARANTEE for developing a distributed execution platform for home safety.

The problem of quality composability is also of great interest when combining services. It is basic to know the global quality of a set of interconnected components of services. This knowledge can be used as a means for adaptation and for decision making on which services/components to use and how. This composition can be done at design or at execution time.

### **Adaptive servers with guarantees (ETH Zurich, SSSA)**

Many real-time applications are designed to work in different operating modes each characterized by different functionality and resource demands. With each mode change, resource demands of applications change, and static resource reservations may not be feasible anymore. Dynamic environments where applications may be added and removed online also need to adapt their resource reservations. In such scenarios, resource reconfigurations are needed for changing the resource reservations during runtime and achieve better resource allocations. There are a lot of results in the scientific literature of how to find the optimal amount of resources needed by an application in the different operating modes, or how an application can perform safe mode transitions. However, the problem of resource reconfigurations for systems with reservations has not been addressed. A resource



scheduler should be reconfigured online in such a way that it still guarantees a certain amount of resources during the reconfiguration process, otherwise applications may miss deadlines.

The joint work by ETHZ and SSSA proposes a framework for scheduling real-time applications through scheduling servers that provide resource reservations, and algorithms for changing the resource reservations online while still guaranteeing the feasibility of the system and the schedulability of applications. The framework analysis is integrated into a well-known modular performance analysis paradigm based on Real-Time Calculus. The results are illustrated with examples and a case study.

There has been substantial progress in the understanding of adaptive servers and their real-time properties. What still remains to be done is the implementation of these strategies as well as the power-aware adaptivity results on concrete embedded systems in order to evaluate their feasibility.

### **Adaptive power management (ETH Zurich, SSSA)**

Dynamic power management has become essential for battery-driven embedded systems. The joint work by ETHZ and SSSA explores how to efficiently and effectively reduce the energy consumption of a device (system) for serving multiple event streams. Considering two different preemptive scheduling, i.e., earliest deadline first and fixed priority, they propose a new method to adaptively control the power mode of the device according to historical arrivals of events. The method can not only tackle arbitrary event arrivals but also provides hard real-time guarantees with respect to both timing and backlog constraints. Simulation results demonstrate the effectiveness of the approach. The results are described in one joint publication.

### **Sampling mechanisms for event-driven control systems (UPC, ULUND, SSSA)**

In event-driven control approaches, control updates are triggered by event conditions that are often characterized by different types of boundaries defined in the state-space domain. An event-driven control approach has been developed by UPC where boundaries are manifolds characterized as invariant sets. With such a boundary, a control update will only be activated when the system trajectory intersects the boundary. And the system trajectory must intersect again the boundary to activate the next control update. For linear systems, a scaling property for these boundaries that permits to regulate the accuracy of the control without altering the timing and resource demands offered by the scaled boundary has been derived. The work of ULUND on event-based control is documented in the OS and Networks deliverable on resource management.

### **Feedback scheduling vs. event-driven control (UPC)**

A simulated evaluation of approaches aimed at minimizing aggregated control cost of a set of controllers that concurrently execute sharing limited computing resources has been performed by UPC. The evaluation focuses on feedback scheduling and event-driven control methods. The analysis reveals that event-driven self-triggered controllers provide the best control performance while using the same or similar amount of computing resources than those consumed by feedback scheduling approaches. Accordingly, a preliminary study of optimal self-triggered controllers has been also developed.

### **Optimal online sampling period assignment (ULUND, UPC)**

In embedded systems, the computing resources are often scarce and several control tasks may have to share the same computer. In this context, and assuming that a set of feedback

controllers should be implemented on a single-CPU platform, joint work has been performed on studying the problem of optimal sampling period assignment, where the goal is to assign sampling rates to the controllers so that the overall control performance is maximized. Expressions relating the expected cost over a finite horizon to the sampling period, the computational delay, and the amount of noise acting on the plant have been derived. Based on this, a feedback scheduler has been developed that periodically assigns new sampling periods based on estimates of the current plant states and noise intensities. Extensive experiments show that online sampling period assignment can deliver significantly better control performance than the state-of-the-art, static period assignment. The joint publication resulting from this is part of the OS and Networks deliverable on resource management.

### 3.1.2 *Adaptive Networking*

#### **Adaptivity in wireless networks (UPorto, UCatania)**

UPorto is running several activities related to Adaptivity in wireless networks. One topic is development of an adaptive dual-rate beacon management in cluster-tree wireless networks to save energy in target tracking applications by balancing the tracking accuracy with the beacon rate while allowing different rates to coexist in the network (cooperation UnivPorto - Zhejiang University).

Another example is the development of an adaptive method to allow the RT-WMP real-time wireless network protocol to tolerate alien traffic exhibiting graceful degradation. This protocol is based on fixed timeout windows that can be fully taken by alien traffic when present and prevent the protocol traffic from being transmitted in time. The developed method defers the timeout count whenever alien traffic is detected (cooperation UnivPorto - University of Zaragoza).

The work by UCatania focuses on approaches to adapt network resources to dynamically changing working conditions (network errors, workload changes due to moving nodes, etc.) The Y3 achievements include a novel load balancing algorithm that takes into account both the bandwidth utilization and the state of the wireless channel, so as to compensate dynamically for fluctuations in the wireless link characteristics as well as the load of mobile nodes that join and leave the Access Point (AP). The approach that is based on migration of nodes from an overloaded AP to another AP capable of supporting their traffic has been assessed through simulations, and proved to be significantly advantageous comparing with both the standard AP selection mechanism and previously known load balancing algorithms based on the network throughput.

#### **Adaptivity in distributed systems (UPorto, MDH, UAveiro, UPC)**

Here UPorto pursues an implementation and experimental characterization of an adaptive distributed dual-rate switched control system based on CAN. The expected savings in CPU and network bandwidth were confirmed in a particular ball on beam setup (cooperation UPorto - Aveiro - Catalonia). A joint publication is in preparation.

UPorto is also working reconfigurable Ethernet switches. They have implemented a reconfigurable hierarchical scheduling framework within an enhanced Ethernet switch. This framework allows creating partitions that can be adapted online with minimal overhead to cope with variable communication requirements. This work is further developed in the resource management activity (cooperation UnivPorto - Aveiro -Malardalen).

### **Adaptive management in energy harvesting systems (ETH Zurich, UBologna)**

Recently, there has been a substantial interest in the design of systems that receive their energy from regenerative sources such as solar cells. In contrast to approaches that minimize the power consumption subject to performance constraints, ETHZ and TUBologna are concerned with optimizing the performance of an application while respecting the limited and time-varying amount of available power. In the work they address power management of, e.g., wireless sensor nodes which receive their energy from solar cells. Based on a prediction of the future available energy, they adapt parameters of the application in order to maximize the utility in a long-term perspective. They have derived a formal model of the corresponding optimization problem including constraints concerning buffer sizes, timing, and rates. Instead of solving the optimization problem online which may be prohibitively complex in terms of running time and energy consumption, they apply multiparametric programming to precompute the application parameters offline for different environmental conditions and system states. In order to guarantee sustainable operation, they propose a hierarchical software design which comprises a worst-case prediction of the incoming energy. As a further contribution, they suggest a new method for approximate multiparametric linear programming which substantially lowers the computational demand and memory requirement of the embedded software. The approaches are evaluated using long-term measurements of solar energy in an outdoor environment.

### **Adaptive energy management of wireless smart camera networks (UBologna)**

In Y3, UBologna has continued the research on adaptive energy management policies for wireless sensor networks, in particular in the scenario of wireless smart camera networks. Normally a video system needs a huge amount of data and multicore platforms are used to address the computation requirements. Thus minimizing the power consumption is a hard challenge onto these platforms if they are battery operated and they must guarantee also wireless communication. UBologna designed a Resource Manager (RM) for multicore platforms which can adapt the power consumption and the overall performance of the architecture according to the application requirements and the surrounding environment, such as workload, battery level, requests from application in terms of QoS. An embedded Linux RM based capable to change the CPU frequency and a power management framework have been developed and tested on SPEAr600 from STMicroelectronics, a dual ARM9 processor and a customizable equivalent ASIC gates. Sensors which detect movements in the monitoring scenario, i.e. Pyroelectric infrared, helped the application to decide when the system can be switched in a sleep power state and above all when it has to wake up again to run the application. One of most important feature is the power saving tool, which provides a System Control State Machine and Dynamic Frequency Scaling. To assess the Adaptive Resource Manager, an abandoned/removed video surveillance application was used. The results show a reduction of power consumption about to 60%.

### **Adaptive TDMA bus allocation and elastic scheduling (UBologna, SSSA)**

University of Bologna together with Scuola Superiore Sant'Anna (SSSA), designed a system where Elastic Scheduling and the TDMA bus work synergistically to ensure the highest utilization of the processors even in case of dynamic variations of the workload at run-time. When a processor is subject to a workload change, it makes a request to a Master Processor to adapt its share of bus bandwidth acting on the TDMA scheduling. The Master mediates among requests and produces a new allocation of the shared resource. As a consequence of the new bus scheduling, memory latencies change for all the processors, and so do task

execution times as well. Thus, WCET analysis must be recomputed in a fast and light way and task periods may be adjusted, by the adoption of Elastic Scheduling, to reach a desired (typically maximum) utilization of the processors.

