IST-004527 ARTIST2
Network of Excellence
on Embedded Systems Design

Final plan for using and disseminating the knowledge

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With inputs from the Artist2 Consortium

Policy Objective (abstract)

The ARTIST2 NoE is structured around a set of intra and inter-cluster research activities on cutting-edge topics in embedded systems design, reflecting the following decomposition of the embedded systems design flow. This forms the essential ingredient of the NoE, which has strongly motivated the participating research teams.

This strong technical focus has led to very specific technical aims composing the strategy for using and disseminating knowledge created within the NoE.

We will continue to pursue this strategy in the ArtistDesign NoE.

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1. Overview

1.1 Strategy for using and disseminating knowledge

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This strong technical focus has led to very specific technical aims composing the strategy for using and disseminating knowledge created within the NoE.

Our strategy for dissemination and use of knowledge is at 3 levels:

1. *Targeted towards the NoE partners*
   Artist2 core partners are the heaviest users of all the dissemination actions described in this document – both as organisers and as participants.
2. *Targeted towards affiliated partners*
   Affiliated partners are not core members in the consortium, but receive support for travelling to Artist2 meetings, and actively contribute to the implementation of the Joint Programme of Activities (JPA). These affiliated partners include industrial, SME, academic, and international affiliates.
3. *Targeted towards the scientific and technical community in the large*
   This is achieved mainly bottom-up through the organisation of scientific events, publications, distribution of tools and components, industrial partnerships (not funded by Artist2), education; and through the Artist2 web pages.

Regarding Scientific events, we distinguish between conferences and workshops, schools, and high-level events mainly for International Collaboration.

- **High Level Events for International Collaboration**
  High-level Events are intended to gather together the very best world-leading experts from academia and industry, to discuss progress on the state of the art, relevant work directions.
- **Publications**
  The Artist2 community has been very active in publishing in scientific journals and conferences, as attested by the list of publications provided in this document. Clearly, this represents a huge amount of work. Publication of research is a bottom-up process, which may seem chaotic – but this is intrinsic to research.
- **Tools and Components**
  The Artist2 community plays a leading role in the distribution of software tools and components, on verification/validation tools. Some tools are distributed free of charge, such as UPAAL, IF. Others are commercialised, such as AbsInt, SymTA/S. For many other tools used in the platforms, and shared between the Artist partners, a common dissemination policy has not yet been defined.

- **Industrial Liaison**
  Artist2 has a wide array of affiliated industrial and SME partners. Most of these partners have participated in some way in the Artist2 technical meetings and the overall effort. There is strong, high-level industry participation through the various Spreading Excellence events organised by Artist2. Our active involvement in the European Technology Platform ARTEMIS also could have a significant and long-term impact.

  In addition, each Artist2 partner has an outstanding track record for interaction with industry. Globally, the Artist2 consortium has a very strong impact on European R&D in embedded systems. This impact is visible via the achievements in STREP and Integrated Projects.

  We believe that the strong involvement of four main Artist2 partners in the SPEEDS Integrated Project has a very positive impact on progress in the state of the art, in component-based embedded systems engineering.

1.2 Intended Audience

The intended audience for this “Final plan for using and disseminating the knowledge” includes but is not limited to members of the Artist2 consortium, affiliated partners, industrial partners, academics, tool providers, educators, and more generally the entire extended embedded systems design community.

It is hoped that this document will contain useful information about the large body of knowledge that has been amassed and disseminated via the Artist2 NoE. This effort will continue and increase in the ArtistDesign FP7 Network of Excellence.

2. Artist2 Events

Events organised and funded by the Artist2 Network of Excellence have been the main "in person" (as opposed to via the website) means by which the NoE has disseminated knowledge. We plan to continue this in the ArtistDesign Network of Excellence.

Both the Artist FP5 project, and then the Artist2 Network of Excellence has organised and funded a huge number of events on Embedded Systems Design:

- Embedded Systems: Industrial Applications '08 *November 12-13, 2008*
- WS on Multicores: Theory and Practice *October 28th, 2008*
- UML&FM'08 *October 27th, 2008*
- WESE'08: WS on Embedded Systems Education *October 23rd, 2008*
- Workshop on Foundations and Applications of Component-based Design (WFCD'2008) *October 19th, 2008*
- RNTS'08 *October 16-17, 2008*
- ACES^{MB} 2008 *September 29th, 2008*
- ARTIST2 Summer School 2008 in Europe *September 8-12, 2008*
- ARTIST2 South-American School for Embedded Systems 2008 *August 25-29, 2008*
- Artist2 Summer School in China 2008 *July 12-18, 2008*
- MoCC 2008 *July 3-4, 2008*
- WCET'08 *July 1st, 2008*
- OSPERT 2008 *July 1st, 2008*
- MPSoc 2008 *June 23-27, 2008*
- Movep'08 *June 23-27, 2008*
- Real-Time Kernels for Microcontrollers: Theory and Practice *June 23-25, 2008*
- COMES 2008 *June 17-18, 2008*
- Mapping of Applications to MPSoCs *June 16-17, 2008*
- ARTIST2 Graduate Course on: Automated Formal Methods for Embedded Systems 2008 *June 16-24, 2008*
- ARTIST2 Graduate Course on Embedded Control Systems *May 26-30, 2008*
- ArtistDesign Workshop on Design for Adaptivity *May 13-14, 2008*
- DataFlow Modeling for Embedded Systems 2008 *May 5th, 2008*
- APRES'08 *April 21st, 2008*
- SLA++P'2008 *April 5th, 2008*
- UML&AADL'2008 *April 2nd, 2008*
- Scopes 2008 *March 13-14, 2008*
- ARTIST2 Timing Analysis activity meeting 2008 *March 13th, 2008*
- ArtistDesign Automotive Systems Day 2008 *March 12th, 2008*

- ATESST Open Workshop *March 3rd, 2008*
- Synchron 2007 *November 26-30, 2007*
- ARTIST2 meeting on Integrated Modular Avionics *November 12-13, 2007*
- WESE'07: WS on Embedded Systems Education *October 4-5, 2007*
- EmSoft'07 *October 1-3, 2007*
- Embedded Systems Week 2007 *September 30th - October 5th 2007*
- Foundations of Component-based Design *September 30th, 2007*
- Between Control and Software (in honor of Paul Caspi) *September 28th, 2007*
- EPSD 2007 *September 10-14, 2007*
- FOSAD 2007 *September 9-15, 2007*
- First European-SouthAmerican School for Embedded Systems *August 21-24, 2007*
- Artist2 / UNU-IIST School in China - 2007 *August 1-10, 2007*
- UML&AADL'2007 *July 14th, 2007*
- FCC 2007 *July 4-5, 2007*
- CAV 2007 *July 3-7, 2007*
- ARTIST WS: Tool Platforms for ES Modelling, Analysis and Validation *July 1-2, 2007*
- ARTIST2 PhD Course on: Automated Formal Methods for Embedded Systems *June 4-12, 2007*
- 2nd Int'l ARTIST Workshop on Control for Embedded Systems *May 31st - June 1st 2007*
- FMGALS'2007 *May 29th, 2007*
- ARTIST2 Graduate Course on Embedded Control Systems *May 7-11, 2007*
- SCOPES 2007 *April 20th, 2007*
- Towards a Systematic Approach to Embedded System Design *April 20th, 2007*
- IRTAW-13 *April 17-19, 2007*
- HSCC'07 *April 3-5, 2007*
- NeRES 2007 *April 2nd, 2007*
- SLA++P 2007 *March 31st, 2007*
- Real-Time Microcontroller Systems: OSEK Standard and experiments on µcontroller devices *March 26-28, 2007*
- ARCS 2007 *March 12-15, 2007*
- ARTIST2 - MOTIVES 2007 *February 19-23, 2007*
- CASTNESS'07 Workshop and School *January 15-17, 2007*
- CASTNESS'07 Workshop and School *January 15-17, 2007*
- ARTIST2 Workshop on Basic Concepts in Mobile Embedded Systems *December 4-5, 2006*
- Synchron 2006 *November 27th - December 1st 2006*

- ARTIST2 Workshop on Timing Analysis in the Industrial Development Process (ISoLA 2006) *November 17th, 2006*
- MoCC - Models of Computation and Communication *November 16-17, 2006*
- Artist2 - Foundations and Applications of Component-based Design *October 26th, 2006*
- WESE'06 - Embedded Systems Education *October 26th, 2006*
- ATVA China 2006 *October 23-26, 2006*
- ATVA China 2006 *October 23-26, 2006*
- JTRES 2006 *October 11-13, 2006*
- MARTES 2006 *October 2nd, 2006*
- ADSD 2006: Advanced Digital Systems Design *September 25-29, 2006*
- FOSAD 2006: 6th International School on Foundations of Security Analysis and Design *September 10-16, 2006*
- First European Laboratory on Real-Time and Control for Embedded Systems *July 10-14, 2006*
- CORDIE'06: Concurrency, Real-Time and Distribution in Eiffel–like Languages *July 4-5, 2006*
- ARTIST2 Workshop on Requirements for Flexible Scheduling in Complex Embedded Systems *June 16th, 2006*
- ARTIST2 Workshop on Execution Platforms / Cluster Meeting *May 22-23, 2006*
- ARTIST2 Workshop on Specification and Verification of Secure Embedded Systems *May 18th, 2006*
- ARTIST2 / UNU-IIST Spring School in China 2006 *April 3-15, 2006*
- ARTIST2 Graduate Course on Embedded Control Systems *April 3-7, 2006*
- ARTIST2 Workshop Beyond AutoSar *March 23-24, 2006*
- ARTIST Workshop at DATE'06 *March 10th, 2006*
- Workshop: Distributed Embedded Systems *November 21-24, 2005*
- ARTIST2 Summer School 2005 *September 29th - October 2nd 2005*
- WESE'05 - ARTIST2 Workshop on Embedded Systems Education *September 22nd, 2005*
- 31st EUROMICRO Conference - Special session: Model Driven Engineering (MDE) *August 30th - September 3rd 2005*
- ACM-IEEE MEMOCODE'2005 *July 11-14, 2005*
- IST/NSF: Transatlantic Research Agenda on Future Challenges in Embedded Systems Design *July 8th, 2005*
- EU/US: Component-based Engineering for Embedded Systems *July 7th, 2005*
- OSPERT 2005 *July 5th, 2005*
- ARTIST Seminar on Adaptive Real-Time Systems *June 20-23, 2005*
- ARTIST Workshop at DATE'05 *March 11th, 2005*
- HSCC '05 - Hybrid Systems: Computation and Control *March 9-11, 2005*
- First S.Ha.R.K. Workshop *February 28th - March 4th 2005*

3. International Collaboration

The Artist2 Network of Excellence has always pursued an extremely active policy for organizing and funding International Collaboration events:

In Year 4 alone, we have had a very large number of International Collaboration events that we plan to pursue into the ArtistDesign NoE:

Year 4 Event: Foundations of Component-based Design
September 30th, 2007 Salzburg, Austria - within EmSoft / ES Week
http://www.artist-embedded.org/artist/-Foundations-of-Component-based-.html

Artist2 organised and funded this event, within Embedded Systems Week.

Discuss recent results on component-based design with emphasis on design frameworks for real-time systems encompassing heterogeneous composition and models of computation. Especially frameworks for handling non-functional and resource constraints, design under conflicting dependability criteria, trade-offs between average performance and predictability.

The workshop aims to gather together researchers from computer science and electrical engineering and will seek a synthesis between the underlying paradigms and techniques. The focus is not only on fundamental results but also on their implementation in methods and tools and their concrete application in areas such as automotive, avionics, consumer electronics and automation.

Year 4 Event: Workshop on Embedded Systems Education (WESE 2007)
October 4-5, 2007 Salzburg, Austria (within ES Week)
http://www.artist-embedded.org/artist/-WESE-07-.html

It is widely recognized that the embedded system domain is a multidisciplinary one, requiring a large variety of skills from control and signal processing theory, electronics, computer engineering and science, telecommunication, etc., as well as application domain knowledge.

This has motivated a recent but ever growing interest in the question of educating specialists in this domain and this has also been recognized as a particularly difficult problem.

This third workshop on the subject aims to bring researchers, educators, and industrial representatives together to assess needs and share design, research, and experiences in embedded systems education. Industrial needs regarding embedded systems education

Year 4 Event: ARTIST2 meeting on Integrated Modular Avionics
November 12-13, 2007 Roma, Italy
http://www.artist-embedded.org/artist/-ARTIST2-meeting-on-Integrated-.html

Today, the exponentially increasing diversity of airborne systems results in an ever increasing number of computers and controllers for system management, monitoring, and control. The development of specific ad-hoc solutions causes increases in costs, which in turn impacts purchase prices and operational costs. To overcome this, standardization principles and reuse of function units are now considered, via Integrated Modular Avionics.

Integrated Modular Avionics (IMA) has set the principles of standardized components and interfaces of hardware and software in aircraft. These principles have been applied for the first time in the development of the Airbus A380. Further developing IMA raises a number of issues that require fundamental research efforts, in tight coordination with engineering needs.

ARTIST2, the European Network of Excellence on embedded systems has organized, as part of its activity on "scientific challenges in specific industrial sectors", a two-day workshop dedicated to Systems, Software, and Architecture, aspects of IMA.

Year 4 Event: Artist2 Summer School in China 2008
http://www.artist-embedded.org/artist/-Artist2-Summer-School-in-China-.html
July 12-18, 2008 Shanghai, China

This was the 3rd edition of a school on Embedded Systems Design.
This year, the school was organized in collaboration with the SEI/ECNU and the LIAMA.

This year, we were able to do a far stricter degree of selection amongst the candidates.
We selected 81– the fill list is available here.

Year 4 Event: ARTIST2 South-American School for Embedded Systems 2008
http://www.artist-embedded.org/artist/-ARTIST-2-South-American-School-.html
August 25-29, 2008 Universidade Federal de Santa Catarina, Florianopolis, Brazil

After the successful First ARTIST2 South-American School for Embedded Systems in Buenos Aires, Argentina, this second edition in Florianopolis, Brazil, strengthens the cooperation between Europe and South America in the area of embedded systems, both at educational and research levels. For this purpose, the goal of the school is to provide state-of-the-art courses on embedded systems oriented towards advanced students and young researchers.

We believe the school provides the ground for cross-fertilization between Europe and South-America with an expected mutual high added-value. Therefore, the lectures given by European researchers were accompanied by talks and a poster session for participants to present and discuss their ongoing work.

4. Interaction with Industry

4.1 Interaction with the automotive industry

Specific effort has been dedicated to interacting with the automotive industry. Recall that the automotive industry is one of the two driving sectors for drastic changes to embedded systems design methods, and is certainly *the* sector where changes have been deepest and quickest. This effort was made possible thanks to prior personal strong ties that some key participants (including: Werner Damm (OFFIS), Alberto Ferrari and Alberto Sangiovanni-Vincentelli (PARADES), Martin Törngren (KTH), Rolf Ernst (U. Braunschweig), Sébastien Gérard (CEA)), and affiliates (including: Stefan Kowalewski (RWTH Aachen)) of ARTIST2 had with the Autosar consortium. Albert Benveniste (INRIA) and Werner Damm (OFFIS) jointly organized the *ARTIST2 Workshop* ***Beyond Autosar***[1], held in Innsbruck on March 23-24 2006. The workshop discussed in particular issues related to timing in the Autosar model (the so-called *timing model* of Autosar). More generally, the workshop helped making the academic community aware of the research issues raised by this approach from automotive industry. An elaboration of the results has been presented at EMSOFT 2006 and at a GM Workshop in Bengalore (January 2007).

OFFIS has become a development member of Autosar. This move was proposed to OFFIS by BMW, following in depth technical discussion on the link between the SPEEDS HRC meta-model and the Autosar meta-model regarding timing and safety aspects.

The integrated project SPEEDS has developed a layered meta-model of heterogeneous rich components (HRC) and standardized approaches for the integration of commercial industry standard modelling tools to assemble system-level design models with rich interface specifications by combining models expressed in any authoring tool compliant to the integration standard. A SPEEDS Automotive Day was organized to discuss with the automotive industry how the AUTOSAR methodology can be supported by SPEEDS technologies striving to reconcile the advantage of early system-level analysis with the overall AUTOSAR objective of decoupling function design from its implementation. These results have been presented in several highly visible events, including the DATE 2008 Automotive Day, and a keynote presentation at the Annual Mathworks Automotive Conference 2008 in Stuttgart. More in depth technical discussion on the relation between Speeds HRC model and Autosar were conducted at meetings with BMW, Bosch, and Daimler; see also section on standardization.