UBologna implemented the technique on an MPSoC cycle accurate simulator and performed exhaustive experiments to validate the proposed approach and to test its effectiveness with real case automotive and avionics application tasks. The resulting system is robust to dynamic workload variations, and showed the effectiveness of the approach using a very well known Quality of Control Index.

SSSA enhanced the ERIKA kernel with the implementation of the elastic scheduling algorithm, which allows handling overload conditions on the task set by changing the task periods. The scheduler has been used in conjunction with the TDMA bus arbiter to allocate higher bandwidth to tasks that need to run with higher activation rates

### **Fault Tolerant and Reliable Communication Platforms (KTH)**

KTH is developing a fault tolerant on-chip communication platform covering the link level, network level and end-to-end level. In the course of further technology scaling, the complete avoidance of faults will be more and more expensive. It is expected that both wear-out permanent, intermittent, and transient faults will occur more frequently in future technology generations, and architecture-level techniques have to be deployed to tolerate them. To address these concerns, KTH has developed two fault tolerant routing schemes that offer different trade-offs in the design space of cost-performance-fault tolerance.

A Fault-on-Neighbor (FoN) aware deflection routing algorithm makes routing decisions based on the link status of neighbor switches within 2 hops to avoid faulty links and switches. Simulation results demonstrate that in the presence of faults, the saturated throughput of the FoN switch is 13% higher on average than comparable routing algorithms with up to 70% lower latency with 25% of the power and 50% of the area overhead. While the FoN algorithm is very cost efficient and can tolerate a large class of faults, it cannot tolerate all types of concave fault regions. In contrast, the developed reconfigurable fault-tolerant routing algorithm (FTDR) based on reinforcement learning can tolerate any type of fault region but is more expensive. The algorithm reconfigures the routing table through reinforcement learning - Q-learning using 2-hop fault information. It is topology-agnostic and insensitive to the shape of the fault region. In order to reduce the routing table size, a hierarchical Q-learning based deflection routing algorithm (FTDR-H) has been developed leading to an area reduction up to 27% for a switch in an 8x8 mesh.

#### **3.1.3 Hardware-Based Adaptivity**

##### **eDNA: Reconfigurable self-organising and self-healing hardware platform (DTU)**

The eDNA architecture has been further developed and a prototype has been constructed and tested. The prototype has been the key platform in setting up a test suit at NASA's JPL in Pasadena (CA). The eDNA architecture consists of a distributed array of multiple homogenous processing units called *electronic cells* (eCells). The job of the eCells is to implement the eDNA program, which is specified by the programmer. The eDNA program is translated into a binary version of the program, which is then fed to all eCells which all store it in a RAM block. Each eCell implements a part of the eDNA program. The specific part, that an eCell implements, is called the *gene* of this particular eCell. Each eCell contains a microprocessor and a 32 bit ALU that is configured by the microprocessor to perform a certain function described by the gene. The program run by the microprocessor is termed the *ribosomal DNA* (referring to the intracellular organelle in biological cells, responsible for synthesizing proteins and consequently functionality of the cells). The ribosomal DNA is a program written for the eCell microprocessor, which performs *self-organizing* and *self-healing* of the eDNA architecture. All

eCells contain a copy of this program. I.e., there is no centralized processing unit. Hence, the eCells complete the self-organizing and self-healing completely autonomous. The eCells communicate with each other through a Network-on-Chip (NoC) 2D-mesh-8 architecture, where each eCell communicates with at most 8 adjacent neighbours depending on position. The position of an eCell in the NoC is represented by an (X,Y)-coordinate set. The NoC completes package transfers between eCells using a fault-tolerant data-transfer protocol, which can route around dead links.

The patent application on the eDNA architecture was published on June 3<sup>rd</sup> 2010 by the World Intellectual Property Organization as per the usual PCT application process.

Finally, an article about the eDNA platform published on the front page of DTU Avisen under the title, "*DTU opfinder den selvreparerende computer*" started an avalanche of press coverage including live interviews in Danish radio and television. The eDNA research was nominated for "the research project of the year" by the Danish research dissemination consortium, Videnskab.dk.

### **Adaptive allocation of applications on MPSoC platforms (ETH Zurich, SSSA)**

Multi-Processor Systems-on-Chip (MPSoC) are an increasingly important design paradigm not only for mobile embedded systems but also for industrial applications such as automotive and avionic systems. Such systems typically execute multiple concurrent applications, with different execution modes. Modes define differences in functionality and computational resource demands and are assigned with an execution probability. ETHZ and SSSA propose a dynamic mapping approach to maintain low power consumption over the system lifetime. Mapping templates for different application modes and execution probabilities are computed offline and stored on the system. At runtime a manager monitors the system and chooses an appropriate pre-computed template. Experiments show that the approach outperforms global static mapping approaches up to 45%. The results are described in a joint publication.

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

## **3.2 Individual Publications Resulting from these Achievements**

In certain cases publications that also are relevant for this activity has instead been presented in the corresponding cluster deliverable without being listed here.

### **ULUND**

Mikael Lindberg, "A convex optimization-based approach to control of uncertain execution platforms", In *Proceedings of 49th IEEE Conference on Decision and Control (CDC 2010)*, December 2010

Mikael Lindberg, Karl-Erik Årzén, "Feedback control of cyber-physical systems with multi resource dependencies and model uncertainties", In *Proceedings of the 31st IEEE Real-Time Systems Symposium (RTSS 2010)*, December 2010.

Mikael Lindberg, "Convex programming-based resource management for uncertain execution platforms", In *Proceedings of the Workshop on Adaptive Resource Management (WARM 2010)*, Stockholm, April 2010

Mikael Lindberg, "Adaptive Resource Management for Uncertain Execution Platforms", Licentiate thesis, Lund University, September 2010.

Martin Ansbjerg Kjær, Anders Robertsson, "Analysis of Buffer Delay in Web-Server Control", In *Proc. American Control Conference*, Baltimore, Maryland, USA, June 2010.



Vanessa Romero Segovia, Karl-Erik Årzén, "Towards Adaptive Resource Management of Dataflow Applications on Multi-Core Platforms", In *Proc. of the Work-in-progress session at Euromicro Conference on Real-Time Systems (ECRTS)*, Brussels, Belgium, July 2010.

### **TU Braunschweig**

Steffen Stein, Moritz Neukirchner, Harald Schrom, und Rolf Ernst, "Consistency Challenges in Self-Organizing Distributed Hard Real-Time Systems," in Workshop on Self-Organizing Real-Time Systems - SORT 2010, 2010

Steffen Stein, Matthias Ivers, Jonas Diemer, und Rolf Ernst, "A polynomial time algorithm for computing response time bounds in static priority scheduling with convex event models," in Euromicro Conference on Real-Time Systems (ECRTS'10), July 2010

Moritz Neukirchner, Steffen Stein, Harald Schrom and Rolf Ernst. "A software Update Service with Self-Protection Capabilities". In Proceedings of the conference on Design, Automation and Test in Europe (DATE), Dresden, Germany, March 2010 Anbei finden Sie sch

### **UPC**

M. Velasco, P. Martí. "Invariant Manifolds as Boundaries for Event-Driven Control Systems". In Work-in-progress session of the 13th International Conference on Hybrid Systems: Computation and Control (HSCC2010), Stockholm, Sweden, April 2010.

C. Lozoya, P. Martí, M. Velasco. "Minimizing Control Cost in Resource-Constrained Control Systems: from Feedback Scheduling to Event-driven Control". In 18th Mediterranean Conference on Control and Automation (MED2010), Marrakech, Morocco, June 2010.

### **UYork**

Yue Lu, Johan Kraft, Thomas Nolte, and Iain Bate, "A Statistical Approach to Simulation Model Validation in Response-Time Analysis of Complex Real-Time Embedded Systems", The 26th ACM Symposium on Applied Computing (SAC2011), To Appear, 2011

### **KTH**

DeJiu Chen, Martin Törngren, Magnus Persson, Lei Feng and Tahir Naseer Qureshi. "Towards Model-Based Engineering of Self-Configuring Embedded Systems". Model-Based Engineering of Embedded Real-Time Systems. Holger Giese, Bernard Rumpe, Bernard Schätz (eds). Series: Lecture Notes in Computer Science. Vol. 6100. Springer Verlag, 2010. ISBN: 978-3-642-16276-3.

Chaochao Feng, Zhonghai Lu, Axel Jantsch, Jinwen Li, and Minxuan Zhang, "FoN: Fault-on-Neighbor aware Routing Algorithm for Networks-on-Chip", International SOC Conference, Las Vegas, Nevada, September 2010.

Chaochao Feng, Zhonghai Lu, Axel Jantsch, Jinwen Li, and Minxuan Zhang, "A Reconfigurable Fault-tolerant Deflection Routing Algorithm Based on Reinforcement Learning for Networks-on-Chip", Proceedings of the International Workshop on Network on Chip Architectures (NoCArc), Atlanta, Gorgia, November 2010.

### **IPPorto**

L. Nogueira, L. M. Pinho, J. Coelho, "Flexible and Dynamic Replication Control for Interdependent Distributed Real-Time Embedded Systems," in Distributed, Parallel and Biologically Inspired Systems. IFIP Advances in Information and Communication Technology, pp. 66-77

J. Marinho, S. Petters, "Runtime CRPD Management for Rate-Based Scheduling", Proceedings of the Workshop on Adaptive Resource Management (WARM 2010) during CPSWEEK 2010, 12.04.2010, Stockholm, Sweden

## IMEC

Song, H.; Miao, C.; Wuyts, R.; Shen, Z. and Catthoor, F. "Implementation of fuzzy cognitive maps based on fuzzy neural network and application in prediction of time series". In *IEEE Transactions on Fuzzy Systems*, Vol 18, nr. 2, pp 233-250.

Palkovic, M.; Hartmann, M.; Allam, O.; Raghavan, P. and Catthoor, F. "Time-space energy consumption modeling of dynamic reconfigurable coarse-grain array processor datapath for wireless applications." In *IEEE Workshop on Signal Processing Systems (SiPS)*, Cupertino, CA, 2010

## TUKL

Anand Kotra, Gerhard Fohler, "Demo : Resource aware real-time stream adaptation for MPEG-2 transport streams in constrained bandwidth networks", Proceedings of IEEE International Conference on Multimedia & Expo (ICME), Singapore, July 2010.

Rodrigo Ferreira Coelho, Anand Kotra, Gerhard Fohler, "A Control Theory Approach to Video Stream Adaptation for Restricted Bandwidth Networks", Proceedings of 1st Workshop on Adaptive Resource Management (WARM10), Stockholm, Sweden, April 2010.

## VERIMAG

T. Abdellatif, J. Combaz and J. Sifakis. "Model-Based Implementation of Real-Time Applications". In Proceedings of the 10th ACM International Conference on Embedded Software (EMSOFT 2010) Scottsdale, Arizona, USA.

## DTU

Boesen, Michael R., Madsen, Jan and Keymeulen, Didier. "Integration of the Self-Healing eDNA Architecture in an Embedded System and Evaluation of it Using a Fourier Transform Spectrometer Instrument Application". Presentation at the ReSpace/MAPLD 2010 conference.

Boesen, Michael R., Madsen, Jan and Keymeulen, Didier. "Autonomous Distributed Self-Organizing and Self-Healing Hardware Architecture – the eDNA concept". Accepted at the IEEE Aerospace Conference 2011 to be held in Big Sky, MT in March 2011.

Boesen, Michael R., Keymeulen, Didier., Madsen, Jan., Lu, Thomas and Chao, Tien-Hsin. "Integration of the Reconfigurable Self-Healing eDNA Architecture in an Embedded System." Accepted at the IEEE Aerospace Conference 2011 to be held in Big Sky, MT in March 2011.

Patent Application (WO2010060923): Biologically Inspired Hardware Cell Architecture

## UPorto

R. Santos, P. Pedreiras, M. Behnam, T. Nolte, L. Almeida. "Hierarchical Server-Based Traffic Scheduling in Ethernet Switches". Demo at CRTS 2010 - 3rd Workshop on Compositional Theory and Technology for Real-Time Embedded Systems (satellite of RTSS 2010), San Diego, USA, November 29, 2010.

R. Santos, A. Vieira, R. Marau, P. Pedreiras, A. Oliveira, L. Almeida, T. Nolte. "Improving the efficiency of Ethernet switches for real-time communication". WARM 2010 - Workshop on Adaptive Resource Management (within the Cyber-Physical Systems Week), Stockholm, Sweden, 12 April 2010.

Shantao Chen, Luis Almeida, Zhi Wang. "A Dynamic Dual-Rate Beacon Scheduling Method of ZigBee/IEEE 802.15.4 for Target Tracking". MSN 2010, 6th Int. Conf. on Mobile Ad-hoc and Sensor Networks. Hangzhou, China. 20-22 Dec 2010.

Danilo Tardioli, Luis Almeida, Jose Luis Villarroel. "Adding alien traffic endurance to wireless token-passing real-time protocols". APCSS 2010, 5th 2010 IEEE Asia-Pacific Services Computing Conference. Hangzhou, China. 6-10 Dec 2010.



## UPM

Javier F. Briones, Alejandro Alonso, Miguel A. de Miguel, and Juan Pedro Silva, "Evaluating non-functional properties globally", In Proceedings of the 2010 3rd Simposio de Sistemas de Tiempo Real in the Congreso Español de Informática (CEDI), Sept 2010, Valencia, Spain ISBN 978-84-92812-64-6

Javier F. Briones, Miguel de Miguel, Juan Pedro Silva, Alejandro Alonso, "On the requirements for quality composability modeling and analysis", In Proceedings of the 2010 1st IEEE International Workshop on Model-Based Engineering for Real-Time Embedded Systems Design (MoBE-RTES), May 2010, Carmona, Spain. IEEE Computer Society, Los Alamitos, CA, USA, pp. 123-129 ISBN 978-0-7695-4038-2, DOI 10.1109/ISORC.2010.27

Javier F. Briones, Miguel A. de Miguel, Alejandro Alonso, and Juan Pedro Silva, "Analysis of Quality Dependencies in the Composition of Software Architectures", In Proceedings of 13th Jornadas de Tiempo Real, 4-5 Feb. 2010, Granada, Spain ISBN 978-84-92757-51-0

## ETHZ

Chuan-Yue Yang; Jian-Jia Chen; Thiele, L.; Tei-Wei Kuo; , "Energy-efficient real-time task scheduling with temperature-dependent leakage," Design, Automation & Test in Europe Conference & Exhibition (DATE), 2010 , vol., no., pp.9-14, 8-12 March 2010

## UBologna

V. Jelcic, M.Magno, D. Brunelli, L. Benini. "An Energy Efficient Multimodal Wireless Video Sensor Network," The 5th International Conference on Pervasive Computing and Applications (ICPCA10) Slovenia, December 2010.

Michele Magno; Alessandro Lanza, Davide Brunelli; Luigi Di Stefano, Luca Benini. "Energy aware multimodal video surveillance embedded system". 18th IEEE International Conference on VLSI and System-on-Chip (VLSI-SOC2010) ;. Madrid. Sept 2010.

**-- The above are new references, not present in the Y2 deliverable --**

### 3.3 Joint Publications Resulting from these Achievements

Vanessa Romero Segovia, Karl-Erik Årzén, Stefan Schorr, Raphael Guerra, Gerhard Fohler, Johan Eker, Harald Gustafsson, "Adaptive Resource Management Framework for Mobile Terminals - the ACTORS Approach", In *Proc of the First International Workshop on Adaptive Resource Management (WARM 2010)*, April 2010.

Baloukas, C.; Papadopoulos, L.; Soudris, D.; Stuijk, S.; Jovanovic, O.; Schmoll, F.; Cordes, D.; Pyka, R.; Mallik, A.; Mamagkakis, S.; Capman, F.; Collet, S.; Mitas, N. and Kritharidis, D. "Mapping embedded applications on MPSoC - The MNEMEE approach." In *IEEE Computer Society Annual Symposium on VLSI – ISVLSI*, Lixouri, Greece (2010). Also listed in the Scheduling and Resource Management deliverable.

Iosifidis, Y.; Mallik, A.; Mamagkakis, S.; De Greef, E.; Bartzas, A.; Soudris, D. and Catthoor, F. "A framework for automatic parallelization, static and dynamic memory optimization in MPSoC platforms". In *Proceedings of the 47th ACM/IEEE Design Automation Conference – DAC*, Anaheim, USA (2010). Also listed in Software Synthesis, Code Generation deliverable.

Nikolay Stoimenov, Lothar Thiele, Luca Santinelli, Giorgio C. Buttazzo. "Resource Adaptations with Servers for Hard Real-Time Systems". EMSOFT 10: Proceedings of the tenth ACM

international conference on Embedded software, ACM, Scottsdale, Arizona, USA, pages 269--278, October, 2010.

Kai Huang, Luca Santinelli, Jian-Jia Chen, Lothar Thiele, Giorgio C. Buttazzo. "Adaptive Power Management for Real-Time Event Streams". 15th IEEE Conf. on Asia and South Pacific Design Automation Conference (ASP-DAC), IEEE, Taiwan, pages 7-12, January, 2010.

Andreas Schranzhofer, Jian-Jia Chen, Luca Santinelli, Lothar Thiele. "Dynamic and Adaptive Allocation of Applications on MPSoC Platforms". Design Automation Conference (ASP-DAC), 2010 15th Asia and South Pacific, IEEE, Taipei, Taiwan, pages 885--890, January, 2010.