Sébastien Gérard (CEA) and Henrik Lönn (Volvo Tech) are organizing a workshop in the context of the ATESST project which aims are inviting key persons working on the context of automotive domain in order to share experience on the usage of standards like MARTE, AADL and Autosar especially in the context of the Architecture Description Language for Automotive, EAST-ADL. They also have setup a new project, ADAMS, (in collaboration with Laurent Rioux from Thales and Julio Medina from Cantabria) dedicated to promote the usage of MARTE in the context of the automotive domain. Let's notice also that this project has to deal also with the aeronautics domain.

MDH has strategic long-term co-operations with seven companies: ABB Corporate Research, ABB Robotics, Arcticus Systems, Bombardier Transportation, CC-Systems, Ericsson, and Volvo Construction Equipment. In recent years, the cooperation has been extended to international subsidiaries and partners of these companies. In addition to this strategic cooperation we have cooperation also with several other Swedish and international

[1] http://www.artist-embedded.org/FP6/ARTIST2Events/Events/Innsbruck06/

companies[2]. The strategy has resulted in substantial industrial support, including a 9.6 MSEK donation from ABB, close to 30 graduate students funded by industry, an industrial lab (currently been set up in cooperation with Ericsson and ABB), a top-talent program for recruitment of international master level students, Adjunct industrial professors from ABB and Volvo, as well as a large number of national and international joint research projects. The cooperation includes the following concrete results:

- further development of the Rubus component model inspired by the Save component model and its implementation in, e.g., Volvo Construction Equipment,
- development of component repository used at CC systems, including components and additional artefacts such as requirements, models and implementations, tests,
- model extraction tools used experimentally at ABB Robotics for modelling real-time properties of legacy systems,
- introduction of model-based approaches for modelling and developing applications in Ericsson,
- work on software decomposition of legacy systems and transformation of development to product-line development at ABB Substation Automation,
- development of a real-time database in cooperation with Mimer,
- in cooperation with core partners building a master program in industrial software engineering focussing on design, architectural analysis, component-based development and dependability of embedded systems.

PARADES has tight links with the ST automotive division and with the Joint Development Group ST-FreeScale and has helped in defining roadmaps for design methodologies, tools and architectures for fault tolerant products. It has a number of interactions with Tier 1 companies including Bosch and Nippon Denso on this very topic. Alberto Sangiovanni Vincentelli is a member of the GM Science and Technology Advisory Board and has fostered joint work with General Motors on distributed embedded system design. In addition, PARADES has contributed to the design of an advanced intelligent component in a tire that consists of a set of sensors, a computing engine, an energy scavenger and wireless communication with Pirelli.

4.2 Interaction with the aeronautics industry

Specific effort has been launched to interacting with the aeronautics industry. This effort was made possible thanks to prior personal strong ties that some key participants (including: Werner Damm (OFFIS), Albert Benveniste (INRIA), and Paul Caspi (Verimag)) had with this industry in EU. RTC cluster felt that it was important that the research community around ARTIST2 was made aware of the scientific and technical issues raised by the move to Integrated Modular Avionics (IMA) approach. Recall that the aeronautics industry is one of the two driving sectors for drastic changes to embedded systems design methods, and is certainly *the* sector where changes are most demanding.

Albert Benveniste (INRIA) and Paul Caspi (Verimag), in tight cooperation with John Rushby (SRI, Stanford), have organised an ARTIST2 workshop on IMA, held on November 12-13 2007 in Rome at PARADES location. Speakers include key persons from Airbus, Dassault-Aviation,

[2] Additional national cooperation includes PhD-students funded by Ardendo, Level21, Prevas, and Scania, as well as joint projects with around 10 SMEs; internationally we cooperate both with giants, such as Nokia, Philips, and Tata, as well as with SMEs, such as Symtavision, Absint, and Rapita Systems.

Israeli Aerospace Industries, Honeywell and WindRiver, plus John Rushby and ARTIST2 participants.

Verimag has recently started a direct collaboration with the European Space Agency ESA which has the objective to adapt results of the OMEGA and the ASSERT project to the needs of the engineers at ESA. A first step consists in an adaptation of the IF tool for UML to UML 2 and to the current version of Rhapsody.

4.3 Interaction with the consumer electronics industry

Thanks to the International Collaboration Days organized within the ARTIST2 project, the ART cluster got in contact with two major companies, Philips and Ericsson, acting in the domain of consumer electronics. After a tight interaction with the engineers responsible for the software development process, a number of industrial needs have been identified, that would make new generation products more robust and flexible.

To cope with a constantly increasing complexity of software applications (already consisting of several million lines of code and hundreds of concurrent activities), a system supporting memory and temporal protection would allow safely mixing real-time and non real-time applications with the benefit of achieving a more scalable platform. Therefore, the work on resource reservation carried out within the ART cluster is of crucial importance to manage the increased complexity of the applications in this domain.

In addition, multimedia systems exhibit a highly dynamic behaviour, 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. Again, the expertise existing in the ART cluster on overload management is of high interest for these companies, since it allows building flexible as well as predictable real-time systems that can react to load changes and perform QoS adaptation in a controlled fashion.

4.4 Interaction with the electronics industry

A new interaction of the ART cluster with Microchip Technology has been started on real-time embedded platforms for monitoring and control. In particular, the expertise existing in the ART cluster on real-time embedded control applications and real-time operating systems is extremely attractive for Microchip, who is interested in pushing the development of real-time embedded applications using 16-bit microcontrollers (as the dsPIC30 and the dsPIC33).

In this context, a big opportunity for the ART cluster is to find an agreement with Microchip to define the characteristics of a small real-time embedded platform for sensory acquisition and motor control that can be used (in conjunction with a wireless card) as a node of a mobile wireless network. This unit would be more powerful and flexible than a mote and could be used to carry out experiments on sensor networks, embedded control, mobile robot teams and distributed control systems.

4.5 Other Cross-sectorial Interaction with Industry

Since April 2008, the INRIA team has started a cooperation with an electronics faculty and a local SME (DeltaDore). This company is a national leader in the domain of home and industrial building equipment. A framework for cooperation has been set up in order to transfer know-how on timed component based architectures. This domain of industry is a promising field for the dissemination of embedded, soft real time component architectures. The challenges of this

field lie in the frequent evolutions of deployed architectures. These evolutions call for self configurable and self adaptable components.

In future and many state-of-art projects a convergence of different application domains can be observed for different industrial applications (for example, a multimedia system and safety-critical functions are integrated in a car). In January 2009, the EU STREP project GENESYS (http://www.genesys-platform.eu/) has started with coordination by TU Vienna. The objective of the GENESYS project is to develop a cross-domain reference architecture for embedded systems that can be instantiated for different application domains to meet the requirements and constraints documented in the ARTEMIS strategic research agenda. These requirements are composability, networking, security, robustness, diagnosis, integrated resource management and evolvability. The project will result in a conceptualization of the cross-domain architecture, a specification of cross-domain core services and optional services for the selected application domains, and four exploratory prototypes that will demonstrate and help to evaluate the feasibility of selected central architectural concepts in the different application domains. The analysis of the requirements and the definition of an architectural style with fundamental principles for cross-domain embedded systems have been completed. The next steps will be the definition of the architectural services, the completion of the methodology framework, the implementation of the prototypes and the assessment of the architecture.

The Inria Triskell team is now part of the S3 (Software Services and Systems) European network of excellence. This network started in March 2008 and will end in 2012. The Inria Triskell team is involved in two joint research activities: adaptation and monitoring principles, techniques and methodologies for service based systems, and End to end quality provision and service level agreement conformance. The Triskell team intends to adapt results gained from Artist cooperation on timed components and use these results in the S3 collaborations in the joint research activities mentioned above. The crossbreed between components for embedded systems (Artist2) and service based architectures (S3) will be supported by experiments in the building automation industrial field. Software architectures in this field require real time, reliability, predictability as well as openness and dynamic reconfiguration.

Within the German Competence Cluster SafeTRANS, two SafeTRANS Industrial focussing on V&V methods and on architecture assessments have been organized, with participants from automotive, aerospace, and rail industries. OFFIS is a founding member of SafeTRANS, with Werner Damm being the SafeTRANS Chairman. SafeTRANS has – through its role as a founding cluster of EICOSE - been as well instrumental in deriving research priorities and subprogram formation for the Artemis Joint Undertaking, see below.

OFFIS is also represented through Werner Damm at the Steering Board level of the German Innovation Alliance on Embedded Systems SPES 2020, which is about to be launched in November 2008. This alliance puts together Academic Institutions and Industrial Stakeholders in Embedded Systems development, providing a foundational basis for applications in multiple industrial sectors, including automation, automotive, aerospace, energy, and medical.

Within the Artemis Innovation Cluster on Transportation, EICOSE, the European Expert Group on Transportation has in several meetings identified research priorities for embedded systems from the perspective of the transportation sector, leading to a proposal of the three candidates for subprogrammes (on cost-efficient methods for the development of safety relevant embedded systems, SP1; on Computing Environments for Embedded Systems, SP5, and on Human Centred Design for Embedded Systems, SP8) for the Joint Undertaking Artemis. All three proposals for subprogrammes were after modification integrated in the Artemins Multi-Annual Strategic Work-Plan. All subprogrammes are cross-sectorial in nature, addressing in particular all transportation sectors. From Artist2, Werner Damm from OFFIS as well as Didier Juvien from CEA are members of the Eicose Steering Board, with Werner Damm serving as EICOSE chairman until May 2008.

4.6 Involvement in ARTEMIS

Several RTC Cluster partners, including CEA, INRIA, OFFIS, PARADES, VERIMAG; and TU Vienna, are actively involved in ARTEMIS, an initiative to form a European technology platform on embedded systems supporting the needs for various industrial and academic embedded application domains, such as the automotive, avionics, but also the real-time requirements of consumer electronics. The interaction with ARTEMIS is expected to influence the work within ARTIST2 positively towards establishing a well-defined conceptual fundament that is useful for academia and industry. Several partners (CEA, INRIA, OFFIS) are involved in EICOSE, the recently established European Institute for COmplex and Safety Critical Embedded Systems Engineering pushed by two French clusters System@tic Paris Région and Aerospace in association with the German cluster SafeTrans. EICOSE has been selected as the ARTEMIS Innovation Cluster on Transportation. VERIMAG and FT R&D contribute within French MINALOGIC cluster to promote the creation of a center of excellence in ARTEMIS encompassing "Nomadic environments" and "Private space" application contexts of the ARTEMIS SRA chart. Contacts have been taken with Nokia and ElectroBit from the Finlandais Symetra Consortium.

The Joint Undertaking Artemis has been created in February 2008, and is about to close the evaluation of proposals submitted to the first call of the Artemis Joint Undertaking. As described above, EICOSE has played an instrumental role in coordinating the research prioirities of both industrial and academic stakeholders in the transportation domain, contributing significantly to the Artemis Multi Annual Strategic Plan in the formation of three out of eight subprograms also forming the basis for the 1st call. Both OFFIS and CEA are members of the EICOSE steering board.

5. Publications

5.1 Major Surveys, Textbooks and Roadmaps

We cite here some of the major studies, surveys, and roadmaps from both Artist FP5 (the first Artist project) and Artist2.

5.1.1 Artist FP5 Guidelines for a Graduate Curriculum on Embedded

http://www.artist-embedded.org//docs/Publications/Education.pdf

The design of real-time embedded systems requires skills from three specific disciplines: control theory, computer science, and electronic engineering, and their combination. This often involves experts from differing backgrounds, who do not recognize that they address different issues from complementary angles.

The motivation for defining a specific curriculum in embedded systems is mainly to promote the training of engineers with expertise in the above three disciplines.

5.1.2 Artist FP5 / ACM Transactions in Embedded Computing Systems Special Issue on Education

http://www.artist-embedded.org/artist/ACM-Special-Issue-on-Education.html

Embedded systems applications now include a very large proportion of the advanced products designed in the world, spanning transport (avionics, space, automotive, trains), electrical and electronic appliances (cameras, toys, television, washers, dryers, audio systems, and cellular phones), process control (energy production and distribution, factory automation and optimization), telecommunications (satellites, mobile phones and telecom networks), and security (e-commerce, smart cards), etc.. The relative weight of software in the value of embedded systems is constantly expanding. The extensive and increasing use of embedded systems and their integration in everyday products marks a significant evolution in information science and technology.

There is now a strategic shift in emphasis for embedded systems designers: from simply achieving feasibility, to achieving optimality. Optimal design of embedded systems means targeting a given market segment at the lowest cost and delivery time possible. Optimality means seamless integration with the physical and electronic environment while respecting real-world constraints such as hard deadlines, reliability, availability, robustness, power consumption, and cost. In our view, optimality can only be achieved through the emergence of embedded systems as a discipline in its own right.

An important factor for the emergence of embedded systems as a discipline is the existence of integrated curricula for training engineers and researchers, able to tackle a range of topics which until now had been spread across many different areas, including: general computer science and engineering, real-time computing, systems architecture, control and signal processing, security and privacy, networking, mathematics, electronics.

This special issue of the ACM Transactions in Embedded Computing Systems aims to provide the basis for integrated undergraduate and graduate curricula covering the essential areas of knowledge for tomorrow’s embedded systems engineers and researchers.

5.1.3 ARTIST FP5 Roadmap for Embedded Software and Systems

http://www.artist-embedded.org/artist/ARTIST-FP5-Roadmap-for-Embedded.html

This extensive and increasing use of embedded systems and their integration in everyday products mark a significant evolution in information science and technology. Nowadays embedded systems design is subject to seamless integration with the physical and electronic environment while meeting requirements like reliability, availability, robustness, power consumption, cost, and deadlines. Thus, embedded systems design raises challenging problems for research, such as security, reliable and mobile services, large-scale heterogeneous distributed systems, adaptation, component-based development, and validation and tool-based certification.

This book results from the ARTIST FP5 project funded by the European Commission. By integration 28 leading European research institutions with many top researchers in the area, this book assesses and strategically advances the state of the art in embedded systems. The coherently written monograph-like book is a valuable source of reference for researchers active in the field and serves well as an introduction to scientists and professionals interested in learning about embedded systems design.

5.1.4 "Embedded System Design" textbook by Peter Marwedel, TU Dortmund

http://www.artist-embedded.org/artist/Embedded-Systems-Design,441.html

Embedded systems can be defined as information processing systems embedded into enclosing products such as cars, telecommunication or fabrication equipment. Such systems come with a large number of common characteristics, including real-time constraints, and dependability as well as efficiency requirements. Following the success of information technology (IT) for office and workflow applications, embedded systems are considered to be the most important application area of IT during the coming years. This importance of embedded systems is so far not well reflected in many of the current curricula. Embedded System Design is intended as an aid for changing this situation. It provides the material for a first course on embedded systems, but can also be used by PhD students and professors.

A key goal of this book is to provide an overview of embedded system design and to relate the most important topics in embedded system design to each other. It should help to motivate students as well as professors to put more emphasis on education in embedded systems.

5.1.5 Artist2: Languages and Tools for Hybrid Systems Design

http://www.artist-embedded.org/artist/Languages-and-Tools-for-Hybrid,442.html

The explosive growth of embedded electronics is bringing information and control systems of increasing complexity to every aspect of our lives. The most challenging designs are safety-critical systems, such as transportation systems (e.g., airplanes, cars, and trains), industrial plants and health care monitoring. The difficulties reside in accommodating constraints both on functionality and implementation. The correct behaviour must be guaranteed under diverse states of the environment and potential failures; implementation has to meet cost, size, and power consumption requirements. The design is therefore subject to extensive mathematical analysis and simulation. However, traditional models of information systems do not interface well to the continuous evolving nature of the environment in which these devices operate. Thus, in practice, different mathematical representations have to be mixed to analyze the overall behaviour of the system. Hybrid systems are a particular class of mixed models that focus on the combination of discrete and continuous subsystems. There is a wealth of tools and languages that have been proposed over the years to handle hybrid systems. However, each tool makes different assumptions on the environment, resulting in somewhat different notions of hybrid system. This makes it difficult to share information among tools. Thus, the

community cannot maximally leverage the substantial amount of work that has been directed to this important topic. In this paper, we review and compare hybrid system tools by highlighting their differences in terms of their underlying semantics, expressive power and mathematical mechanisms. We conclude our review with a comparative summary, which suggests the need for a unifying approach to hybrid systems design. As a step in this direction, we make the case for a semantic-aware interchange format, which would enable the use of joint techniques, make a formal comparison between different approaches possible, and facilitate exporting and importing design representations.

5.1.6 Artist2: Tools for Real--Time Control Systems Codesign

http://www.artist-embedded.org/artist/Tools-for-Real-Time-Control,445.html

Authors: Dan Henriksson, Ola Redell, Jad ElKhoury, Martin Törngren, and KarlErik Årzén: Department of Automatic Control Lund Institute of Technology April 2005

This report presents a survey of current simulation tools in the area of integrated control and real- time systems design. Each tool is presented with a quick overview followed by a more detailed section describing comparative aspects of the tool. These aspects describe the context and purpose of the tool (scenarios, development stages, activities, and qualities constraints being addressedE and the actual tool technology Dtool architecture, inputs, outputs, modeling content, extensibility and availability).

The tools presented in the survey are the following; Jitterbug and TrueTime from the Department of Automatic Control at Lund University, Sweden, AIDA and XILO from the Department of Machine Design at the Royal Institute of Technology, Sweden, Ptolemy II from the Department of Electrical Engineering and Computer Sciences at Berkeley, California, RTSIM from the RETIS Laboratory, Pisa, Italy, and Syndex and Orccad from INRIA, France.

The survey also briefly describes some existing commercial tools related to the area of real-time control systems.

5.1.7 Artist2 Survey of Programming Languages

http://www.artist-embedded.org/artist/ARTIST-Survey-of-Programming.html

Alan Burns (Editor)

The production of real-time and embedded systems involves the use of many different tools and techniques. As these systems become more software centric, programming languages employed in the production of this software are now of crucial importance. Any language has the dual role of enabling expression whilst at the same time limiting the framework of concept and abstractions within which that expressive power may be applied. If a language does not support a particular notion then programmers cannot apply it and may even be totally unaware of its existence. For real-time programming languages there are many such concepts that are supported to a greater or lesser extent in a range of languages that purports to be appropriate for the embedded systems domain. For example: time, clocks, concurrency, deadlines, events and signals, exceptions, periodicity, scheduling and predictability are all important notions that programmers may wish to address and which should therefore be available to them via the implementation languages that they can employ.

This survey considers over twenty programming languages. The short reports available on each language aim to introduce the main features of the language, provide the links to further sources of information, and give an indication of the current developments within the language. Some languages are mature, used widely and are the subject of rigorous standardisation procedures. Others are research languages, with a small user population and an informal definition. All languages covered in the survey are implementation languages in

that they are supported by tools (typically compilers) which generate executable code for the designated hardware platform. To give a structure to the survey each language is placed in one of five classes: imperative, functional, synchronous, model-based, and platform-based. However this is a loose classification as some languages could easily be placed in more than one category, and imperative languages can usually be constrained to mimic the other styles.

A final point to note about this survey is that it is inevitably incomplete and it is a dynamic document. Extra contributions can easily be added (email the editor). Similarly, additional surveys of the languages that are covered can be included.

The report covers :

- Imperative Languages
- Functional Languages
- Synchronous Languages
- Model-Based Languages
- Platform-Based Language

5.1.8 Artist2 Roadmap on Control of Real-Time Computing Systems

Written by the cluster: Control for Embedded Systems Cluster, 2005
http://www.artist-embedded.org/docs/Events/2005/Artist2_Y1Review/Deliverables/Artist2/18b_Control_Roadmap.pdf

An important result of the EU ARTIST FP5 project was four roadmaps on Hard Real-Time Development Environments, Component-Based Design and Implementation Platforms, Adaptive Real-Time Systems for Quality of Service Management, and Execution Platforms respectively, [Bouyssounouse and Sifakis, 2005]. The current roadmap written by the partners of the Control for Embedded Systems cluster within the EU/IST FP6 Network of Excellence ARTIST2 can partly be viewed as an extension of the adaptive real-time system roadmap. The focus is how flexibility, adaptivity, performance and robustness can be achieved in a real-time computing or communication system through the use of control theory.

Similar to the ARTIST roadmaps this roadmap is intended as a roadmap for research rather than an roadmap on industrial R & D in general. The roadmap is **not** a roadmap on real-time control. In real-time control the real-time computing system is used as an implementation platform for a control system controlling some external dynamical system, often a physical plant with external inputs and outputs. Here, it is instead the real-time computing system that is the subject to the control. The item that is controlled is in most cases the allocation of computing and communication resources, e.g., the distribution or scheduling of CPU time among different competing tasks, jobs, requests, or transactions. Due to this, control of computing systems also goes under the name of feedback scheduling.

The roadmap assumes basic knowledge in real-time computing and control engineering from the readers. In parallel to the current roadmap a separate roadmap on Real-Time Techniques in Control System Implementation has been developed.

5.2 Artist Mailing List

The Artist Mailing List is used for widespread dissemination of short announcements about events, calls for papers, open positions and other announcements in Embedded Systems Design. Several announements are disseminated on the Artist Mailing List each week.

Anyone may subscribe to the Artist Mailing List.

Anyone who has subscribed to the Artist Mailing List may post announcements to it, although certain restrictions (see belox) apply. The list is moderated by the Artist Technical Coordinator.

The Artist Mailing List is separate from the one for the Artist Newsletter.

How to Subscribe

To subscribe or unsubscribe to the Artist Mailing List, the subscriber simply sends an appropriate message to the mail server, then *confirms his/her identity* by replying to the message sent by the mail server.

New subscribers receive a welcome message confirming their subscription to the Artist Mailing List.

Submitting an Announcement

To submit an announcement, a subscriber simply sends their message to: announcements@lists.artist-embedded.org.

Once the moderator has approved it, the message is sent to the mailing list as is.

Restrictions on Messages

To ensure that interest in the list remains high, the list is moderated to check that these few common-sense guidelines are followed:

1. Only announcements of **interest to the general community**, of a non-commercial nature, will be accepted.
2. Please plan to submit **only one announcement** for a given event.
3. Attachments should be **very small**. If you want to provide larger information, make it available on a website and just provide the link.
4. The **name of the person** sending the message should appear clearly in the "From" field (eg: Fred Astaire <fastaire@domain.uk>).
5. The topic must appear clearly on the subject line (preferably just the title of the event or announcement)
6. The **Body of the message** must contain the main elements. Details may be provided in an attachment, but it's not OK to have only an attachment.
7. A **Subject line** is needed. It's best to put only the full title of the event or announcement.

Privacy Policy

Artist has a very strict privacy policy: we will not give the list of subscribers to any outside parties, including the Artist core participants.

5.3 Videos

In Year4, the Artist2 Summer school has started recording videos of the lectures, which will be made available free of charge via the Artist web portal.

At the time of this writing, the videos were still in post-production, but a number of these are ready here:

- **Klaus Havelund** (NASA JPL)
  Rule-based Runtime Verification
- **Giorgio Buttazzo** (Pisa)
  Real-Time Scheduling and Resource Management
- **Reinhard Wilhelm** (Saarland)
  Timing Analysis and Timing Predictability
- **Kai Richter** (Symtavision)
  Establishing Formal Scheduling Analysis in Automotive Design Processes
- **Karl Erik Arzen** (Lund)
  Pedro Albertos (UP Valencia)
  Implementation of control systems in resource-constrained embedded systems
- **Ed Brinksm** (ESI)
  Quantitative Testing Theory
- **Michael Gonzalez** (U. Cantabria)
  Contract-based resource reservation and scheduling
- **Lothar Thiele** (ETHZ)
  Performance analysis of distributed real-time systems
- **Diederik Verkest** (IMEC)
  Mapping C code on MPSoC for Nomadic Embedded Systems
- **Luis Almeida** (U. Aveiro)
  The challenges of flexible real-time communication
- **Kim Larsen** (Aalborg)
  Quantitative Verification and Synthesis for Embedded Systems
- **Hermann Haertig** (TU Dresden)
  Enforceable Component-Based Realtime Contracts
- **Peter Marwedel & Heiko Falk** (TU Dortmund)
  Memory architecture aware compilation
- **Rance Cleaveland** (University of Maryland, USA)
  An instrumentation -based Approach to Controller Model Validation
- **Raj Rajkumar** (Carnegie Mellon University)
  Building Blocks for Large-Scale Wireless Sensor Networks

- **Marta Kwiatkowska** (Oxford U.)
  Quantitative Probabilistic Verification of Systems

- **Gerard Berry** (Esterel Technologies)
  The evolution of the synchronous model

- **Marco Bekooij** (NXP)
  Dataflow analysis for predictable multiprocessor design

- **Steve Vestal** (Honeywell)
  Automating compositional safety analysis for IMA systems

An overview video clip of the school was also made:

- **ARTIST2 Summer School 2008 in Europe**
  http://artist.imavox.ch/clip_autrans/

5.4 Research Publications

The Artist2 partners publish a huge number of research papers, and exert a wide influence in the area.

The lists of references for joint papers alone (research papers authored by representatives from two or more Artist2 partners), across the 4 years of the NoE, span 43 pages.

5.5 Newsletter

The Artist2 Network of Excellence has also published a high-quality Newsletter, which will be continued into ArtistDesign. http://www.artist-embedded.org/artist/Artist2-Newsletter,438.html

The following pages show a sample edition of the Newsletter.

The newletter is distributed electronically to a mailing list with over 20000 entries.

ARTIST Newsletter n°4

ARTIST Newsletter n°4
September 2007

Newsletter Subscription

Subscription to this newsletter is free of charge. If you would like to be added or removed from the subscription list, simply send a message to the editor:

Bruno.Bouyssounouse@imag.fr

Online

This newsletter is also available online:
http://www.artist-embedded.org/artist/Artist2-Newsletter-438.html

Overview of this issue

This issue includes:

- descriptions of the main upcoming European workshops, conferences and schools on embedded systems design;
- invited articles from EADS on «Component-based Design and Implementation of Avionics Systems» and from Nokia on «Performance / Power Measurements for Embedded Multi-Core Processors»;
- a series of focus articles on Adaptive Real Time.

About Artist2

The long-term objective of the ARTIST2 Network of Excellence on Embedded Systems Design (http://www.artist-embedded.org/) is to build a durable European research community on Embedded Systems Design, by integrating the topics, teams, competencies, from 7 essential topics: Real-Time Components, Adaptive Real-Time, Compilers and Timing Analysis, Execution Platforms, Control for Embedded Systems, Testing and Verification.

The overall objective of Artist2 is the emergence of Embedded Systems Design as a mature scientific and engineering discipline, through tight integration of central players from the European research community. A central mission for the NoE is to disseminate excellence in the area, through an ambitious Joint Programme of Activities for Spreading Excellence, including Education and Training, Dissemination and Communication, Industrial Liaison, and International Collaboration.

Artist2 has 40 partners, including 2 large industrial and 3 SMEs. It integrates joint research activities at two levels:

- *Integration within clusters*. Currently, efforts in the area are fragmented, and no single European research group gathers sufficient critical mass. Integrating the clusters is the first step towards integrating the area as a whole.
- *Integration between cluster topics* to create the multi-disciplinary community that will pilot the embedded systems design area. This will be achieved through research and integration activities that will bring together teams from different clusters.

Expected Results

ARTIST2 has a durable structuring effect on European research:

- There is a direct impact on the integration of academic research. It allows for new, coherent theoretical frameworks to emerge, particularly those that can contribute to the unification of the area. For this, the NoE takes measures to overcome the inherent contextual, cultural, and disciplinary diversity.
- ARTIST2 will impact R&D activity from an organizational perspective. ARTIST2 explicitly aims to create a context, an infrastructure and a culture for the design of joint, multi-organisational, multi-disciplinary R&D work in embedded systems design.
- ARTIST2 has a structural impact on European education in Embedded Systems Design, by:
  - Integrating state of the art knowledge into the curricula and accelerating convergence towards multi-disciplinary approaches.
  - Promoting approaches and techniques, which are well-adapted to meeting current and future industrial needs.

Table of Contents

Mailing List

To receive *frequent* information on topics in Embedded Systems Design (workshops, open positions, etc), subscribe to our mailing list:

http://www.artist-embedded.org/artist/Artist-Mailing-List.html

This list is separate from the one for the Artist newsletter.

Workshops

Newsletter
September 2007

Artist Web Portal

The list of upcoming ARTIST-related events is available online:
http://www.artist-embedded.org/

MARTES'07

Modeling and Analysis of Real-Time and Embedded Systems
Oct 2nd 2007
Nashville, Tenessee (USA)
with MoDELS/UML 2007
organised with Artist partners

This workshop addresses all aspects of the representation, analysis, and implementation of DRES models, related to, but not limited to, the following principal topics:

- Modeling RT/E using modeling languages such as UML
- Semantic aspects of real-time in UML and similar modeling languages
- Methods and tools for analysis of RT systems and components

http://www.artist-embedded.org/artist/-MARTES-2007-.htmlWCET-07.html

Between Control and Software

In honor of Paul Caspi
September 28th, 2007
VERIMAG - Grenoble, France
organised and funded by Artist

The relationship between control and computation has been in the focus of the research of Paul Caspi, leading, among other things, to the development of the Lustre language which combines the high-level description of control loops as viewed by the control engineer, with insights coming from the theory and practice of programming languages.

http://www.artist-embedded.org/artist/Between-Control-and-Software.html

Upcoming Major Workshops and Seminars

within EmSoft / ES Week
Foundations of Component-based Design

September 30th, 2007
Salzburg,Austria
Organised,funded by Artist

The workshop aims to gather together researchers from computer science and electrical engineering and will seek a synthesis between the the underlying paradigms and techniques. The focus is not only on fundamental results but also on their implementation in methods and tools and their concrete application in areas such as automotive, avionics, consumer electronics and automation.

The workshop will address specific challenges such as:

- Foundations and Expressiveness of System Description Formalisms:
  - *basic concepts,*
  - *componentinteraction,*
  - *resource modeling (energy, memory, time, ...),*
  - *combining synchrony vs. asynchrony, event-triggered/data-triggered/ time triggered, separation of concerns;*
- Component-based Design, Methods and Tools:
  - *analysis methods (compositional verification techniques; resource usage);*
  - *designmethods(property preserving structuring principles; refinement/ implementation relations)*
  - *tradeoffs between predictability and efficiency*
  - *implementation methodologies and tools*
- Application Scenarios and Relevant Case Studies

http://www.artist-embedded.org/artist/-Foundations-of-Component-based-.html

WESE'07
Workshop on Embedded Systems Education

October 4-5, 2007
Salzburg,Austria
Organised,funded by Artist

It is widely recognized that the embedded system domain is a multidisciplinary one, requiring a large variety of skills from control and signal processing theory, electronics, computer engineering and science, telecommunication, etc., as well as application domain knowledge.

This has motivated a recent but ever growing interest in the question of educating specialists in this domain and this has also been recognized as a particularly difficult problem.

This third workshop on the subject aims to bring researchers, educators, and industrial representatives together to assess needs and share design, research, and experiences in embedded systems education.

Organisers

- Jeff Jackson
  University of Alabama, USA
- Martin Törngren
  Royal Institute of Technology, Sweden

Programme Committee

- Reiner Hartenstein, Kaiserslautern University of Technology, Germany
- Yann-Hang Lee, Arizona State University, USA
- Jogesh Muppala, The Hong Kong University of Science and Technology, Hong Kong
- Kenneth G. Ricks, The University of Alabama, USA
- Falk Salewski, Aachen University, Germany
- Chi-Sheng (Daniel) Shih, National Taiwan University
- Stewart Tansley, Microsoft, Redmond, WA, USA
- Wayne Wolf, Princeton University, USA

http://www.artist-embedded.org/artist/WESE-07.html

Integrated Modular Avionics
ARTIST2 meeting on Integrated Modular Avionics

November 12-13, 2007
Rome, Italy
Organised, funded by Artist

Today, the exponentially increasing diversity of airborne systems results in an ever increasingnumberofcomputers and controllers for system management, monitoring, and control. The development of specific ad-hoc solutions causes increases in costs, which in turn impacts purchase prices and operational costs. To overcome this, standardization principles and reuse of function units are now considered, via Integrated Modular Avionics.