Moser, C., Thiele, L.; Brunelli, D.; Benini, L. "Adaptive Power Management for Environmentally Powered Systems". IEEE Transactions on Computers (59:4), 2011.

P. Burgio, M. Ruggiero, F. Esposito, M. Marinoni, G. Buttazzo and L. Benini, "Adaptive TDMA bus Allocation and Elastic Scheduling: a unified approach for enhancing robustness in multi-core RT systems", 28<sup>th</sup> International Conference of Computer Design (ICCD), Amsterdam, 2010. Also reported in the MPSoC deliverable.

Bini, Enrico, Buttazzo, Giorgio, Eker, Johan, Schorr, Stefan, Guerra, Raphael, Fohler, Gerhard, Arzen, Karl-Erik, Romero, Vanessa, Scordino, Claudio, "Resource Management on Multi-core Systems: the ACTORS approach", IEEE Micro, Accepted for Publication

**-- The above are new references, not present in the Y2 deliverable --**

### **3.4 Keynotes, Workshops, Tutorials**

#### **Keynotes**

##### **Keynote: Control for Embedded Systems (Karl-Erik Årzén, ULUND)**

The First Virtual Control Conference 2010 (VCC-10), Sep 22, 2010

<http://www.vcc-10.org/>

##### **Keynote: Safety, Efficiency and Autonomy – Mastering Conflicting Trends in Embedded Systems Design (Rolf Ernst, TU Braunschweig)**

DIPES Conference, Brisbane, Australia, September 20, 2010

##### **Keynote: "ARTEMIS - Deriving Research Problems from Complex Societal Challenges" (Rolf Ernst, TU Braunschweig)**

ARTEMIS Summer Camp

*Rome, Italy, June 10, 2010*

The ARTEMIS Industry Association for R&D actors in embedded systems in Europe is the meeting place where key industry and R&D actors identify topics for major R&D project proposals and form consortia. In his keynote talk at the ARTEMIS Summer Camp 2010, Rolf Ernst highlighted the need for new design processes of adaptive embedded systems that requires (partially) autonomous systems that should have self-optimization, self-healing and

self-protection capabilities to work in unreliable network environments. (see also the activity report on Platform and MPSoC Design)

[http://www.artemis-association.org/presentations\\_2](http://www.artemis-association.org/presentations_2)

**Keynote: Embedded Systems Research for Complex Societal Challenges,  
(Rolf Ernst, TU Braunschweig)**

ESI Symposium 2010

*Eindhoven, December 2, 2010*

On December 2, 2010, ESI the Embedded Systems Institute located at the university campus in Eindhoven, Netherlands, had the third annual symposium. The symposium covered a wide range of applied research topics on embedded systems and was organized together with Point One, an open association of high-tech industry and knowledge institutes with research and development in the Netherlands on nanoelectronics, embedded systems, and mechatronics. In this keynote Rolf Ernst highlighted the need for introducing in-field design support for safe updates and reconfiguration, and presented a proposal for a self-protecting update process. (see also the activity report on Platform and MPSoC Design)

<http://www.esi.nl/symposium/>

## **Courses and Tutorials**

**Tutorial: Sampling in Event-driven Control Systems (Manel Velasco, UPC)**

In the CDC2010 satellite workshop "Co-design of Control and Real-Time Computing: Perspectives, Techniques and Research Directions"

[http://ee.nd.edu/faculty/vgupta/research/funding/qtcddc10\\_workshop.html](http://ee.nd.edu/faculty/vgupta/research/funding/qtcddc10_workshop.html)

**Tutorial: Real-Time Calculus**

Pisa, Italy, 22.3.-23.3. 2010

The two-day tutorial was given by ETHZ (Lothar Thiele) in cooperation with SSSA (Giorgio Buttazzo)

The objectives of the course were to:

- Introduce the concepts of compositional real-time analysis to graduate students
- Provide basic concepts of interface-based design
- Discuss applications in on-line adaptation of system characteristics

**Graduate Course on Embedded Control Systems: Theory and Practice**

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

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

Objectives for the course: The course was aimed at:

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

Organizers:

- Giorgio Buttazzo - Scuola Superiore Sant'Anna, Italy
- Pau Marti - Technical University of Catalonia, Barcelona, Spain
- Ettore Ricciardi – ISTI-CNR, Pisa

## ***Workshops and Special Sessions***

### **Workshop: First International Workshop on Adaptive Resource Management (WARM 2010), Cyber-Physical Systems Week 2010, April 12, 2010, Stockholm, Sweden**

The focus of WARM was software-based approaches to adaptive resource management for soft or adaptive embedded real-time applications, e.g., multimedia applications or non-safety critical control applications. Special emphasis was given to multi-resource management and to multi-core platforms.

The programme included 8 submitted presentations, 3 invited presentations and one keynote on challenges and solutions for adaptive resource management in cyber-physical systems given by Prof Raj Rajkumar, CMU.

Organizers:

- Prof. Giorgio Buttazzo, Scuola Superiore Sant'Anna, Pisa
- Prof. Gerhard Fohler, TU Kaiserslautern
- Prof. Alan Burns, University of York
- Prof. Luis Almeida, University of Porto
- Prof. Karl-Erik Årzén, Lund University
- Prof. Michael Gonzalez Harbour, University of Cantabria

URL: <http://www.artist-embedded.org/artist/Theme.html>

**Special Session: QoS and Resource management in adaptable real-time systems** 15th IEEE International Conference Emerging Technologies and Factory Automation in Bilbao, September 2010.

Organizers:

- Alejandro Alonso, Universidad Politécnica de Madrid,
- Marisol García Valls, Universidad Carlos III de Madrid

## ***Invited Lectures and Presentations***

**Invited Lecture: Formal Performance Analysis and Optimization of Safety-related Embedded Systems**

**(Rolf Ernst, TU Braunschweig)**

Artist Summer School Europe 2010

*Autrans, France, September 6, 2010*

The lecture was given at the fifth edition of the Artist Summer School Europe organized by the Artist Design European Network of Excellence on Embedded Systems Design. An important part of the lecture was the presentation of a proposal for system self-protection against system performance failures due to incorrect system updates or extensions. *(Further topics addressed in this lecture are related to the activity report on Platform and MPSoC Analysis and Design)*

<http://www.artist-embedded.org/artist/Invited-Speakers.2065>

**Invited Presentation: Adaptivity and Resource Control in Embedded Systems (Karl-Erik Årzén, ULUND)**

LCCC Workshop on Adaptation and Learning in Autonomous Systems. Lund Sweden, April 22, 2010.

An overview of adaptivity and resource control in embedded system was given.

<http://www.lccc.lth.se/index.php?page=workshop-program-WS04>

**Invited Presentation: Synthesizing real-time implementations from abstract specifications based on timed automata** (Jacques Combaz, Joseph Sifakis and Tesnim Abdellatif, VERIMAG)

Workshop on Software Synthesis (WSS'10), ESWEEK 2010, Scottsdale, Arizona, USA:

A general model-based implementation method for real-time systems was presented based on the use of two models .

- An abstract model representing the behavior of real-time software as a timed automaton. The latter describes user-defined platform-independent timing constraints. Its transitions are timeless and correspond to the execution of statements of the real-time software.
- A physical model representing the behavior of the real-time software running on a given platform. It is obtained by assigning execution times to the transitions of the abstract model.

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

## 4. Overall Assessment and Vision for the Transversal Activity

### 4.1 *Assessment for Year 3*

The assessment of the work that has been performed within the activity continues to be positive. Several workshops and meetings have been organized by the partners. The meetings act as the interface between the different clusters on issues related to embedded system adaptivity. The partners work on a number of challenging research issues, both individually and together, in the latter case often within the umbrella of STREP projects. The level of participation among the partners in embedded FP7 projects is very high. The fact that most of these projects are currently in a hectic final stage and the preparations for the next embedded system call has somewhat decreased the emphasis on workshop and summer school organization among the partners, though.

The partners have contributed to education about adaptive and feedback-based approaches. There are also several contacts between industry and academia within the activity, e.g., collaborations involving NXP, Ericsson, Volvo, IMEC, and Evidence just to name a few.

A major challenge for this activity continuous to be how to integrate the more hardware-oriented partners from, e.g., the MPSoC cluster with the more software-oriented partners from the OS and networks cluster. Currently the activity is dominated by partners from the latter cluster.

During the year the main workshop organized was WARM 2010. For 2011 we plan to continue along these lines with the third workshop on Adaptive and Reconfigurable Embedded Systems (APRES'11) in conjunction with CPSWEEK 2011.

The members of the activity are organizing a special issue on Adaptive Embedded Systems for Real-Time Systems Journal with Årzén (ULUND) as guest editor. The deadline for submissions is Sep 2011 which fits quite nicely with the end of ArtistDesign, making it possible for the members of the activity to submit their work there.

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

### 4.2 *Overall Assessment since the start of the ArtistDesign NoE*

The integration among the partners is demonstrated by the number of joint publications, projects and events organized within the cluster. The main examples are workshops, graduate courses, and the various research consortia that collaborate within, e.g. European embedded systems projects, like ACTORS, and PREDATOR. During Year 3 the positive development from Year 1 and 2 has continued.

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



### 4.3 Indicators for Integration

The indicators for integration for Year 3 in the Year 2 report were as follows::

- At least 10 joint publications
  - *During Year 3 9 joint publications were reported. The goal was almost met.*
- More than 10 research collaborations
  - *In Section 3.1 at least 11 research collaborations are reported. The goal was met.*
- More than 10 meetings or workshops organized by the partners.
  - *Seven workshops, meetings and summer schools have been held. Hence, the goal has only partially been met.*
- Two educational events.
  - *Only one educational event was organized. Hence the goal has not been met.*
- The content of the wiki will be substantially expanded.
  - *The content of the wiki is the same as last year. Hence the goal has not been met.*

The indicators for integration for Year 4 involve the following goals:

- At least 10 joint publications
- More than 10 research collaborations
- More than 10 meetings or workshops organized by the partners.
- Two educational events organized by the partners.
- The completion of a joint white paper on Adaptivity in embedded systems.
  - *Based on the request from the Y2 review the work on a joint white paper on adaptivity has been started. A set of authors has been selected and an initial outline of the report has been developed. The white paper will first be written as an internal Artist white paper available on the Artist home page and later transformed into a survey article.*

Hence, compared to the indicators for Year 3 the goals are similar with the exception that the Wiki development has been de-emphasized.

#### -- Changes wrt Y2 deliverable --

*This section has been updated compared to Year 2.*

### 4.4 Long-Term Vision

The use of adaptivity and feedback to provide performance and robustness in embedded systems becomes more natural, the more complex and hard to statically analyze the systems are. Since increased complexity and an ever increasing amount of software is one of the most prominent trends in embedded systems today we are convinced that adaptive techniques will be increasingly important for the future. New application domains are also emerging for adaptive systems, illustrated by, e.g., the iLAND project (<https://www.artemisias-association.org/iland>, with UPorto as a partner), applying adaptability to intelligent houses.

The long-term vision for this activity on the 4-year horizon is to generate a substantial advance in theory, methods and tools of relevance to adaptivity in embedded systems and to disseminate this into industry and to the scientific community at large. Important issues include how to make trade-off in choosing the right level of adaptivity and verification of adaptivity mechanisms to ensure they can be used in cost and mission critical system.



In addition to the adaptivity of embedded systems with respect to changing task properties and environmental changes, we are increasingly faced with non-functional properties such as power and temperature. The major challenge we are facing is to change system properties such as operation voltage and on-off behaviour in order to guarantee an upperbound on the temperature of a multiprocessor system. At the same time, guarantees on the timeliness of operation must be given. Control strategies are needed that are either based on off-line information or take into account on-line measurements on task arrivals, execution times and temperatures (if available).

**-- Changes wrt Y2 deliverable --**

*This section is unchanged compared to last year.*

## 5. Work Related to the Joint Programme of Integration Activities (JPIA)

### 5.1 Joint Technical Meetings

**Meeting:** Retis Laboratory

Pisa, 22.3. – 23.3.2010

Objectives for the meeting: Discuss the current progress in the joint research program on adaptivity and servers.

Participants: ETHZ, SSSA

Organizer: Giorgio Buttazzo, RETIS Laboratory

**Meeting:** Retis Laboratory

Pisa, 17.12.2010.

Objectives for the meeting: Discuss the current progress in the joint research program on adaptivity and servers. Discuss PhD thesis of Luca Santinelli (was exchange student at ETH Zurich)

Participants: ETHZ, SSSA

Organizer: Giorgio Buttazzo, RETIS Laboratory

**Workshop: First International Workshop on Adaptive Resource Management (WARM 2010), Cyber-Physical Systems Week 2010, April 12, 2010, Stockholm, Sweden**

The focus of WARM was software-based approaches to adaptive resource management for soft or adaptive embedded real-time applications, e.g., multimedia applications or non-safety critical control applications. Special emphasis was given to multi-resource management and to multi-core platforms.

The programme included 8 submitted presentations, 3 invited presentations and one keynote on challenges and solutions for adaptive resource management in cyber-physical systems given by Prof Raj Rajkumar, CMU.

Organizers:

- Prof. Giorgio Buttazzo, Scuola Superiore Sant'Anna, Pisa
- Prof. Gerhard Fohler, TU Kaiserslautern
- Prof. Alan Burns, University of York
- Prof. Luis Almeida, University of Porto
- Prof. Karl-Erik Årzén, Lund University
- Prof. Michael Gonzalez Harbour, University of Cantabria

URL: <http://www.artist-embedded.org/artist/Theme.html>

In addition to the above several meetings involving the partners have been held within the projects, typically, FP7 STREP projects (COMBEST, ACTORS, PREDATOR, ...), where the actual collaborative work mostly is being performed.

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

## 5.2 Staff Mobility and Exchanges

**Visiting researcher : Vana Jelacic** (Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia)

Team visited: UNIBO (Micrel Lab), led by Luca Benini

*Bologna, Italy – March, 2010 to June, 2010*

*Approximate cost for travel and lodging: 7000 €*

Reason for the visit: Investigation of power aware policies for multimodal wireless sensor networks. Conclusions/objectives reached: The scientific work achieved good results. An algorithm for optimizing power consumption in multimodal wireless sensor network has been developed. The WSN is based on low-power piezoelectric sensors and more CMOS cameras for security and surveillance applications. The outcomes have been published in a well-known conference.

**Visiting Researcher: Martin Radetzki** (Prof. at University of Stuttgart, Germany)

Team visited: KTH in Stockholm, led by Axel Jantsch

Stockholm, Sweden – October – December 2010-12-23

Approximate cost for travel and lodging: 3500 Euro

Reason for visit: Cooperation on fault tolerant on-chip communication infrastructure. In addition to technical cooperation on developing techniques for network and link-level fault tolerance we have initiated a joint survey paper reviewing the very substantial state of the art.

**Visiting Student: Sergi Fernandez** (UPC)

Team visited: RETIS Lab, SSSA led by Giorgio Buttazzo

Appr. Cost: 900€

Reason for visit: Attending the "ARTIST Graduate School on RT Kernels for Microcontrollers", organised and funded by ARTIST, June 14-18, 2010, at Scuola Superiore Sant'Anna, Pisa, Italy

Conclusion: The course has been an excellent opportunity to get familiar with the most important concepts and methodologies used to develop a real-time embedded system, including fundamentals of real-time scheduling, control and distributed systems. Also, it served to show how to apply these concepts in practice, using an embedded platform and a real-time operating system to develop simple control applications and make experience with wireless sensor networks.

**Visiting researcher: Michael Reibel Boesen** (DTU)

Team visited: Jet Propulsion Laboratory, Pasadena, CA

Reason for visit: Michael Reibel Boesen has spent 5 months at NASA's Jet Propulsion Laboratory in Pasadena (CA) to integrate and implement the control and data processing algorithms of a Liquid Crystal Waveguide Fourier Transform Spectrometer on the eDNA prototype platform. A prototype was programmed on a Xilinx Virtex 5 FPGA and was later ported to a National Instruments CompactRIO embedded platform in order to interact with the spectrometer of NASA.

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

## 5.3 Tools and Platforms

### 5.3.1 SWEET (SWEdish Execution Time tool)

#### Objectives

SWEET is a WCET analysis tool. It is an academic prototype: the main objective is to use it as a test bench for methods in WCET analysis, and then mainly flow analysis to produce program flow constraints (upper bounds on # of loop iterations, information about infeasible paths, etc.).

#### Main Results

SWEET has been used to develop and test various methods for constraining program flow. It has also been used in industrial case studies. The results indicate that the developed methods do improve on the number of automatically detected program flow constraints, as well as on the precision of the resulting WCET bound. Recently, SWEET has been reengineered to use the “ALF” format for its flow analysis, and it has been provided with backends to generate program flow constraints for the commercial WCET analysis tools aiT and RapiTime from AbsInt GmbH and Rapita Systems Ltd, respectively. Translators to ALF from C, and the PPC and NECV850 binary formats, have been implemented as well.

#### Current work

A version of SWEET that performs parametric WCET analysis is currently being implemented. An alternative C-to-ALF translator, which uses the LLVM compiler framework, is also under implementation.

#### Participating partners:

- Mälardalen University  
Maintains and develops SWEET, develops methods for parametric WCET analysis.
- Saarland University  
Collaboration partner for parametric WCET analysis.

#### Web

<http://www.mrtc.mdh.se/projects/wcet/sweet.html>

### 5.3.2 Hardware setup to demonstrate self-protection and adaptability of embedded Real-Time Systems

#### Objectives

A demonstrator for self-protection and adaptability in real-time systems is being developed. It demonstrates the feasibility and cost of run-time adaptation and protection with respect to performance metrics such as end-to-end latencies. Furthermore, the demonstrator acts as a platform to evaluate performance of the proposed methodologies.