Integrated Modular Avionics (IMA) has set the principles of standardized components and interfaces of hardware and software in aircraft. These principles have been applied for the first time in the development of the Airbus A380. Further developing IMA raises a number of issues that require fundamental research efforts, in tight coordination with engineering needs.

ARTIST2, the European Network of Excellence on embedded systems has decided to organize, as part of its activity on «scientific challenges in specific industrial sectors», a two-day workshop dedicated to Systems, Software, and Architecture, aspects of IMA.

http://www.artist-embedded.org/artist/Integrated-Modular-Avionics.html

Other Conferences

The full set of conferences referenced by Artist is available here:
http://www.artist-embedded.org/artist/Conferences-63.html

See Also

FORMATS'07
October 3-5, 2007
Salzburg, Austria
organised with Artist partners
Researchers interested in semantics, verification and performance analysis study models such as timed automata and timed Petri nets. the digital design community focus on propagation and switching delays while designers of embedded controllers have to take account for the time taken by controllers to compute their responses after sampling the environment.
http://www.ulb.ac.be/di/formats07/

RTSS 2007
December 3-6, 2007
Tucson, Arizona, USA
organised with Artist partners
RTSS provides a forum for the presentation of high-quality, original research covering all aspects of real-time systems design, analysis, implementation, evaluation, and case-studies. RTSS'07 continues the trend of making RTSS an expansive and inclusive symposium, looking to embrace new and emerging areas of real-time systems research.
http://www.rss.org/

Embedded Systems Week 2007

Sept 30th - Oct 5th, 2007

HARDWARE - SOFTWARE CODESIGN AND SYSTEM SYNTHESIS

CODES+ISSS

The Conference covers all aspects of embedded computing systems, including but not limited to:

- *High-level, architectural and system-level synthesis* Synthesis, partitioning, design space exploration
- *HW/SW co-design* Co-design methodologies, HW/SW interface.
- *Spec languages and models* System-level models & semantics, timing analysis, power, formal properties, heter. systems.
- *Simulation and verification* HW/SW cosimulation, HW acceleration, test meth., design for testability
- *Power-aware design meth.* Power mgt / modeling, low-power design meth.
- *ES architecture* Application-specific architectures, memory & comm. optimization
- *Multiprocessors and NoC* Multiproc architectures, communication protocols, design space exploration, MPSoC and NoC.
- *Embedded software* Compilers, virtual machines, scheduling, power-aware OS, RT support and middleware.
- *Application-specific design and algorithms* Network & media processors, hardware accelerators, reconfigurable processors, securities
- *Industrial practices and design case studies* New approaches to areas such as cell phones, sensor networks, automotive, multimedia, med. systems.
- *Emerging techniques* arising from increased heterogeneity, new technologies / applications, Networked embedded systems.

ANNUAL ACM SIGBED CONFERENCE ON EMBEDDED SYSTEMS SOFTWARE

EMSOFT ***Sponsored by Artist2***

EMSOFT is an annual ACM Conference on Embedded Systems Software sponsored by ACM SIGBED (Special Interest Group on Embedded Systems).

Embedded software must meet demanding criteria for correctness, performance, power consumption, and development cost. EMSOFT aims at covering all aspects of embedded software with focus on principles of embedded software development. Topics of Interest include (but are not limited to):

- Design and implementation of embedded software
- Modeling and validation
- Model- and component-based software design and analysis
- Programming languages and compilers
- Software engineering and programming methodologies
- Scheduling and execution time analysis
- Operating systems and middleware
- QoS management and performance analysis
- Hardware-dependent software and interfaces
- Networked embedded systems and security
- Software for distributed/ multiprocessor embedded systems
- Application areas, e.g. automotive, avionics, telecommunication, and multimedia

COMPILERS, ARCHITECTURE, AND SYNTHESIS FOR EMBEDDED SYSTEMS

CASES

Conference topics include, but are not limited to, the following areas:

- Application-specific and domain-specific embedded systems
- Compilation techniques that focus on embedded architectures
- Dynamic compilation and managed runtime environments for embedded systems
- Design, specification, and synthesis of embedded systems
- Customizable processors and digital signal processors
- Embedded uses of instruction-level parallelism, including VLIW, EPIC and superscalar
- Embedded system integration and testing
- Multiprocessing on chip (hardware and software issues)
- Memory management, smart caches and compiler controlled memories
- Novel architectures and micro-architectures for embedded systems
- Low-power architectures and compilation, power vs. performance tradeoffs
- Profiling, measurement, and analysis techniques of embedded applications
- Reconfigurable embedded computing systems
- Validation, verification, and debugging techniques for embedded software
- VLSI and circuit techniques for embedded system design

http://www.esweek.org/

Component-based Design and Implementation of Avionics Systems

Olaf Heinzinger and Maria Sorea
EADS Innovation Works, Germany

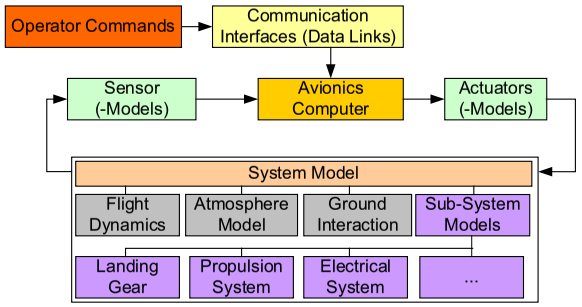
The development of modern aircraft and avionics systems has reached a degree of complexity where a highly integrated design process between various disciplines, such as electrical engineering, computer science, and control theory is necessary.

Sharc, an unmanned aerial vehicle (UAV) is an example of such an avionics system developed at EADS. With a maximum take-off weight of 190 kg, the system can accommodate 50 kg of mission equipment in its payload compartments. Sharc is equipped with a digital flight-control unit, a laser altimeter, and control and data link. Sharc has been designed as an unmanned aerial vehicle without hydraulic compo-nents, the rotors being controlled by means of electrical actuators.

Autonomous systems such as Sharc are mostly computer-controlled and are character-ized by real-time computations, as well as strong interactions and coupling effects between the components and the environment. These aspects, together with require-ments of fault tolerance, make the design, analysis and verification of such embedded systems inherently difficult.

In order to design such complex systems, and to gain confidence in the validity of the design itself, precise models of the components and of the surrounding relevant envi-ronment need to be constructed. As shown in the figure on the right, the system model of Sharc consists not only of the aircraft components but also of atmospheric phenomena and terrain representation. We use mainly Stateflow and Simulink for expressing these models. The models are validated using a simulator or rapid prototype, allowing also for exploration against various "what-if" scenarios. To attain the desired – or required – level of confidence in correct behaviour, however, mere testing and simulation is usually insufficient; in fact, it is argued that the kind of reliability required for highly safety-critical applications cannot be achieved without a careful formal analysis of the mechanisms and algorithms involved. Besides the usual simulation runs we are exploring state-of-the-practice verification methods, such as model checking for hybrid systems to achieve a high level of confidence into the functional behaviour of the design. Model-checking is used for increasing the ro-bustness of the design using a technique called model-based safety analysis. The models are extended with "what-if" scenarios for modeling both failure of the aircraft and unexpected behaviour of the environment, and model checking is used to automatically examine all possible failure scenarios. We are currently investigating the possibility of using model-checking for exhaustively exploring sufficiently precise abstractions of the aircraft and environmental models. The main challenge here is to develop sufficiently powerful verification techniques for distributed, real-time, embedded systems with non-linear dynamics. In addition, for industrial dissemination, these verification techniques need to be fully integrated into the design cycle and the development tool chain.

Following design validation, the subsystem models are used for analyzing the interac-tion of the represented components with the developed avionics system running on its target hardware (hardware-in-the-loop simulation). This reduces the risk when operat-ing and testing the operational prototype. For the creation of such a development envi-ronment, a distributed set of embedded systems is the best solution for a flexible test and development process and for a realistic system representation including bus and communication structures of an integrated modular avionics (IMA) architecture.



Performance / Power Measurements for Embedded Multi-Core Processors

Dr. Jörg Brakensiek
Nokia Research Center, SRC Bochum

Recently main PC computing performance gains has been achieved by increasing the number of CPUs instead of higher clock rates because of technological limitations. In the embedded world other restrictions exist. Nevertheless, multi core solutions might also be an option here. From the embedded perspective, the processing efficiency (Eq. 1) is more important than pure performance numbers.

$$\text{Efficiency} = \frac{\text{ComputingPerformance}}{\text{Energy}} \qquad \text{(Eq. 1)}$$

So the question needs to be answered, whether a multi-core solution is actually more efficient than single core one (Efficiency Gain > 1, Eq. 2).

$$\text{EfficiencyGain} = \frac{\text{Efficiency}_{MultiCPU}}{\text{Efficiency}_{SingleCPU}} \qquad \text{(Eq. 2)}$$

The Nokia Research Center in Bochum, Germany has been investigating the embedded ARM multi-core processor test chip (ARM CT11 MPCore [1]) on the ARM Versatile EB [2] in order to find specific answers to the above question.

We have been analyzing a set of low-level and high-level benchmarks. In order to get comparable results, we used the following Frequency & Number-of-CPUs settings.

$$f_i \cdot N_i = f_j \cdot N_j$$

The measurement results from Dhrystone benchmarks are shown in figures below. They first show the expected linear performance over frequency as well as over number of CPUs (figure 1).

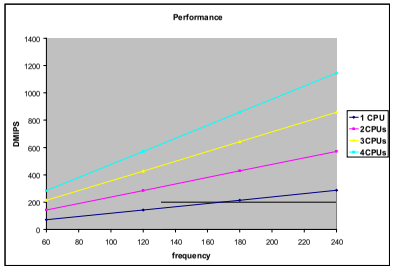


figure 1

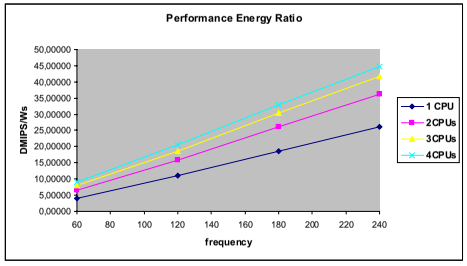


figure 2

When it comes to the performance efficiency (figure 2), the results are showing a linear dependency from the frequency and a non-linear dependency from the number of cores.

In all cases, increasing the number of cores and frequency is increasing the efficiency of the multi-core system.

An example for high-level (i.e. application level) benchmark results is shown in the following figures. The efficiency results and corresponding efficiency gains for different configurations for the multi-threaded FFPlay (an open source media player) is shown. It has to be noticed that the video output has been disabled to eliminate the influence of the low IO bandwidth of the Versatile EB.

FFPlay 25fps Video	1 Thread	2 Thread	4 Thread
	1 CPU @ 240 MHz	1 CPU @ 240 MHz	1 CPU @ 240 MHz
2 CPU @ 120 MHz	1,32	1,29	1,33
4 CPU @ 60 MHz	0,74	1,44	1,40
	2 CPU @ 120 MHz	2 CPU @ 120 MHz	2 CPU @ 120 MHz
4 CPU @ 60 MHz	0,56	1,12	1,05
	2 CPU @ 240 MHz	2 CPU @ 240 MHz	2 CPU @ 240 MHz
4 CPU @ 120 MHz	1,29	1,28	1,26

figure 3

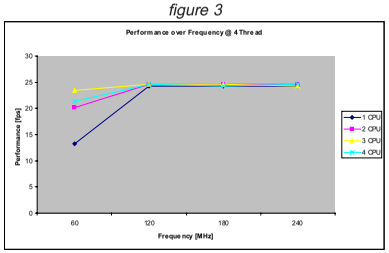


figure 4

It can be seen that the target frame rate (25 fps) can be achieved for all frequency settings above 120 MHz in the 4-threaded case (left figure). Achievable efficiency gains (right figure) are between 20% - 30% (the efficiency value from the first column settings are divided by the one of the 2nd to 4th column). The values in the second and third row are not completely comparable, as the final frame rate cannot be achieved (figure 4).

The current state of the analysis has shown that in case of well distributable workload the efficiency of such a multi-core environment is in many cases much higher compared to a single-core environment.

The analysis has turned out that there is complex dependency of the achievable efficiency from the system configuration and setup, which still requires more understanding with respect to the software and hardware side in order to take full advantage of this technology.

References

[1] Core Tile for ARM11 MPCore, User Guide; ARM Limited, 2005; http://www.arm.com/pdfs/DUI0318C_core_tile_11mpcore_ug.pdf
[2] Versatile EB Board; http://www.arm.com/products/DevTools/EB.html
[3] H. Bothe, "Increase Performance with Embedded Multi-Core Processors", ARM IQ, Volume 5, No 4, 2006.
[4] J. Brakensiek, "Multi Execution Environments @ Multi Cores Use Cases, Requirements and Concepts", Presentation on MultiCore Expo, Santa Clara, 29.03.2007.

Current and Recent Schools and Courses

Artist2 / UNU-IIST School in China - 2007
August 1-10th
Suzhou, China
http://www.artist-embedded.org/artist/-Artist2-UNU-IIST-School-in-China-.html
Organised by the Artist2 NoE

ARTIST2 has organized, in collaboration with UNU-IIST, the 2nd edition of a school on embedded systems design in Suzhou (near Shanghai).

Topics Covered included: MPSoCs, Interaction between Control and Scheduling, Model-based development, Automata and hybrid systems, Semantics Issues of Stateflow, Mixed Continuous and Discrete-event Systems, Verification Techniques, Optimal Scheduling, Controller Synthesis.

Lecturers

- Prof. Karl-Erik Arzen
  Lund University - Sweden
- Prof. Dr. Luca Benini
  University of Bologna - Italy
- Paul Caspi
  Verimag Lab - France
- Prof. Kim Larsen
  Aalborg Univ. - Denmark

Joint EU-China Organisation

The ARTIST2 / UNU-IIST / China Spring School was initialized and organized
jointly by the ARTIST2 Network of Excellence, and UNU-IIST, Macao.

First European-SouthAmerican School for Embedded Systems
August 21-24, 2007
Buenos Aires - Argentina
http://www.artist-embedded.org/artist/-First-European-SouthAmerican-.html
Organised by the Artist2 NoE

The purpose of the school is to foster dynamic research cooperation between groups in Europe and South America, by allowing South-American students (specially graduate), to meet european researchers. We strongly believe this will offer an excellent opportunity to strengthen the relationships with mutual benefit.

The school will be a repeated event on a yearly basis. Besides the lectures given by european researchers, there will be invited talks by southamerican researchers and space (poster session) for graduate students to present and discuss their work.

Topics

- Component-based modeling of heterogeneous real-time systems
- Adaptive Real-time systems
- Networks for embedded control systems

Lecturers

- Prof. Luis Almeida
  Univ. of Aviero - Portugal
- Prof. Gerhard Fohler
  TU Kaiserslautern - Germany
- Joseph Sifakis
  Verimag Lab - France

FOSAD'07
Foundations of Security Analysis and Design
September 9-15, 2007
Bertinoro - Italy

http://www.sti.uniurb.it/events/fosad/
Sponsored by the Artist2 NoE

Security in computer systems and networks emerged as one of the most challenging research areas. The International School on Foundations of Security Analysis and Design (FOSAD) has been one of the foremost events established with the goal of disseminating knowledge in this critical area. The main aim of the FOSAD school is to offer a good spectrum of current research in foundations of security - ranging from programming languages to analysis of protocols, from cryptographic algorithms to access control policies and trust management - that can be of help for graduate students and young researchers from academia or industry that intend to approach the field.