#### Main Results

The demonstrator consisting of a timing sensitive control application as well as a second disturbing application (audio streaming) has been completed and is used to show self-protection (audio streaming is denied access to the system) as well as self-configuration using the optimization techniques developed last year (audio streaming is allowed at low priority).

The demonstrator has been extended by a memory protection scheme using the available MMU of the PPC603e core, which efficiently isolates the runtime environment from user applications as well as user applications from each other.

#### **Participating partners:**

- TU Braunschweig
- Symtavigation GmbH
- Universität Erlangen

#### **Related Publications**

Moritz Neukirchner, Steffen Stein, Harald Schrom and Rolf Ernst. A software Update Service with Self-Protection Capabilities. In Proceedings of the conference on Design, Automation and Test in Europe (DATE), Dresden, Germany, March 2010

#### **5.3.3 *TrueTime***

#### **Objectives**

To provide a flexible simulation platform for networked embedded real-time systems with a particular focus on control applications. TrueTime implements simulation models for a multi-tasking real-time kernel and data link layer network protocols that execute embedded in the Matlab/Simulink environment. Using TrueTime it is possible to experiment with adaptive resource management and network protocols and investigate how this influence application performance.

#### **Main Results**

TrueTime has been continuously developed since 1999. During Y3 three new versions have been released:

- 2010-05-06 – TrueTime 2.0 Beta 5 was released. Changes to allow TrueTime to compile under Matlab R2009 and under Mac OS X.
- 2010-06-10 - **TrueTime Network for Modelica** was released. Two versions have been developed -- one based on an external C code implementation for the Dymola simulation tool and one based on native Modelica.
- 2010-07-16 – TrueTime 2.0 Beta 6 was released. Added support for the Network Code Machine by Sebastian Fischmeister et al.

## Current work

The current not yet released development version also supports partitioned multicore scheduling and hierarchical schedulers. This is currently being used in the ACTORS project.

## Participating partners:

- ULUND  
Toolbox development.
- SSSA, TUKL, Aveiro, KTH ...  
Users of the toolbox

## Web

<http://www.control.lth.se/truetime/>

### 5.3.4 Other Tools and Platforms

## BACC: Budget ACCountant (UPM)

BACC is a module for resource management, with low-level means for dynamic adaptation. The implementation has been adapted to the latest versions of the Linux kernel. It has been added support for multi-core architectures.

### -- Changes wrt Y2 deliverable --

*The text above only contains the tools / platforms for which something significant has changed with respect to Year 2. Tools such as SHARK, ERIKA or ForSyDe mentioned in the Year 1 and 2 deliverables are still of relevance to this activity.*





## 6. Transversal Activity Participants


### -- Changes in the Cluster Participants wrt Y2 deliverable --


*The partner description of IMEC has been updated. Maja D'hondt has replaced Stylianos Mamagkakis as the team leader for IMEC.*

### 6.1 Core Partners


| Transversal Activity Leader & Team Leader   |   |
|---|---|
|  | <p>Professor Karl-Erik Årzén<br/>Lund University<br/>URL: <a href="http://www.control.lth.se/user/karlerik/">http://www.control.lth.se/user/karlerik/</a></p>   |
| 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, feedback applied to computer systems   |
| Role in leading conferences/journals/etc in the area                              | <p>Co Chair 4th Intl. Workshop on Feedback Control Implementation and Design in Computing Systems &amp; Networks (FeBID 2009)<br/>Co Chair Workshop on Adaptive Resource Management (WARM 2010)<br/>Program Chair of Euromicro Real-Time Systems Conference 2011 (ECRTS'11)</p> |
| Notable past projects   | HRTC, CHEM, 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   |
| Further Information   | Leader for the cluster for Control for Embedded Systems in Artist2 (2005-2008)  |

| Team Leader   |   |
|---|---|
|  | <p>Prof. Gerhard Fohler</p> <p>Technical University of Kaiserslautern (TUKL)</p> <p>URL: <a href="http://www.eit.uni-kl.de/fohler">www.eit.uni-kl.de/fohler</a></p>   |
| Technical role(s) within ArtistDesign   | <p>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 analysis of algorithms for video streaming applications. A further focus is on flexible scheduling, with the aim of integrating offline and online approaches.</p>   |
| Research interests  | <p>Real-time scheduling, integration of offline and online scheduling, QoS management, video streaming and media processing.</p>  |
| Role in leading conferences/journals/etc in the area                              | <p>Chairman, technical committee on real-time systems, Euromicro</p> <p>Member of executive board technical committees on, IEEE real-time systems, IE embedded systems</p> <p>Area editor real-time, Journal of System Architecture, Elsevier</p> <p>Program chair, IEEE Real-Time Systems Symposium, 2006</p> <p>Program chair, sub track real-time systems, DATE 2005-2007</p> <p>Program committee member of most real-time related conferences</p>  |
| Notable past projects   | <p>FRESCOR - Framework for Real-time Embedded Systems based on COnTracts, EU IST STREP</p> <p>WASP - Wirelessly Accessible Sensor Populations, EU IST IP</p> <p>BETSY - BEing on Time Saves energy continuous multimedia experience with low battery power, EU IST STREP</p> <p>FIRST - Flexible Integrated Real-Time System Technology, EU IST STREP</p> <p>FABRIC: Federated Applications Based on Real_time Interacting Components", IST-2001-37167 (2002-2003) investigated QoS management methods for home networks.</p> |
| Awards / Decorations  | <p>Best paper award, ECRTS 2008</p>   |


| <b>Team Leader</b><br><b>Activity Leader for “Real-Time Networks”</b>             |   |
|---|---|
|  | <p>Prof. Luis Almeida<br/>University of Aveiro<br/>URL: <a href="http://www.ieeta.pt/lse">http://www.ieeta.pt/lse</a></p>   |
| Technical role(s) within ArtistDesign   | Leader of the team from the University of Aveiro.   |
| Research interests  | <p>Real-time communication (traffic scheduling, protocols,...)</p> <p>Flexible architectures for distributed embedded systems</p>   |
| Role in leading conferences/journals/etc in the area                              | <p>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)</p>  |
| Notable past projects   | <p>ARTIST (FP5 accompanying measure).</p> <p>CAMBADA – Cooperative Autonomous roBots with Advanced Distributed Architecture. Specification and development of a team of cooperating autonomous robots for the Robocup Middle-Size Soccer League. Particular focus has been devoted to the architecture of each robot and their communication for information sharing.<br/><a href="http://www.ieeta.pt/atri/cambada/">http://www.ieeta.pt/atri/cambada/</a></p> <p>DISCO, DIStributed embeddable systems for COntrol applications. The objectives of the project were to investigate techniques and to develop solutions to improve flexibility and adaptability in distributed embedded control systems in order to reduce operation and maintenance costs while maximizing the utilization of system resources.<br/><a href="http://www.ieeta.pt/lse/DISCO_web.pdf">http://www.ieeta.pt/lse/DISCO_web.pdf</a></p> <p>CIDER, Communication Infrastructure for Dependable and Evolvable Real-time systems. The project pursued two objectives: to analyze the usability of Ethernet in dependable applications (static set-up) and to devise the necessary mechanisms to allow the set-up to change dynamically (dynamic set of services and hosts) while providing the required dependability.<br/><a href="http://www.hurray.isep.ipp.pt/activities/cider/">http://www.hurray.isep.ipp.pt/activities/cider/</a></p> |
| Awards  | <p>Best Paper Award in WFCS 2004</p> <p>Best Paper Award in SICICA 2000</p>   |

| Team Leader   |  |
|---|--|
|  | <p>Prof. Luca Benini, University of Bologna<br/> <a href="http://www-micrel.deis.unibo.it/%7Ebenini/">http://www-micrel.deis.unibo.it/%7Ebenini/</a></p>   |
| Technical role(s) within ArtistDesign   | <p>Member of the Strategic Management Board<br/> Co-leads Hardware Platforms and MPSoC Design<br/> Participates in Intercluster activity: Design for Adaptivity<br/> Participates in Intercluster activity: Design for Predictability and Performance<br/> Leader of the JPRA Activity: "Platform and MPSoC Design"</p>  |
| Research interests  | <p>(i) Development of power modeling and estimation framework for systems-on-chip.<br/> (ii) Development of optimal allocation and scheduling techniques for energy-efficient mapping of multi-task applications onto multi-processor systems-on-chips.<br/> (iii) Development of energy-scavenging techniques for ultra-low power sensor network platforms.</p>   |
| Role in leading conferences/journals/etc in the area                              | <ul style="list-style-type: none"> <li>▪ Program chair and vice-chair of Design Automation and Test in Europe Conference.</li> <li>▪ Member of the 2003 MEDEA+ EDA roadmap committee 2003.</li> <li>▪ Member of the IST Embedded System Technology Platform Initiative (ARTEMIS): working group on Design Methodologies</li> <li>▪ Member of the Strategic Management Board of the ARTIST2 Network of excellence on Embedded Systems</li> <li>▪ Member of the Advisory group on Computing Systems of the IST Embedded Systems Unit.</li> <li>▪ Member of the technical program committee and organizing committee of several technical conferences, including the Design Automation Conference, International Symposium on Low Power Design, the Symposium on Hardware-Software Codesign. He is Associate Editor of the IEEE Transactions on Computer-Aided Design of Circuits and Systems and of the ACM Journal on Emerging Technologies in Computing Systems.</li> <li>▪ Fellow of the IEEE.</li> </ul> |
| Notable past projects   | <p>ICT-Project <b>REALITY - <i>Reliable and variability tolerant system-on-a-chip design in more-moore technologies</i></b>. Funded under 7th FWP (Seventh Framework Programme). ICT-2007.3.1 Next-Generation Nanoelectronics Components and Electronics Integration. Start date: 01/01/2008; Duration: 30 months; Contract Type: Collaborative project; Project Reference: 216537; Project Cost: 4.45 million euro; Project Funding: 2.9 million euro.</p> <p>ICT-Project <b>PREDATOR - <i>Design for predictability and efficiency</i></b>. Funded under 7th FWP (Seventh Framework Programme). ICT-2007.3.3 Embedded Systems Design. Start date:</p>  |


|  |   |
|--|---|
|  | <p>01/02/2008; Duration: 36 months; Contract Type: Collaborative project; Project Reference: 216008; Project Cost: 3.93 million euro; Project Funding: 2.8 million euro.</p> <p>ICT-Project <b>GALAXY - interface for complex digital system integration</b>. Funded under 7th FWP (Seventh Framework Programme). ICT-2007.3.3 Embedded Systems Design. Start date: 01/12/2007; Duration: 36 months; Contract Type: Collaborative project; Project Reference: 214364; Project Cost: 4.08 million euro; Project Funding: 2.9 million euro.</p> <p>ICT-Project <b>DINAMICS - Diagnostic Nanotech and Microtech Sensors</b>. Funded under 6th FWP (Sixth Framework Programme). FP6-NMP 'Nanotechnologies and nanosciences, knowledge-based multifunctional materials and new production processes and devices'. Contract Type: Integrated project; Project Reference: IP 026804-2. Start date: 01/04/2007. Duration: 18 + 30 months. Project Cost: 7276856 Euro. Project Funding: 4499542 Euro.<br/><a href="http://www.dinamics-project.eu/">http://www.dinamics-project.eu/</a></p> <p>ICT-Project <b>SHARE - Sharing open source software middleware to improve industry competitiveness in the embedded systems domain</b>. Funded under 7th FWP (Seventh Framework Programme). ICT-2007.3.7 Network embedded and control systems. Start date: 01/05/2008; Duration: 24 months; Contract Type: Coordination and support actions; Project Reference: 224170; Project Cost: 1.1 million euro; Project Funding: 590000.00 euro.</p> |
|--|---|


| Team Leader   |   |
|---|---|
|  | <p>Prof. Eduardo Tovar<br/>Polytechnic Institute of Porto (ISEP-IPP), Porto (Portugal)<br/>URL: <a href="http://www.hurray.isep.ipp.pt/asp/show_people.asp?id=1">http://www.hurray.isep.ipp.pt/asp/show_people.asp?id=1</a></p>   |
| 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 in the area                                | Executive Board Member of the Euromicro Technical Committee on Real-Time Systems.   |

|                       |  |
|-----------------------|--|
|                       | <p>Program Chair ECRTS'05, RTN'02, WDES'06.</p> <p>General Chair of WFCS'00, ECRTS'03.</p> <p>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.</p> <p>Reviewer for Real-Time Systems, IEEE Transactions on Computers, ACM Transactions on Embedded Computing, IEEE Transactions on Industrial Informatics.</p>   |
| Notable past projects | <p>"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).</p> <p>"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 networks. Mobility protocols and end-to-end deadlines..</p> <p>"CABERNET: Network of Excellence in Distributed Computing Systems Architectures", IST-2000-25088 (2001-2003).</p> <p>"CIDER: Communication Infrastructure for Dependable Evolvable Real-time systems", POSI/1999/CHS/33139 (2001-2003), Portuguese Science Foundation project on real-time communication networks.</p> |
| Further Information   | Senior Member of IEEE  |

|   |  |
|---|--|
|  | <p>Prof. Björn Lisper (Mälardalen University)<br/><a href="http://www.idt.mdh.se/personal/blr/">http://www.idt.mdh.se/personal/blr/</a></p>  |
| Technical role(s) within ArtistDesign   | <p>Activity leader for "Timing Analysis"</p> <p>Timing analysis, program analysis.</p>   |
| Research interests  | Timing analysis, static program analysis, language design for embedded and real-time systems, program transformations, parallelism   |
| Notable past projects   | <p>FP7 STREP ALL-TIMES, Integrating European Timing Analysis Technology (coordinator). <a href="http://www.all-times.org">http://www.all-times.org</a></p> <p>Several national projects, funded by Swedish Research Council, VINNOVA, KKS, SSF, Ericsson</p> |




| Team Leader   |   |
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|  | <p>Professor Alan Burns<br/>University of York, UK<br/>URL: <a href="http://www.cs.york.ac.uk/~burns">www.cs.york.ac.uk/~burns</a></p>  |
| 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, modeling 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   | <p>DIRC – Dependability Interdisciplinary Research Collaborations – A large, UK, 6-year, multisite project looking at dependability of computer-based systems. Burns was a PI and managed the work on temporal aspects of dependability.</p> <p>FIRST – EU funded project concerning flexible scheduling</p> <p>FRESCOR – EU follow on project to FIRST</p> |


| Team Leader   |  |
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|  | <p>Lothar Thiele (ETH Zurich)</p>  |
| Technical role(s) within ArtistDesign   | <p>Main areas of research: Embedded Systems and Software</p> <p>Artist2 activities and role: Communication Centric Systems: Formal Performance Analysis, Linking Simulation and Verification, Design Space Exploration of Embedded Systems</p> |
| Research interests  | Research interests include models, methods and software tools for the design of embedded systems, embedded software and bioinspired optimization techniques.   |


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| Awards / Decorations | In 1986 he received the "Dissertation Award" of the Technical University of Munich, in 1987, the "Outstanding Young Author Award" of the IEEE Circuits and Systems Society, in 1988, the Browder J. Thompson Memorial Award of the IEEE, and in 2000-2001, the "IBM Faculty Partnership Award". In 2004, he joined the German Academy of Natural Scientists Leopoldina. In 2005-2006, he was the recipient of the Honorary Blaise Pascal Chair of University Leiden, The Netherlands. Chair of ACM SIGBED. |
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| Team Leader   |  |
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|  | <p>Prof. Giorgio Buttazzo</p> <p>Scuola Superiore Sant'Anna (SSSA), Pisa (Italy)</p> <p>URL: <a href="http://feanor.sssup.it/~giorgio/">http://feanor.sssup.it/~giorgio/</a></p>   |
| Technical role(s) within ArtistDesign   | <p>Coordinating the cluster on Operating Systems and Network and the activity entitled "Resource-Aware Operating Systems".</p> <p>Providing support on real-time scheduling, operating systems, resource management, overload handling, energy aware algorithms, and quality-of-service strategies.</p>  |
| 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                              | <p>Editor-in-Chief of the Journal of Real-Time Systems (Springer).</p> <p>Associate Editor of the Journal of Embedded Computing (Cambridge International Science Publishing).</p> <p>Executive Board Member of the Euromicro Conference on Real-Time Systems.</p> <p>Program Chair of RTSS'01, ECRTS'03, EMSOFT'04, HSCC'07.</p> <p>General Chair of RTSS'02, EMSOFT'04, ECRTS'07.</p> <p>Reviewer for Real-Time Systems, IEEE Transactions on Computers, ACM Transactions on Embedded Computing.</p> <p>Program committee member of most real-time related conferences.</p> |
| Notable past projects   | <p>"FIRST: Flexible Integrated Real-time Systems Technology", IST-2001-32467 (2002-2005) investigated advanced scheduling for handling applications with various real-time requirements.</p> <p>"OCERA: Open Components for Embedded Real-time Applications", IST-2001-35102 (2002-2005) integrated advanced real-time mechanisms in open-source kernels.</p> <p>"FABRIC: Federated Applications Based on Real_time Interacting Components", IST-2001-37167 (2002-2003) investigated QoS</p>   |