Courses

- API Security and Security Economics
- Low-level Software Security
- Application of Formal Methods to Cryptographic Protocol Analysis
- Trusted Mobile Platforms
- Language-Based Security
- Cryptographic Algorithm Engineering and Provable Security
- Embedded Systems Security and Cryptographic Coprocessors
- Quantitative Aspects in the Analysis of Crypographic Protocols

Applied Software Verification
LASER Summer School on Software Engineering
September 9-15, 2007
Elba - Italy

http://se.inf.ethz.ch/laser/2007/

The LASER school is intended both for researchers (including PhD students) and for professional software engineers and managers who want to benefit from the best in software technology advances. The focus of LASER is resolutely applied, although theory is welcome to establish solid foundations. The format of the school favors extensive interaction between participants and speakers.

The 2007 LASER school is part of the ongoing «Grand Challenge» on software verification, initiated by Tony Hoare. It has a special focus on tools for software verification. This means in particular that it has a highly practical character and will provide participants with a clear view of techologies and tools available today to verify software.

EPSD 2007
Embedded Programmable System Design
September 9-15, 2007
EPFL, Lausanne, Switzerland
http://www.mead.ch/htm/ch/EPSD-Program.html

- Introduction to Embedded Systems
- Software Design Principles
- Real-Time Scheduling and Performance Estimation
- VLIW Architectures
- Embedded Memory Systems
- Memory Architecture Aware Compilation
- Retargetable Compilers
- Automatic Processor Specialization
- From Algorithms to Architectures: A Case Study
- Power Analysis and Low Power Design
- System-Level Power Optimization

The Role of Networking in Embedded Systems

Luis Almeida, University of Aveiro, Portugal
Eduardo Tovar, Polytechnic Institute of Porto, Portugal

Looking at the current scenario in embedded systems we see a permanently growing role of networking, ranging from the connection of autonomous devices such as cell phones, PDAs, laptops and their peripherals, to the provision of pervasive access to multimedia and telecommunication networks, to the deployment and operation of large-scale sensor networks, to intelligence distribution in complex embedded systems, or even, at a small physical scale, to connect multiple processing cores within Systems-on-Chip (SoCs).

In this vast horizon, the ongoing Artist2 NoE's activity on Dynamic and Pervasive Networks of the ARTIST2 Adaptive Real-Time Systems (ART) cluster focuses on Wireless Sensor Networks (WSNs), Mobile Ad-hoc Networks (MANETs) and Networked Embedded Systems (NESs), areas in which many open challenges remain, and many new problems arose in the past few years. For example, energy-aware communication is turning out to become a major research challenge for WSNs, imposing innovative and efficient networking protocols that manage communications periodicity, nodes synchronization and transmitting power; As WSNs grow into very large-scale networks with thousands of nodes and more, efficient data aggregation becomes essential being imperative that its time-complexity does not depend on the number of sensor nodes; Quality-of-Service (QoS) adaptation and the collaborative computing paradigms require protocol mechanisms to monitor instantaneous bandwidth usage, enforce minimum agreed QoS levels (e.g. through contracts and traffic policing) and leverage the access to free bandwidth (to increase QoS whenever possible); Higher software integration in distributed embedded systems requiring integrated global resource management together with effective and efficient temporal partitioning (e.g., using hierarchical scheduling techniques), as well as flexible mapping between software and hardware architectures; Replacement and/or extension of wired with wireless networking technologies, coping with more error-prone channels and security risks but profiting from simplified deployment and elimination of cabling.

Moreover, distributed sensing, actuation and cooperative computing involving small and tiny computing platforms appear as a basilar functionality in an ever crescent range of applications, including surveillance, environment and critical infrastructures monitoring, disaster recovery operations, distributed control, military operations, etc. The requirements imposed by these diverse applications necessarily imply different trade-off options on supported functionality, quality of service, efficiency, platforms, protocols, architectures, etc.

Among the initiatives being carried out in this activity we highlight two, the real-time communication and collaboration in wireless networks and cyber-physical systems lead by the Politechnic Institute of Porto, and the network support for dynamic reconfiguration, which was the topic of the NeRES workshop that took place on the 2nd of April, this year, in Aveiro, Portugal (http://www.artist-embedded.org/artist/-NERES-2007-.html). These two initiatives are briefly described in the following articles.

Adaptive Real Time for Embedded Systems

Giorgio Buttazzo, Scuola Superiore Sant'Ana, Pisa, Italy

Achieving adaptivity in embedded real-time systems is a complex task that requires expertize from several disciplines, including operating systems, scheduling theory, network communication, control theory, and quality of service management. To cover these issues, the ART cluster includes the following activities:

1. A common infrastructure for adaptive real-time systems show how current operating systems and network protocols can be extended to support emerging real-time applications that exhibit a high degree of complexity and operate in dynamic environments.
2. Flexible Scheduling and Resource Management provides models, policies and analysis techniques to efficiently manage the available resources.
3. Dynamic and Pervasive Networking addresses the numerous research challenges in the frameworks of Wireless Sensor Networks, Mobile Ad-hoc Networks and Embedded Networked Systems.

Networks for Reconfigurable ES

Luis Almeida, University of Aveiro, Portugal
Paulo Pedreiras, University of Aveiro, Portugal

Reconfigurability has long been recognized as a way to improve efficiency in the use of system resources, for example, when a system undergoes variable load situations, when it evolves during its lifetime or even when faults affect part of its structure. This means that reconfigurability, in a broad sense, may be beneficial to areas that range from Quality of Service (QoS), e.g., when the number of system users or the environmental operating conditions vary, to Dependability, e.g., through graceful degradation.

However, achieving reconfigurability may conflict with operational goals such as continued real-time and safe operation, and it becomes more difficult when the system is distributed, requiring adequate support from the network. One approach that has been followed in certain application domains to cope with such difficulty is the use of multiple operational modes, which are statically defined off-line. Nevertheless, more flexible approaches to reconfigurability are needed to improve resource efficiency in a vast range of applications, exploiting paradigms such as flexible modes, flexible scheduling, dynamic QoS management, stateful schedules, etc, particularly at the network level. This opens the way to keep costs low while improving dependability as the overall system complexity increases.

The NeRES workshop (Networks for Reconfigurable Embedded Systems) that took place on April 2nd in Aveiro, Portugal, aimed at discussing these problems associated to dynamic reconfiguration in distributed embedded systems and, particularly, the role of the network to support it. It gathered 26 participants from 15 institutions in 6 countries, with one industrial representative and several other academic participants presenting industrial case studies. There were 13 presentations covering aspects that ranged from flexible middleware, namely based on components, on resource contracts, on services and on the support for flexible scheduling, to dependability, integration, wireless mobile ad-hoc communication, intelligent telecommunication networks, industrial automation, automatic control systems, automotive and avionic systems.

More information can be found here:
http://www.artist-embedded.org/artist/-NERES-2007-.html

Focus on Adaptive Real Time

ARTIST Newsletter n°4
September 2007

Real Time Communication / Collaboration in Wireless Networks and Cyber-Physical Systems

Björn Andersson, Polytechnic Institute of Porto, Portugal
Mário Alves, Polytechnic Institute of Porto, Portugal

The use of wireless communication networks has undergone a revolution during recent years, in application areas such as factory automation, home automation, vehicle-to-vehicle communications and wireless sensor networks (WSN). Several communication standards are established and transceivers are commercially available at low cost. Unfortunately, they were not designed for satisfying real-time requirements. Researchers of the ARTIST2 NoE's Adaptive Real-Time Systems (ART) cluster are addressing these issues from the complementary perspectives of: (i) the use of commercially available technologies versus the use of new solutions untethered by existing standards; (ii) the use of time-triggered paradigms versus event-triggered paradigms; (iii) the provision of short-term solutions recognizing the needs of companies for wireless solutions with mature implementations and compliant with standards in order to simplify interoperability versus the need to push the state-of-art and explore new innovative solutions. ART-WiSe and WiDOM are two representative ongoing research frameworks addressing these complementary perspectives.

The ART-WiSE (Architecture for Real-Time communications in Wireless Sensor networks, http://www.hurray.isep.ipp.pt/art-wise) research framework aims at the specification of a scalable two-tiered communication architecture for improving the timing and reliability behaviour of WSNs. One of the major goals is to use, as far as possible, existing standard communication protocols and commercial-off-the-shell (COTS) technologies – IEEE 802.15.4/ZigBee for Tier 1 and IEEE 802.11 for Tier 2 (Fig. 1).

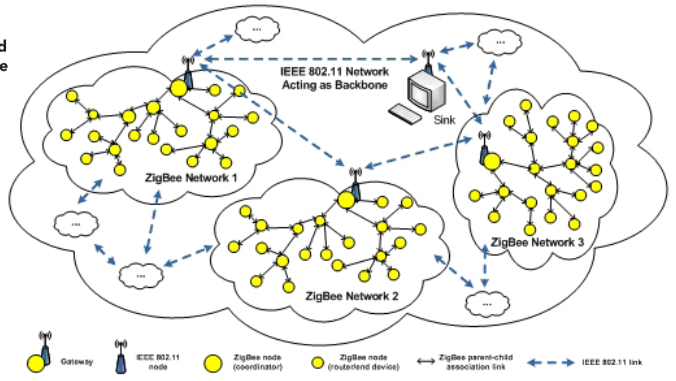
Results obtained thus far include the provisions of methodologies to analyse and dimension star and cluster-tree 802.15.4/ZigBee networks, namely being able to compute throughput and message delay bounds for the Guaranteed Time Slot (GTS) mechanism and ZigBee Router's buffer requirements in cluster-tree networks. Important add-ons to these protocols that are backward compatible, have already been proposed and tested: (i) a traffic differentiation mechanism for CSMA/CA to provide more guarantees to high priority messages by appropriate tuning of MAC parameters; (ii) an implicit GTS allocation mechanism (i-GAME) allowing improved bandwidth utilization and adaptation by nodes sharing a GTS; (iii) beacon/superframe scheduling in ZigBee cluster-tree networks enabling a synchronized cluster-tree WSN where each cluster may operate with different and low duty-cycle, thus prolonging network lifetime.

An open-source toolset for the IEEE 802.15.4/ZigBee protocols have been made publicly available: http://www.open-zb-net, which includes: (i) the implementation of the IEEE 802.15.4 protocol in TinyOS, for both the MICAz and TelosB motes; (ii) the implementation of the ZigBee Network Layer for supporting synchronized multiple cluster topologies (the Cluster-Tree topology) in TinyOS, for the TelosB motes; (iii) a simulation model of the IEEE 802.15.4 protocol in OPNET; (iv) tools for timing analysis and network dimensioning.

The Artist2 NoE's ART cluster has also recognized that no existing communication standard performs well for sporadic message streams with real-time requirements. For this reason, a novel MAC protocol, dubbed Wireless Dominance Protocol (WiDOM), was designed for wireless systems (http://www.hurray.isep.ipp.pt/activities/WiDOM/). This protocol gives the wireless channel a similar behavior as a Controller Area Network (CAN) bus. It is prioritized and this can be achieved even without having the ability to listen and transmit simultaneously. Because of the prioritization, it is possible to compute message response-times of sporadic message streams.

The WiDOM protocol elects the computer node with the highest priority (lowest number) and gives it access to the medium. This election procedure can also be used to compute the minimum value of sensor readings distributed on different computer nodes and, remarkably, this computation can be performed with a time-complexity that is independent of the number of computer nodes. This procedure forms a building block for other useful calculations; for example, it is possible to efficiently extract an interpolation of sensor readings and this can be performed with a time-complexity that is independent of the number of computer nodes. This is a crucial asset for addressing problems in future Large-Scale Dense Sensor Networks for Cyber-Physical Systems.

Figure 1:
Example of the ART-WiSe two-tiered network architecture



6. Work on Standards

Real Time Components (RTC) cluster

The RTC cluster has been, through CEA, Cantabria, INRIA and Thales, the driving force in the work of developing a profile of the Unified Modeling Language (UML™) for MARTE (Modelling and Analysing of Real-Time and Embedded systems). CEA is leading the OMG task force in charge of finalizing the standard and dealing with its evolutions.

To get feedback on the profile, several tutorials and presentations have been performed and a specif action project, ADAMS – CSA/FP7, has been submitted to the EC – FP7. This focussed action project has been accepted and started in June 2008. In addition, use and integration of MARTE is in the kernel on numerous industrial collaborative projects, in avionics, automotive, telecommunication and railways (e.g; INTERESTED – IP/FP7, Lambda – Systematic Paris region cluster, ATESST 2 – STREP/FP7, EDONA – System@tic Paris Région, TIMMO – ITEA, IMOFIS – System@tic Paris Région… Particular concerted actions are done to disseminate this standard to automotive domain by integrating its conceptual elements (meta-model) to AUTOSAR standard (objective, namely, of TIMMO – ITEA project). To support this, CEA has solicited, and been accepted in summer 2008, to become an official AUTOSAR member.

Tutorials on MARTE have been provided in several conferences or summer schools by CEA, U. Cantabria and INRIA during 2007 and 2008 (ARTIST2 Winter School 2007 – MOTIVES, "UML for the design of Real-Time Embedded Systems" - www.artist-embedded.org/artist/Overview,577.html; “UML Tutorial: MARTE”, Forum on specification & Design Languages, FDL'07, Barcelona, Spain, September 20, 2007 - www.ecsi-association.org/ecsi/fdl/fdl07/def.htm; “MARTE: A New Standard for Modeling and Analysis of Real-Time and Embedded Systems”, 19th Euromicro Conference on Real-Time Systems ECRTS 07) Pisa, Italy, July 3, 2007 - http://feanor.sssup.it/ecrts07/tutorial.shtml). In 2008, Verimag and CEA have coorganised with other partners the 1st International Workshop on Model Based Architecting and Construction of Embedded Systems which evolved from the MARTES workshop.

Continuing and activity started in 2006, PARADES in collaboration with the University of California at Berkeley and Columbia University is participating in the definition of APIs for the Open Access (OA) initiative sponsored by SI2 to connect the standard OA physical information database with system-level design tools.

VERIMAG is involved in the AADL standardisation committee and CEA has established good contacts to Peter Feiler, one of the main drivers of the AADL standard. The platform for component-based modelling and verification includes several tools for handling AADL specifications, in particular, translations from AADL to Lustre and to BIP have been realised with the aim to (1) analysing AADL specifications and (2) providing a formal semantics for AADL. In previous years, Peter Feiler was involved in the MARTES workshop organised by CEA and Verimag. This year, two workshops related to AADL have been organised by Artist: the “*EAST-ADL, AADL, MARTE, Autosar harmonization workshop*” and the workshop on UML&AADL (see section 2.4.9)

Adaptive Real Time (ART) cluster

It includes the following activities:

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

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

- POSIX 1003
  URL: http://www.artist-embedded.org/artist/POSIX-IEEE-1003.html
  Member: Michael Gonzalez Harbour, Univ. of Catabria.

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

- ETHERNET powerlink
  URL: http://www.artist-embedded.org/artist/ETHERNET-Powerlink.html
  Member: Lucia Lo Bello, Univ. of Catania (affiliated to Pisa).

Compilers and Timing Analysis (CTA) cluster

Definition of AIR (ARTIST2 Intermediate program representation for WCET tools)
A file format specification was developed to define the AIR ('ARTIST2 Intermediate') format that may be used by the cluster participants' tools for integration. The format is based on CRL2, which is the successor of CRL. These formats were originally developed in cooperation by Saarland University and AbsInt Angewandte Informatik GmbH over several years of work.

The idea behind AIR is that an interface is to be defined on the file-format level, in contrast to CRL2, whose interface definition only covers the C++ library interface. Internally in AbsInt tools, a specification of the C++ library interface is preferred over a file format specification, simply because all tools use the library and thus the storage on disk is secondary. For ARTIST2, different work groups prefer their own libraries over the usage of proprietary software, so there is a serious demand for a file format specification.

From the release of the first AIR specification on, the CRL2's file format interface will be a dialect of the AIR file format. CRL2 as well as dialects of other work groups are allowed to feature extensions as long as they are not vital for the operation of the tools. E.g., AbsInt tools will only use the plain AIR file format during normal operation, the extensions of CRL2 are mainly implemented for debugging and diagnosis purposes. In the same way, extensions of other dialects shall never be vital to the operation of the corresponding tools
http://www.absint.com/artist2/doc/crl2/air.pdf

7. Course Materials

The Artist2 Network of Excellence makes pointers to course materials from its own events and others, available via its website.