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|                     | <p>management methods for home networks.</p> <p>“ARTIST: Advanced Real-Time Systems”, IST-2001-34820 (2002-2005) investigated adaptive real-time systems for QoS management.</p> <p>“TRACS - Flexible Real-Time Architecture for Traffic Control Systems”, ESPRIT III project No. 6373 (1992-1995) investigated real-time techniques for vessel control systems.</p>  |
| Awards              | <p>Best paper Award at the 10<sup>th</sup> 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”.</p> <p>Award for the best paper and presentation at the ANIPLA Workshop on Operating Systems for Industrial Control Applications, Milan, November 18, 1999.</p> <p>HUSPI Award given by Honeywell for the best journal publication on robotic systems, November 1987.</p> |
| Further Information | Senior Member of IEEE   |

| Team Leader in Activity: Design for Adaptivity                                      |   |
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|  | <p>Professor Axel Jantsch<br/>KTH<br/><a href="http://web.it.kth.se/~axel/">http://web.it.kth.se/~axel/</a></p>   |
| Technical role(s) within ArtistDesign   | A. Jantsch contributes to KTH participation and to the work on formal models of computation and communication and the ForSyDe framework. Furthermore, he also contributes to Hardware Platforms and MPSOC Design with focus on run-time environments and analysis techniques.   |
| Research interests  | A. Jantsch's main research topics are models of computation, modelling and analysis of embedded systems and SoCs, networks on chip.   |
| Notable past projects   | <p><b>ANDRES</b> (Analysis and Design of run-time Reconfigurable, heterogeneous Systems) Project) – EU FP6 (<a href="http://andres.offis.de/">http://andres.offis.de/</a>)</p> <p><b>SPRINT</b> (Open SoC Design Platform for Reuse and Integration of IPs): EU FP6 (<a href="http://www.ecsi-association.org/sprint">http://www.ecsi-association.org/sprint</a>)</p> <p><b>MOSART</b> (Mapping Optimization for Scalable multi-core ARchiTecture) – EU FP7 (<a href="http://www.mosart-project.org/">http://www.mosart-project.org/</a>)</p> |

| Team Leader   |   |
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|  | Jan Madsen (Technical University of Denmark)  |
| Technical role(s) within ArtistDesign   | Main areas of research: Embedded Systems Design and Modeling Artist2 activities and role: System Modelling Infrastructure, Communication-Centric, Systems, Design for Low-Power   |
| Research interests  | Research interests include high-level synthesis, hardware/software codesign, System-on-Chip design methods, and system level modeling, integration and synthesis for embedded computer systems.   |
| Role in leading conferences/journals/etc in the area                              | He is Program Chair for DATE07. He has been Tutorial Chair and Program Vice Chair for DATE06, Workshop Chair for CODES+ISSS'05, General Chair of CODES '01 and Program Chair of CODES '00. He is on the editorial board of the journal "IEE Proceedings – Computers and Digital Techniques" |
| Awards / Decorations  | In 1995 he received the Jorck's Foundation Research Award for his research in hardware/software codesign  |


| Team Leader   |  |
|---|--|
|  | Prof. Dr. Maja D'hondt<br>IMEC vzw.<br><a href="http://www.imec.be">http://www.imec.be</a>   |
| Technical role(s) within ArtistDesign   | Representing IMEC Smart Systems and Energy Technology division in:<br>-Cluster: SW Synthesis, Code Generation and Timing Analysis<br>-Cluster: Operating Systems and Networks<br>-Cluster: Hardware Platforms and MPSoC Design<br>-Intercluster activity: Design for Adaptivity<br>-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  |

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|  | 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                                | Responsible for Scalopes ARTEMIS project<br>( <a href="http://www.scalopes.eu/">http://www.scalopes.eu/</a> ), OptiMMA IWT project<br>( <a href="http://www.imec.be/OptiMMA">www.imec.be/OptiMMA</a> ), and Stadium IWT project<br>( <a href="http://distrinet.cs.kuleuven.be/projects/stadium/">distrinet.cs.kuleuven.be/projects/stadium/</a> ). |


## 6.2 Affiliated Industrial Partners


Ericsson and NXP are affiliated industrial partners. They are, however, described in the corresponding thematic cluster deliverables.

## 6.3 Affiliated Academic Partners

| Activity Leader for "Qos-aware components"  |  |
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|  | Prof. Alejandro Alonso<br>Universidad Politécnica de Madrid.<br>URL: <a href="http://www.dit.upm.es/aalonso">http://www.dit.upm.es/aalonso</a>   |
| Technical role(s) within ArtistDesign   | Activity Leader for "Qos-aware components"<br>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<br>HIJA: High-Integrity Java Applications. The goal is to develop a new Java-based middleware platform for the creation of Architecture-Neutral, high-integrity, distributed Real-Time Systems (ANRTS)<br>ROBOCOP and Space4U. Development of component framework for embedded devices. It includes support for QoS and resource |


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|  | management.<br>TRECOM: Techniques for the development of advanced distributed real-time systems for safety and business critical systems. |
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| Core Teamleader JPRA Activity "Design of Adaptivity"                              |   |
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|  | Prof. Dr.-Ing. Rolf Ernst (TU Braunschweig)<br><br><a href="http://www.ida.ing.tu-bs.de/en/home/faculty_and_staff/ernst/">http://www.ida.ing.tu-bs.de/en/home/faculty_and_staff/ernst/</a>  |
| Technical role(s) within ArtistDesign   | Core Teamleader in Platform and MpSoC Design, Platform and MpSoC Analysis, Design for Adaptivity, Integration Driven by Industrial Applications.<br><br>Affiliated Teamleader in Design for Predictability and Performance  |
| Research interests  | Research interests include embedded architectures, hardware-/software co-design, design automation, real-time systems, and embedded systems engineering.  |
| Role in leading conferences/journals/etc in the area                              | Rolf Ernst chaired major international events, such as the International Conference on Computer Aided Design of VLSI (ICCAD), or the Design Automation and Test in Europe (DATE) Conference and Exhibition, and was Chair of the European Design Automation Association (EDAA). He is a founding member of the ACM Special Interest Group on Embedded System Design (SIGBED), and was a member of the first board of directors. He is an elected member (Fachkollegiat) and Deputy Spokesperson of the "Computer Science" review board of the German DFG (corresponds to NSF). He is an advisor to the German Ministry of Economics and Technology for the high-tech entrepreneurship program EXIST ( <a href="http://www.exist.org">www.exist.org</a> ). |

| Team Leader   |  |
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|  | Prof. Lucia Lo Bello<br>University of Catania (Italy) – Affiliated to SSSA, Pisa<br>URL: <a href="http://www.diit.unict.it/users/llobello/">http://www.diit.unict.it/users/llobello/</a> |
| Technical role(s) within ArtistDesign   | Support for the SHaRK kernel maintenance. Implementation of industrial multimedia system using SHARK. Execution time measurement.  |



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|  | <p>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.</p> <p>Support for real-time communication in distributed embedded systems, with particular reference to networked embedded systems used in factory communication and in automotive environments.</p> <p>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.</p> <p>Design issues and protocols for wireless sensor networks and networked embedded systems.</p>                   |
| Research interests                                   | <p>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.</p>   |
| Role in leading conferences/journals/etc in the area | <p>Program Chair of SOCNE 2010, HSI'09, ETFA 08, ETFA 05.</p> <p>WIP Chair of ETFA 09, SIES 07, ETFA 06.</p> <p>General Chair of ECRTS 04.</p> <p>On the PC of many editions of ECRTS, RTSS, RTAS, WFCS, ETFA, RTN, FET, RTNS, WTR.</p> <p>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.</p> <p>On the Editorial Board of the Journal of Real-time Image Processing, Springer, Germany.</p>  |
| Notable past projects                                | <p>Italian National projects</p> <p>PRIN 04 entitled "Study and development of a real-time land control and monitoring system for fire prevention",</p> <p>COFIN 01 entitled "High-Performance Processing for Applications with High-Intensity Computational Requirements and Real-Time Constraints,</p> <p>both funded by the Italian Ministry of University and Research</p> <p>European project ESPRIT 26951 "NOAH - Network Oriented Application Harmonization.</p>   |
| Further Information                                  | <p>Responsible for the University of Catania of the flexWARE Project, Flexible Wireless Automation in Real-Time Environments, <a href="http://www.flexware.at">www.flexware.at</a> a STREP Project funded by the European Commission within the 7 FP.</p> <p>Involved in standardization activities as Member of the International Electrotechnical Commission (IEC), Technical Committee SC65C, as member of</p> <p>Working Group 16, dealing with Wireless Industrial communication networks.</p> <p>Working Group 17, dealing with Coexistence in Wireless Industrial communication networks.</p> <p>Working Group 11, Real-Time Industrial Ethernet (RTE).</p> <p>Senior member of the IEEE since June 2009.</p> <p>Recipient of the IEEE Industrial Electronics Society 2008 Early Career Award.</p> |

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

#### 6.4 *Affiliated International Partners*

Tarek Abdelzaher and Lui Sha are affiliated international partners to this activity. They are, however, listed in the corresponding thematic cluster deliverables.

## 7. Internal Reviewers for this Deliverable

The reviewers for this deliverable are

- Pau Martí, UPC
- Martin Törngren, KTH