ARTIST2 Summer School 2008 in Europe
September 8-12, 2008 Autrans (near Grenoble), France
http://www.artist-embedded.org/artist/Programme,1319.html

The Summer School offers a number of foundational tutorials, accompanied by a selection of lectures on exciting emerging technologies and industrial applications - given by leading scientific and/or industrial experts.

ARTIST2 South-American School for Embedded Systems 2008
August 25-29, 2008 Universidade Federal de Santa Catarina, Florianopolis, Brazil
http://www.artist-embedded.org/artist/New-article,1287.html

We believe the school should be the ground for cross-fertilization between Europe and South-America with an expected mutual high added-value. Therefore, the lectures given by European researchers, will be accompanied by talks and a poster session for participants to present and discuss their ongoing work.

Artist2 Summer School in China 2008
http://www.artist-embedded.org/artist/Artist2-Summer-School-in-China,1541.html
July 12-18, 2008 Shanghai, China

ARTIST2 will organize the 3rd edition of a school on Embedded Systems Design in Shanghai. This year, the school is organized in collaboration with the SEI/ECNU and the LIAMA.

Real-Time Kernels for Microcontrollers: Theory and Practice
http://www.artist-embedded.org/artist/Real-Time-Kernels-for,1540.html
June 23-25, 2008 Pisa, Italy

The course on Real-Time Kernels for Microcontrollers aims to introduce the basic concepts of Real-time Systems targeted to Embedded Systems, which are often implemented using microcontrollers. The course will briefly illustrate the theoretical background of real-time scheduling, resource-aware techniques, and wireless communication based upon the IEEE 802.15.4 protocol.

ARTIST2 Graduate Course on Embedded Control Systems
http://www.artist-embedded.org/artist/ARTIST2-Graduate-Course-on,1539.html
May 26-30, 2008 Stockholm, Sweden

The course during 2008 was the 4th in a successful series of course instances, providing an overview and account of state of the art theory and techniques that address the connection and integration of the areas of Control systems and Embedded systems.

LASER Summer School on Software Engineering
http://www.artist-embedded.org/artist/LASER-Summer-School-on-Software.html
September 9-15, 2007 Elba, Italy

The LASER summer school (Laboratory for Applied Software Engineering Research), organized by ETH Zurich, brings together the concepts and practice of software engineering.

FOSAD 2007
http://www.artist-embedded.org/artist/FOSAD-2007.html
September 9-15, 2007 Bertinoro, Italy

The International School on Foundations of Security Analysis and Design (FOSAD) has been one of the foremost events established with the goal of disseminating knowledge in this critical area. The main aim of the FOSAD school is to offer a good spectrum of current research in foundations of security - ranging from programming languages to analysis of protocols, from cryptographic algorithms to access control policies and trust management - that can be of help for graduate students and young researchers from academia or industry that intend to approach the field.

First European-SouthAmerican School for Embedded Systems
http://www.artist-embedded.org/artist/First-European-SouthAmerican,1187.html
August 21-24, 2007 Universidad Argentina de la Empresa (UADE), Buenos Aires – Argentina

The purpose of the school is to foster the well established and dynamic research cooperations in the field of embedded systems between groups in Europe and South America, by allowing south-american students (specially graduate), to meet european researchers.

Artist2 / UNU-IIST School in China - 2007
http://www.artist-embedded.org/artist/Artist2-UNU-IIST-School-in-China,1188.html
August 1-10, 2007 Suzhou (near Shanghai), China

ARTIST2 will organize, in collaboration with UNU-IIST, the 2nd edition of a school on embedded systems design in Suzhou (near Shanghai).

ARTIST2 PhD Course on: Automated Formal Methods for Embedded Systems
http://www.artist-embedded.org/artist/ARTIST2-PhD-Course-on-Automated,1189.html
June 4-12, 2007 DTU - Lyngby, Denmark

Embedded systems engage into an ongoing, hardly foreseeable, interaction with their asynchronously evolving environment. This fact contributes to the intrinsic complexity of their design and validation.

ARTIST2 Graduate Course on Embedded Control Systems
http://www.artist-embedded.org/artist/ARTIST2-Graduate-Course-on,1190.html
May 7-11, 2007 Lund, Sweden

The objective of the course is to provide an overview of the main principles and technologies for supporting the development of embedded control systems.

Real-Time Microcontroller Systems: OSEK Standard and experiments on µcontroller devices
http://www.artist-embedded.org/artist/Real-Time-Microcontroller-Systems.html
March 26-28, 2007 RETIS Laboratory, Scuola Superiore Sant'Anna, Pisa, Italy

Training course on Real-Time Systems for Microcontrollers: OSEK Standard and experiments on microcontroller devices Organised in conjunction with Evidence Srl

Seminar on Quantitative Aspects of Embedded Systems Schloss Dagstuhl 2007
http://www.artist-embedded.org/artist/Seminar-on-Quantitative-Aspects-of.html
March 4 - 9, 2007 Schloss Dagstuhl, Germany

This Dagstuhl seminar will bring together experts in embedded software design and implementation, model-based analysis of quantitative system aspects, and researchers working on extending formal methods with quantitative system aspects.

ARTIST2 - MOTIVES
http://www.artist-embedded.org/artist/ARTIST2-MOTIVES.html
February 19-23, 2007 Trento, Italy

ARTIST2 Winter School 2007 offers foundational tutorials and lectures on exciting emerging technologies and industrial applications - given by leading scientific and industrial experts.

CASTNESS'07 Workshop and School
http://www.artist-embedded.org/artist/CASTNESS-07-Workshop-and-School,1040.html
January 15-17, 2007 Rome, Italy

Computing Architectures and Software Tools for Numerical Embedded Scalable Systems

Real-Time and Control for Embedded Systems
http://www.artist-embedded.org/artist/Real-Time-and-Control-for-Embedded.html
July 10-14, 2006 Pisa, Italy

First European Laboratory on Real-Time and Control for Embedded Systems

ADSD 2006: Advanced Digital Systems Design
http://www.artist-embedded.org/artist/ADSD-2006-Advanced-Digital-Systems.html
September 25-29, 2006 Lausanne, Switzerland

Design course for multimillion-transistor Systems-on-Chip and other state-of-the-art embedded products. The course spans from purely digital-design topics to some compiler-related issues.

LASER Summer School on Software Engineering 2006
http://www.artist-embedded.org/artist/Practical-Programming-Processes.html
September 17 - 23, 2006 Elba, Italy

The 2006 LASER takes an in-depth look at Practical Programming Processes. Many approaches have been proposed in the past decade, from new advances in object technology to Patterns, Aspects, Extreme/Agile/Lean methods, incremental development, process standards (CMMI etc.), Open Source and several others.

Foundations of Security Analysis and Design
http://www.artist-embedded.org/artist/Foundations-of-Security-Analysis.html
September 10-16, 2006 Bertinoro, Italy

FOSAD 2006: 6th International School on Foundations of Security Analysis and Design

Model-Driven Design for Distributed Real-time Embedded Systems (MDD4DRES)
http://www.artist-embedded.org/artist/Model-Driven-Design-for.html
September 4-8, 2006 Brest, France

A goal of this summer school is to provide participants with the information needed to understand and apply MDE approaches to the development of embedded systems. The summer school will also include lectures from experts in academia and industry on topics related to MDE practices and methods, and to emerging MDA technologies.

First European Laboratory on Real-Time and Control for Embedded Systems
http://www.artist-embedded.org/artist/First-European-Laboratory-on-Real,721.html
July 10-14, 2006 Pisa, Italy

Real-Time distributed embedded systems play a crucial role in our society including several application domains such as automotive, telecommunications, robotics, and multimedia systems. These systems generally work under precise timing constraints, to achieve the required level of performance and predictability. Consequently, embedded systems design requires expertise in several disciplines, including control theory, networking, real-time computing, and operating systems.

ARTIST2 Graduate Course on Embedded Control Systems
http://www.artist-embedded.org/artist/ARTIST2-Graduate-Course-on.html
April 3-7, 2006 Prague, Czech Republic

The objective of the Course is to provide an overview of the main principles and technologies for supporting the development of embedded control systems.

ARTIST2 / UNU-IIST Spring School in China 2006
http://www.artist-embedded.org/artist/ARTIST2-UNU-IIST-Spring-School-in.html
April 3-15, 2006 Xi'an, China

The first ARTIST / UNU-IIST Spring School gathered more than 50 participants, of which approximately 40 were students from the top universities in mainland China.

ARTIST2 Summer School 2005
http://www.artist-embedded.org/artist/ARTIST2-Summer-School-2005.html
September 29 - October 2, 2005 Nässlingen, Sweden

The ARTIST2 Summer School was held in conjunction with the 3rd International Conference on Formal Modelling and Analysis of Timed Systems (FORMATS'05). The Summer School offered a number of foundational tutorials accompanied by a selection of exiting new emerging technologies all given by absolute leading scientific experts of the community.

8. Artist2 Web Portal

The Artist2 Web Portal (http://www.artist-embedded.org/) is the principal means by which information is dissemainted by the Artist2 NoE within the Embedded Systems Community.

The Artist2 Web Portal will continue to evolve and be maintained as the ArtistDesign Web Portal (2008 – 2010).

8.1 Objectives and Background Information

The aim of the Artist2 Web Portal is rather ambitious: to be the focal point of reference for events and announcements of interest to the embedded systems community.

The web portal disseminates information about contacts (Artist2 core and affiliated partners), the Artist2 JPA activities, as well a fairly thorough set of links to sites of interest to the embedded systems community.

As can be seen, a great deal of effort has been put into the web site, both for ergonomics/graphical quality, as for the contents.

The web site includes several features that help keep it coherent and up to date:

- Authorised users (principally, the Artist2 partners) can access the back end of the site to modify and update information directly. The changes are immediately visible on the site, which greatly streamlines the updating process.
- It's possible to track changes and go back to previous versions of individual web pages.
- Events are automatically sorted by date, and transferred to 'Past Events'. When appropriate.
- Structural information (hierarchy of pages) is maintained automatically.
- Ergnomics are set for the entire site. The "look and feel" of the site is always homogeneous thoughout the site. It's possible to change these ergonomics, and these changes are applied homogeneously throughout the site, via automated machanisms.

8.2 Google keywords used to access the site

A representative sample of recent google searches, used to access the site, include the following. It's very interesting to note how well the portal is placed, when searches on topics not directly related to the NoE are used.

NB1: These links are active, so you can see the results of the google search yourself by clicking on the keywords.
NB2: Over time, google results will shift.

- « castness »
- « hipeac »
- « paul caspi retirement »
- « "semantic level" component »
- « artist2 »
- « cluster testing »
- « FPVI project » (2)
- « EMBEDDED C »
- « spreading excellence in research »
- « presentation material »
- « cédric di tofano »
- « ERTS 2009 embedded »
- « project conclusion application design presentation »
- « ERTS EMBEDDED REAL TIME SOFTWARE 2009 »
- « Towards a traceability model in a MARTE-based methodology for real-time embedded systems »
- « Edward A Lee artist »
- « erts »
- « what is cluster testing » (2)
- « main projects » (2)
- « as level art brief example »
- « neeraj suri »
- « modular avionics design »
- « timing analysis embedded »
- « integrated modular avionics »
- « established trust level EAL7 »
- « Industrial Phd Aalborg »
- « ARTIST DESIGN

- « ARTIST2 Design »
- « Multi-Clock Latency-Insensitive Architecture »
- « Real Time Components »
- « Systems integration activities »
- « Integrated Modular Avionics »
- « ahmed bouajjani »
- « rtcsa 2009 »
- « FORMAL ANALYSIS ART TUTORIAL »
- « NOE structure »
- « RTSS 2009 »
- « artistdesign »
- « Embedded Systems Week 2009 »
- « UML QoS profile »
- « Suitability of dynamic load balancing in resource constrained embedded systems: An overview of challenges and limitations »
- « esweek 2009 »
- « embedded software automotive memory slides »
- « integrated modular avionics »
- « t »
- « survey of programming languages »
- « survey of programming language »
- « EMSOFT 2009 »
- « cluster testing »
- « On the Scalability of Real-Time Scheduling Algorithms on Multicore Platforms: A Case Study »
- « artist design artist2 »
- « artist »
- « "abhijit datar" »
- « artist embedded »
- « artist2 »
- « integrated modular avionics »
- « Automation System links.html »
- « ROBERT BOSCH AG »
- « Integrated modular avionics for first time »
- « Dr. Christian Salzmann BMW »
- « parallel optimization demo platform compiler options »
- « first to use Integrated Modular Avionics (IMA) »
- « Sirena "Real time Embedded Networked Applications" »
- « integrated modular avionic »
- /custom?hl=en&client=pub-899...
- « hardware course material online »
- « nanjing university yue zhang »
- « processor-memory co-exploration driven by memory-aware architecture »
- « mpsoc 2009 »
- « "PARADES" Roma company »
- « real-time embedded system »
- « university of uppsala embedded systems »
- « telecommunication workshops seminars in 2009 »
- « organizational chart of distributed embedded system »
- « Real Time Application Support (AEP), IEEE Std 1003.13-1998 »
- « bound-t »
- « Ptolemy Project »
- « open PhD Positions in Denmark »
- « artistdesign »
- « phan thi xuan linh »
- « artist »
- « artist embedded »
- « artist of this time »
- « artist noe »
- « AADL VTS »
- « quantitative testing »
- embedded »
- « 2009 embedded system »
- « universities in america offering embedded systems course »
- « artemis fp7 »
- « WCPS2008 »
- « summer Engineering courses in Switzerland »
- « Languages and Tools for Hybrid Systems Design »
- « verification assembler code »
- « basics of model checking paul gastin »
- « combest passerone »
- « "roberto zafalon" »
- « security protocol term rewriting »
- « ISO/IEC TR 18037:2004 »
- « Device Power Scheduling via Systems Management »
- « Ndukwu northeastern »
- « artist2 fpga »
- « verification testing tools »
- « CODES-ISSS 2009 »
- « adaptive real-time »
- « truetime lecture »
- « truetime matlab »
- « school in europe »
- « osek oil »
- « what is clusters in strategic management »
- « powerlink matlab toolbox »
- « "eric lenormand" -vin -vins -théatre -pièce -costumes -décors »
- « hardware VLSI research professor .edu home page »
- « international collaboration »
- « uml real time »
- « computing design »
- « Prof. Francky Catthoor »
- « Features of Real-Time Embedded Systems »
- « mailing list artists »

8.3 Structure of the Web Portal

The structure of the Artist2 web site at the end of Year 3 is as follows (visible on the Site Map: http://www.artist-embedded.org/artist/spip.php?page=plan).

The links below are active.

About the Artist2 NoE

- Strategic Objectives
- Approach
- Joint Programme of Activities (JPA)
- Artist2 Core Partners
- Workshops
- Workshops and Conferences
- Education
  - Educational Methods for Embedded Systems Design
  - Events and Publications on Specific Topics
- International Collaboration
- Contributions to Standards
- State of the Art
- Related Projects
- Becoming an Affiliated Partner
- Site Map
- Contracts

Participants

- **Artist2 Participants**
  - Strategic Management Board — Artist2 NoE
  - Artist2 Core Partners - full consortium
  - Artist2 Core Partners - by Cluster topics
    - Cluster: Real-Time Components
    - Cluster: Adaptive Real-Time
    - Cluster: Compilers and Timing Analysis
    - Cluster: Execution Platforms
    - Cluster: Control for Embedded Systems
    - Cluster: Testing and Verification
  - Artist2 Affiliated Partners
    - Affiliated Industrial Partners
    - Affiliated SME Partners
    - Affiliated Academic Partners
    - Affiliated International Collaboration Partners
- **Core Team Leaders**

Research and Integration

- **Cluster: Real-Time Components**
  - Research and Integration Activities for the "Real Time Components" cluster
- **Cluster: Adaptive Real-Time**
  - Research and Integration Activities for the "Adaptive Real Time" cluster

- **Cluster: Compilers and Timing Analysis**
  - Research and Integration Activities for the "Compilers and Timing Analysis" cluster
- **Cluster: Execution Platforms**
  - Research and Integration Activities for the "Excution Platforms" cluster
  - Internal Meetings
    - Execution Platforms Cluster Meeting
- **Cluster: Control for Embedded Systems**
  - Research and Integration Activities for the "Control for Embedded Systems" cluster
- **Cluster: Testing and Verification**
  - Research and Integration Activities for the "Testing and Verification" cluster

Dissemination

- **Workshops**
  - ATESST Open Workshop
  - MARTES 2008
  - ArtistDesign
  - SLA++P'2008
  - SIES'2008
  - UML&AADL'2008
  - Scopes 2008
  - APRES'08
  - WCPS2008
  - WTR 2008
  - Workshop on Foundations and Applications of Component-based Design (WFCD'2008)
  - Mapping of Applications to MPSoCs
  - WCET'08
  - MPSoc 2008
  - ArtistDesign Workshop on Design for Adaptivity
  - DataFlow Modeling for Embedded Systems 2008
  - ARTIST2 Timing Analysis activity meeting 2008
  - MoCC 2008
  - ACES^{MB} 2008
  - UML&FM'08
  - WESE'08: WS on Embedded Systems Education
  - Movep'08
  - IMCSIT'08 - Real Time Systems Workshop
  - OSPERT 2008
  - Embedded Control Systems: From Design to Implementation
  - COMES 2008
  - WS on Multicores: Theory and Practice
  - Mapping Applications to MPSoCs 2009
  - Embedded Systems: Industrial Applications '08
  - SCOPES 2009
  - Optimizations for DSP and Embedded Systems 2009
  - DySCAS 2009
  - Workshops and Seminars in 2007
    - COCV 2007
    - SEUS 2007

- UML&AADL'2007
- SCOPES 2007
- CASTNESS'07 Workshop and School
- DCDS'07
- SIES'2007
- IRTAW-13
- Towards a Systematic Approach to Embedded System Design
- Distributed Object Computing for RT and Embedded Systems
- NeRES 2007
- Software Tools for Multi-Core Systems
- ARTIST2 meeting on Integrated Modular Avionics
- SLA++P 2007
- WPDRTS 2007
- FMGALS'2007
- LCTES'07
- Dagstuhl: Geometry in Sensor Networks
- Dagstuhl: Mobile Interfaces Meet Cognitive Technologies
- Dagstuhl: Tools for the Model-based Development of Certifiable, Dependable Systems
- Dagstuhl: Model-Based Engineering of Embedded Real-Time Systems
- Dagstuhl: Formal Protocol Verification Applied
- FCC 2007
- ARTIST WS: Tool Platforms for ES Modelling, Analysis and Validation
- WCET'07
- Between Control and Software (in honor of Paul Caspi)
- Synchron 2007
- Precise Behavioral Semantics for DSML
- WESE'07: WS on Embedded Systems Education
- Foundations of Component-based Design
- 2nd Int'l ARTIST Workshop on Control for Embedded Systems

- Workshops and Seminars in 2006
  - CORDIE'06: Concurrency, Real-Time and Distribution in Eiffel–like Languages
  - Artist2 - Foundations and Applications of Component-based Design
  - MARTES 2006
  - JTRES 2006
  - WESE'06 - Embedded Systems Education
  - ARTIST2 Workshop on Timing Analysis in the Industrial Development Process (ISoLA 2006)
  - MoCC - Models of Computation and Communication
  - ARTIST2 Workshop on Requirements for Flexible Scheduling in Complex Embedded Systems
  - ARTIST2 Workshop on Specification and Verification of Secure Embedded Systems
  - ARTIST2 Workshop Beyond AutoSar
  - ARTIST Workshop at DATE'06
  - ARTIST2 Workshop on Execution Platforms / Cluster Meeting
  - ARTIST2 Workshop on Basic Concepts in Mobile Embedded Systems
  - Synchron 2006
  - ATVA China 2006
  - ATVA China 2006
- Workshops and Seminars in 2005
  - ACM-IEEE MEMOCODE'2005

    - Workshop: Distributed Embedded Systems
    - WESE'05 - ARTIST2 Workshop on Embedded Systems Education
    - OSPERT 2005
    - ARTIST Seminar on Adaptive Real-Time Systems
    - ARTIST Workshop at DATE'05
    - HSCC '05 - Hybrid Systems: Computation and Control
    - First S.Ha.R.K. Workshop
    - EU/US: Component-based Engineering for Embedded Systems
    - IST/NSF: Transatlantic Research Agenda on Future Challenges in Embedded Systems Design
    - 31st EUROMICRO Conference - Special session: Model Driven Engineering (MDE)

- **Schools and Seminars**
    - ADSD 2006: Advanced Digital Systems Design
    - First European Laboratory on Real-Time and Control for Embedded Systems
    - First European-SouthAmerican School for Embedded Systems
        - First European-SouthAmerican School for Embedded Systems - Programme
    - ARTIST2 Graduate Course on Embedded Control Systems
    - FOSAD 2006: 6th International School on Foundations of Security Analysis and Design
    - ARTIST2 - MOTIVES 2007
        - Social Event
    - ARTIST2 / UNU-IIST Spring School in China 2006
    - ARTIST2 Graduate Course on Embedded Control Systems
    - ARTIST2 Summer School 2005
    - Artist2 / UNU-IIST School in China - 2007
    - MDD4DRES
    - ARTIST2 South-American School for Embedded Systems 2008
        - School posters
    - CASTNESS'07 Workshop and School
    - Quantitative Aspects of Embedded Systems
    - FOSAD 2007
    - ARTIST2 Graduate Course on Embedded Control Systems
    - Real-Time Microcontroller Systems: OSEK Standard and experiments on µcontroller devices
    - EPSD 2007
    - ARTIST2 PhD Course on: Automated Formal Methods for Embedded Systems
    - LASER Summer School on Software Engineering
    - CASTNESS 2008
    - ARTIST2 Summer School 2008 in Europe
    - Artist2 Summer School in China 2008
    - ARTIST2 Graduate Course on: Automated Formal Methods for Embedded Systems 2008
    - Real-Time Kernels for Microcontrollers: Theory and Practice
    - MDD for Distributed Real-time Embedded Systems (MDD4DRES) 2009
    - FOSAD 2009
- **International Collaboration**
- **Publications**
- **Contributions to Standards**

    - Modelling
    - Programming Languages
        - ARTIST Survey of Programming Languages
    - Operating Systems and Middleware
- **Course Materials Available Online**

Embedded System Links

- **Journals**
- **Conferences**
    - MEMOCODE 2007
    - EmSoft'07
    - DAC 2007
    - DATE 2007
    - RTAS 2008
    - CODES+ISSS 2006
    - IST Event 2006
    - RTSS 2006
    - FM 2006
    - CASES 2007
    - ASP-DAC 2008
    - HSCC'07
    - ARCS 2007
    - ECRTS 2007
    - IESS'07
    - ECMDA
    - ESEC/FSE
    - ECC
    - FDL'07
    - CAV 2007
    - SAMOS VII
    - RTSS 2007
    - ETFA 2007
    - RTS 2007
    - Networks-on-Chip Symposium
    - RTNS'2007
    - FORMATS'07
    - Embedded Systems Week 2007
    - Embedded Systems Conference 2007
    - RTCSA 2007
    - CODES-ISSS 2007
    - ECRTS 2008
    - LCTES'08
    - DATE'08
    - ERTS 2008
    - Ada-Europe'08
    - IFAC'08
    - RNTS'08
    - ESWEEK 2008
    - Cyber Physical Systems Week 2008
    - Models'08

    - DCOSS '08
    - CAV 2009
    - DATE 2009
    - Cyber Physical Systems Week 2009
    - LCTES'09
    - POPL 2009
    - ESWeek 2009

- **Hot Topics**
- **Standards**
- **Tools and Platforms**
    - Real-Time Components
    - Adaptive Real-Time
    - Compilers and Timing Analysis
    - Control for Embedded Systems
    - Testing and Verification
- **Main Projects**
    - ARTEMIS European Technology Platform
- **Position Papers**
- **Roadmaps**
- **Newsletters and Magazines**
- **Mainstream Press**
- **Announcements**
    - Artist Mailing List
    - Open Positions in Embedded Systems
        - Previous Open Positions
    - Other Calls
    - Other
- **Publications**

9. Cluster-Level Dissemination and Use of Knowledge

At the cluster level, the Artist2 partners have had significant interaction for dissemination and use of knowledge, both with other clusters and with top teams outside the NoE.

9.1 Real Time Components (RTC) cluster

Interaction with other ARTIST2 Clusters

Since heterogeneity, as well as component-based modelling and analysis naturally involves different aspects of design, then different sub-communities of embedded systems area are interested in this subject, e.g., control, real-time, and hardware. Therefore, RTC topics are a crossing point for several ARTIST2 clusters, in particular RTC, Adaptive Real-Time, Execution Platforms, Control for Embedded Systems, and Verification and Testing. We provide examples of interactions with these clusters.

- **Execution Platforms:** the RTC cluster (Cantabria, EPFL, INRIA, OFFIS, Timisoara, Uppsala, VERIMAG) and the Exeuction Platforms cluster, jointly organized the workshop on "Models of Computation and Communication (MoCC)", organized at ETH Zurich on Nov. 16-17, 2006, by Albert Benveniste, Paul Capsi, and Lothar Thiele (http://www.artist-embedded.org/artist/MoCC-06.html). The objective of the workshop was to survey the different activites in progress concerned with MoCC , gather recognised specialists of the different disciplines in order to attempt to get a panorama of the models used by each discipline, their commonalities and differences, and the several attempts that have already been proposed in order to merge these concepts within some unified view. The problem of compositional analysis of timing and resource properties has been the topic of collaboration during ARTIST2. In 2008, it resulted in a joint publication between ETHZ and Uppsala at EMSORT 2008. **T**here are several new collaborations between the execution platform and the Real-time components cluster. Verimag and ETHZ have collaborated on a translation from the analytic DOL performance evaluation tool to the executable BIP. The newly started Combest project has partners from both clusters (Verimag, EPFL, INRIA, OFFIS, Parades for RTC, and ETHZ and TU Braunschweig for the execution platforms). OFFIS and TU Braunschweig have coorganised a workshop on the certification of safety critical software controlled systems.
- **Control:** Several RTC partners (INRIA, PARADES) are prominent members also in the control community (and some of them are members of the HyCON NoE). Several interactions between the components and control cluster exist. Partners of the control cluster were important contributors to the opening day of the workshop **Beyond Autosar**, which was dedicated to the interaction of distributed embedded software and contro**l.** In year 3, 2 workshops have been organised by participants of different platforms; two of them (at DATE and at CAV) involved partners from the control and component cluster. There are also collaborative projects involving partners from both clusters. In particular, Martin Torngren (KTH) is a core partner in the Control for Embedded systems cluster and collaborates on the "safety critical" platform of the component cluster, in particular through participation in the ATESST project. Short visits have been organised between KTH and CEA in 2008, in order to present work on model based engineering as well as software platforms, and to explore possibilities for joint work.
- **Adaptive Real Time:** TU Vienna is interacting with the group of Eduardo Tovar (ISEP-IPP). Björn Andersson and Rene Cunha from ISEP-IPP participated in the Workshop

on Basic Concepts in Mobile Embedded Systems held at TU Vienna, November 2006. Wilfried Elmenreich from TU Vienna was visting ISEP-IPP from May to June, 2007. University of Cantabria has had a fruitful interaction with the group of Luis Almeida (Universidade de Aveiro/IEETA) in the integration of the distributed capabilities provide by the IST-FRESCOR project to the FTT-SE flexible network resource. This continues the effort by Ricardo Marau from Aveiro/IEETA after his visit to Cantabria in 2006. Wilfried Elmenreich submitted his habilitation thesis on “Time-Triggered Transducer Networks” and got awarded the habilitation in 2008.

- **Verification and Analysis:** The very essence of the component platform activities is to integrate component based development with validation. Several cluster partners are also active in the domain of verification and have already good connections to this community. Also several projects, such as the French OpenEMbeDD, the German AVACS, the IP Speeds, the forthcoming COMBEST connect (1) teams working on modelling and model transformation techniques and semantic frameworks and (2) teams working on verification algorithms (3) teams from the execution platform cluster. In 2007, two workshops have been organised jointly with verification and analysis platform partners (see interaction with control cluster). This year, one workshop at least puts a strong aspect on modelling and verification, the workshop on UML and Formal methods. But most workshops focussing on modelling aspects, also include topics on validation.
- **Multi-cluster interactions:** the ARTIST summer schools organised in China and in France involved topics and speakers from several clusters. The topics covered by the summer school in France include Modeling and Validation, Compilers and Timing Analysis, Adaptive Real Time Systems, Control for Embedded Systems, Execution Platforms and MPSoC.

Organization of summer schools

The RTC cluster has been strong drivers in the organization of summer schools

- The Summer School on Model Driven Development for Real-time and Embedded Systems (www.mdd4dres.info) in Sept. 2006 in Brest. This was the third edition of this summer school which focuses on model-driven related issues in the context of real-time and embedded systems development. A new edition of this summer school will be held in Spring 2009 in Autrans.
- An ARTIST Summer School on embedded systems design has been organised in in Shanghai, July 12-18 2008, in collaboration with the SEI/ECNU and the LIAMA. This is the third Artist summer school organised jointly with China. The aim is to promote collaboration between European and Chinese research community on embedded systems and related areas. In 2009, a third edition of this summer school is planned.
- An Artist summerschool has also been organised in Autrans, France in September 2008 (http://www.artist-embedded.org/artist/ARTIST2-Summer-School-2008.html). It is the fourth such summer school organised by Artist in Europe, and it is meant to be exceptional in terms of both breadth of coverage and invited speakers. The topics covered in this year’s school include Modeling and Validation, Compilers and Timing Analysis, Adaptive Real Time Systems, Control for Embedded Systems, Execution Platforms and MPSoC. A balance is seeked between foundational aspects and applications. Speakers include recognized leading researchers and engineers.

Organization of conferences, workshops, summer schools

The RTC cluster has been co-organizing the following conferences and workshops (for more details: see the deliverable on *Spreading Excellence.*

- Sébastien Gérard (CEA) is also co-organizer of a series of workshops on the UML and AADL. The last edition was hold in conjunction with the 13th IEEE International Conference on Engineering of Complex Computer Systems (ICECCS 2008) in *April 2nd, 2008, in Belfast, Northern Ireland (*http://www.artist-embedded.org/artist/Registration,1370.html*)*.
- Sébastien Gérard (CEA) is also co-organizer of a workshop on UML and formal methods: http://www.artist-embedded.org/artist/New-article,1486.html. This workshop will be held in conjunction with the 10th International Conference on Formal Engineering Methods, ICFEM 2008 (October 27th, 2008, Kitakyushu-City, Japan).
- CEA and INRIA are main organizers of the series of Workshop, MODEVVA (www.modeva.org). The objective of this workshop is to offer a forum for researchers and practitioners who are developing new approaches to V&V in the context of MDE. The workshop will discuss V&V of model transformations and code generation; techniques for validating a model or generating test cases from models including simulation, model-checking, and model-based testing; application of MDE to validation, testing, and verification; tools and automation; case studies and experience reports. In 2006, the MoDeVa workshop was been co-located with the MODELS/UML conference in Genova (Italia), and in 2007, in Nashville. In 2008, it has been collocated with ICST'2008, Lillehammer, Norway: CEA and Supélec organized the MoVaH 2008, Workshop on Modeling, Validation and Heterogeneity co-located with ICST 2008, Lillehammer, Norge (wwwdi.supelec.fr/fb/MoVaH08)
- VERIMAG is also a co-initiator and co-organiser of the symposium on Formal Methods for Components and Objects FMCO (http://fmco.liacs.nl/fmco07.html) the aim of which is to bring together researchers and practioners in the areas of software engineering and formal methods to discuss the concepts of reusability and modifiability in component-based and object-oriented software systems The 5th issue has been organised in November 2006 in Amsterdam; In 2007 has taken place a special issue bringing together groups of a set of related EU projects and NoEs; Artist2 is one of those groups. In 2008, the organisation has been taken over by a new group of people.
- Albert Benveniste (INRIA) and Paul Caspi (Verimag), in tight cooperation with John Rushby (SRI, Stanford), and with local support by Alberto Ferrari and Alberto Sangiovanni Vincentelli (who chaired the meeting) at PARADES have organized an ARTIST2 workshop on Integrated Modular Avionics (IMA), held November 12-13 in Rome at PARADES location. Speakers included key persons from Airbus, Dassault-Aviation, Israeli Aerospace Industries, Honeywell and Windriver, plus John Rushby and ARTIST2 participants. See http://www.artist-embedded.org/artist/-ARTIST2-meeting-on-Integrated-.html
- Tom Henzinger, EPFL, and Werner Damm, OFFIS, have organized the Second International Workshop on Foundations of Component-based Design, held at the Embedded System Week in Salzburg on Sep 30, 2007.
- CEA LIST (Christophe Gaston) and Supélec (Frédéric Boulanger) co-organized the MoVaH workshop (http://wwwdi.supelec.fr/fb/MoVaH08/) at the ICST 2008 conference in Lillehammer in April 2008. The topic of this workshop was the modelling and validation of heterogeneous systems.
- MdH organized the workshop COMES'08) on Component Models for Embedded System. This was a workshop with limited number of attendance to foster intensive

interactions, supported by the PROGRESS research centre, MRTC, and ARTIST2. Its aim was to present and discuss the current research and practical results in development of embedded system using component-based development approaches, as well as to discuss and point out the challenges and possible solution directions in applying the component-based approach to achieve predictability of component-based embedded software systems. The workshop was lively, with over 30 participants from PROGRESS and the international research community. http://www.mrtc.mdh.se/progress/COMES/

- PARADES and EPFL organized the workshop: From Embedded Systems to Cyber-Physical Systems: a Review of the State-of-the-Art and Research Needs on Monday, April 21, 2008 in St. Louis, MO, USA. The theme of the workshop was presenting an overarching view of methodologiesand theories for the design of embedded and critical systems as it has emerged in the past five years and discussing the future in terms of the extension of the notion of embedded systems to Cyber-Physical Systems (CPS). In the overview of the present status of the discipline, the workshop addressed heterogeneous system composition, design methods based on abstraction and refinement, interface theories, mapping of abstract entities to implementation platforms and industrial applications. The presentations featured industry representatives who gave their perspective of what are the gaping holes in the state of the art in their business segment and how to bridge academic accomplishments with industrial practice. The discussion about the extension of the theories and methodologies to the new generation of CPS reviewed the necessary steps and a possible roadmap for research. The discussion included public research organizations. European Community representatives, Werner Damm as Autosar and Artemis representative and Philippe Reynaert, DG INFSO Embedded Systems, provided the state-of-the-art and the research initiatives on embedded systems in the EU.
- OFFIS and TU Braunschweig have organised the workshop “SafeCert 2008 – Certification of Safety-Critical Software Controlled Systems” (http://safecert08.offis.de) as a satellite event of ETAPS 2008. The major question addressed in the workshop was how to embed formal methods and tools in a seamless design process which covers several development phases and which includes an efficient construction of a safety case for the product.
- Alain Girault and Eric Rutten (INRIA) organized the Model-driven High-level Programming of Embedded Systems, SLA++P’08 (a satellite event of the European Joint Conference on Theory and Practice of Software, ETAPS 2008), in Budapest, Hungary, March 2008. The keynote speaker was Grégoire Hamon from Mathworks. See http://www.artist-embedded.org/artist/SLA-P-2008,1231.html
- Thierry Jéron (INRIA) co-organized the MOVEP’08 summer school on modeling and verifying parallel processes, in Orléans, France, June 2008. See http://www.univ-orleans.fr/movep2008/
- In the context of the ATESST project, CEA and KTH organised two workshops. The “EAST-ADL, AADL, MARTE, Autosar harmonization workshop” which provided useful information exchange between the project and the respective standardization initiatives. It was agreed to maintain contacts, and to organize follow up meetings. Identified topics of common interest include Timing, Error modeling and Methodology. The second one is on the “Model based development of automotive embedded systems - The EAST-ADL approach” (march 3, 2008 - www.md.kth.se/RTC/atesst-open-workshop_v1.1.pdf).
- CEA co-organises the workshop on UML and AADL is held in conjunction with the 13th IEEE International Conference on Engineering Complex Computer Systems, ICECCS 2008, this workshop gathered researchers and practitioners interested in all aspects of

the representation, analysis, and implementation of DRE system behaviour and/or architecture models. http://www.artist-embedded.org/artist/-UML-AADL-2008-.html

- CEA and Verimag coorganised (with external partners) the 1st International Workshop on Model Based Architecting and Construction of Embedded Systems held in conjunction with MODELS 2008 as a follow-up workshop of the SVERTS and MARTE workshops organised in previous years, the objective of this workshop is to bring together researchers and practitioners interested in model-based software engineering for real-time embedded systems. We were seeking contributions relating to this subject at different levels, from modelling languages and semantics to concrete application experiments, from model analysis techniques to model-based implementation and deployment. Given the criticality of the application domain, a particular focus is on model-based approaches yielding efficient and provably correct designs. http://www.artist-embedded.org/artist/ACES-MB-08.html
- CEA co-organises (with external partners) the 1st IEEE International workshop UML and Formal Methods as a satellite of ICFEM 2008 in Japan. For more than a decade now, the two communities of UML and formal methods have been working together to produce a simultaneously practical (via UML) and rigorous (via formal methods) approach to software engineering. The fact that the UML semantics is too informal has led many researchers to formalize it with different existing formal languages. The main objective of this workshop is to encourage new initiatives of building bridges between informal, semi-formal and formal notations.

  http://www.artist-embedded.org/artist/UML-FM-08.html
- MdH and Uppsala (via ARTES and SNART) have driven the organization of the Swedish Embedded Systems Meeting in Stockholm, March 5, 2008, where results of Swedish research programs on Embedded systems are presented, and further developments are discussed. http://www.snart.org/conference/2008/ses/

9.2 Adaptive Real Time (ART) cluster

Interaction with the control community

The ART cluster had several interactions with the control community and in particular with the cluster on Control for Embedded Systems. Since the first year, the two cluster leaders, Giorgio Buttazzo (ART) and Karl-Erik Arzen (Control) organized a number of meetings and workshops to exchange ideas and propose more concrete actions to make progress in this area.

A joint work involving people from Pavia, Pisa and Lund has been carried out to integrate feedback control schemes into the Shark operating system (used as a shared platform) and to investigate the effects of different scheduling policies on delays and jitter in control loops.

Another strong collaboration has been established with the hybrid systems community. As a result of this connection, Giorgio Buttazzo has been invited as a co-Program Chair to organize the International Conference on Hybrid Systems: Computation and Control (HSCC 2007).

A joint work involving people from UPC (affiliated to TUKL) and Lund has been carried out to investigate feedback scheduling techniques. A PhD student from UPC spent 5 months in Lund working on the project.

In the last year, Pisa, Lund and TUKL started a collaboration to achieve adaptive resource reservations in multi-core systems. Pisa contributed to identify the most appropriate scheduling algorithms, Lund contributed on feedback control schemes, and TUKL on defining the programming interface.

Interaction with the cluster on compilers and timing analysis

A collaboration has been started with the cluster on compilers and timing analysis to investigate the problem of enhancing the predictability of real-time systems by reducing the variability of task execution times. In fact, internal kernel mechanisms, such as scheduling, mutual exclusion, interrupt handling and communication, can heavily affect task execution behaviour and hence the timing predictability of a system. For example, preemptive scheduling reduces program locality in the cache, increasing the worst-case execution time of tasks compared with non preemptive execution.

To address these issues, a new research was initiated that looks at predictability and efficiency in a synergistic manner and that involves all levels of abstraction and implementation in embedded-system design.

Thanks to the ARTIST2 network of excellence, the ART cluster got in contact with the cluster on Compilers and Timing Analysis. The two clusters started working together to develop a new approach consisting of a combination of several methods, including (a) design-space exploration on the hardware architecture level to identify good designs offering combinations of strong performance with good predictability, (b) appropriate kernel mechanisms for task and resource management that are predictable and analyzable, and (c) a synergistic development of models, design methods and matching analysis tools that extract precise system-behaviour properties.

Interaction with the language community

The ART cluster participated in the development of Ada, (Ada 2005), Java (RTSJ) and POSIX (for use with C and C++). This participation has included membership of the associated standardisation bodies that linked the work within the cluster with international efforts across such languages.

Interaction with the real-time components community

A collaboration between the clusters on components and adaptive real-time has been carried out along the ARTIST2 project. The main goal is to provide support for dealing QoS aspects in component-based systems. This technology is a relevant approach to complex system development and to allow a smooth integration of software from different vendors. QoS management is an adequate mean to provide a predictable quality to end-users. The collaboration between those clusters has brought competencies in component-based design for hard and adaptive real-time systems, to produce advances that would be difficult to achieve without all three.

This cooperation has facilitated the development of a number of technical achievents along four research lines: a) specification of QoS properties using UMNL profiles and aspect-based approachs, b) generation of analyzable models from the UML models, c) composition of QoS-aware components and adaptability, and d) QoS support in run-time components frameworks. The participants in this activity have actively participated in the development of a number of OMG standards

Dissemination

The ART cluster has been quite active in disseminating the research results achieved in the context of the ARTIST2 network of excellence, as an overall strategy for reaching other research/academic/industrial communities with related interests.

The operating system platform developed in the context of the Joint Programme of Integration Activities (JPIA) has been extensively used in summer schools and graduate courses to teach how to develop embedded applications with real-time and performance requirements.

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

- OSPERT 2008: Workshop on Operating Systems Platforms for Embedded Real-Time applications, Prague, Czech Republic, July 1, 2008.
- ETFA 2007: IEEE International Conference on Emerging Technologies and Factory Automation, Patras, Greece, September 25-28, 2007.
- RTSS 2007: IEEE Real-Time Systems Symposium, Tucson, Arizona, USA, December 3-6, 2007.
- ECRTS 2008: Euromicro Conference on Real-Time Systems, Prague, Czech Republic, July 2-4, 2008.
- RTAS 2008: IEEE Real-Time and Embedded Technology and Applications Symposium, St. Louis, MO, United States, April 22-24, 2008.
- HSCC 2007: ACM International Conference on Hybrid Systems: Computation and Control, Pisa, Italy, April 3-5, 2007.
- RTCSA 2008: IEEE International Conference on Embedded and Real-Time Computing Systems and Applications, Kaohsiung, Taiwan, August 25-37, 2008.
- IFAC 2008 World Congress, Seoul, Korea July 6-11, 2008.
- IECON 2007: Annual Conference of the IEEE Industrial Electronics Society, Taipei, Taiwan, November 5-8, 2007.
- WFCS 2008: IEEE International Workshop on Factory Communication Systems, Dresden, Germany, May 20-23, 2008.
- RTN 2008: International Workshop on Real Time Networks, Prague, Czech Republic, July 1, 2008.
- WPDRTS 2008: International Workshop on Parallel and Distributed Real-Time Systems (In conjunction with IPDPS), Miami, Florida, USA, April 14, 2008.
- Ada Europe 2008: International Conference on Reliable Software Technologies, Venice, Italy, June 16-20, 2008.
- ISORC 2008: IEEE International Symposium on Object and component-oriented Real-time distributed Computing, Orlando, Florida, USA, May 5-7, 2008.
- WTR 2007: Brazilian Workshop on Real-Time Systems, Belem, Brazil, May 28th, 2007.
- RTNS 2007: Int. Conf on Real-Time and Networked Embedded Systems, Nancy, France, March 29-30, 2007.
- SAE 2008 World Congress, Detroit, Michigan, USA, April 14-17, 2008.

9.3 Compilers and Timing Analysis (CTA) cluster

Cluster members performed teaching activities (e.g. Peter Marwedel from Dortmund and Rainer Leupers from Aachen at ALARI, Lugano and EPFL, Lausanne) in cooperation with

other ARTIST2 members (e.g. Luca Benini/Bologna and Lothar Thiele/Zürich). Further links of ARTIST2 members existed to the SHAPES project and to the HiPEAC Network of Excellence.

TU Dortmund

The interaction with the local technology transfer centre ICD (see http://www.icd.de/index_eng.html) is key for interacting with industry. ICD is headed by Peter Marwedel. ICD is used for transferring research results to industry. The group promoted education in embedded systems through a published text book and through courses at EPFL, at ALARI and at spring or summer schools in New Zealand, China, Brazil, Portugal, Korea, and Germany. TU Dortmund organizes the SCOPES series of workshops on compilation for embedded systems.

RWTH Aachen

A close cooperation existed with the ARTIST2 Execution Platforms cluster, in particular between Dortmund, Aachen, and Bologna University. RWTH Aachen participated in the HiPEAC network of excellence and started new cooperations related to code optimization, e.g. with Edinburgh University. Furthermore, Aachen maintained tight industry cooperations, e.g. with CoWare, ACE, and Infineon. Since Oct 2006, RWTH Aachen is running the UMIC research cluster (http://www.umic.rwth-aachen.de) of the German excellence initiative.

ACE

ACE worked closely with ST and with Philips having both a commercial relationship with them as well as being co-members of EU project consortia – in one case along with Verimag. ACE has been working closely with Aachen in this domain for some time. One of the results of this cooperation has been the integration of compiler technology in a start-up company that span out of the university. Cooperation with Imperial College and Edinburgh has also started.

AbsInt

Within the EmBounded Project (IST-510255), AbsInt was also involved in the development of the Hume compiler. Hume is a domain-specific high-level programming language for real-time embedded systems.

TU Berlin

TU Berlin is generally involved in methods and tools for software engineering for embedded systems. TU Berlin has cooperated with Edinburgh University (Björn Franke) concerning the optimization of compilers based on machine learning techniques. Furthermore, TU Berlin has done research on the verification of embedded operating systems, also by cooperating with the Fraunhofer institute FIRST. Finally, TU Berlin visited and was visitied by other cluster members, e.g. ACE, RWTH Aachen and TU Vienna.

IMEC

IMEC is integrated in European research networks, including HiPEAC. Moreover, IMEC is the central partner of a Marie Curie Host Fellowship project that involves more than 10 universities across Europe. IMEC also has many industry co-operations including most large European multi-media and communication systems oriented companies.

Mälardalen

The WCET analysis group maintains close contacts with several industrial partners, and has conducted a number of case studies using their production codes. The group also interacts heavily with the Component-based Software Engineering community through the national centre PROGRESS for research on component-based software design for embedded systems.

Saarland University

Timing-Analysis activities in the cluster interacted closely with the Execution-Platform cluster in the area of increasing the timing-predictability of real-time systems. Airbus and Bosch participated in the Predator FP7 proposal aimed at reconciling performance with predictability. The PREDATOR project started in 2008. Saarland University worked on modularizations of the Sagiv/Reps/Wilhelm shape analysis together with Mooly Sagiv, Tel Aviv University, and Arnd Poetzsch-Heffter, University of Kaiserslautern.

Tidorum, York

Tidorum (and partially York through Rapita Systems) were engaged in a project for the European Space Agency to study the timing and verification aspects of cache memories in space systems. The PEAL project ended in February 2007. An extension was started in late 2007. The main partner from the aerospace domain was Thales Alenia Space, France.

TU Vienna

TU Vienna worked on measurement-based timing analysis together with TU Munich. It also maintained a close interaction with the Lawrence Livermore National Laboratory, CA, USA, in optimizing high-level abstractions.

See ARTIST2 Y1, Y2, Y3, and Y4 deliverables on activities for a more exhaustive description of the state of the integration.

9.4 Execution Platforms (EP) cluster

ETH Zurich has been organizing and participating in the CASTENESS Workshop, see www.casteness.org. The workhop put together the expertise of various EU projects such as ARTIST2, SHAPES, AETHER. In addition, ETH Zurich has been given a tutorial on issues that have been investigated in the ARTIST2 context: Analytic Performance Estimation, Mapping Algorithms to Architectures, Scalable SW Construction. The workshop has been sponsored by ARTIST2 and took place 15.-18th of January 2008.

ETH Zurich has given part of a summer school/advanced course on ADVANCED DIGITAL SYSTEMS DESIGN on 10-14 September 2007, Lausanne, Switzerland. The participants are from industry and university. This way, results from the integrated view of embedded system design will be brought to a much larger community.

Lothar Thiele from ETHZ has been given a tutorial at EMSOFT on Sept. 30 2007, the major conference in the area of embedded software. It covered methods for performance analysis of distributed embedded systems and presented outcomes of the ARTIST2 project.

As a follow-up of the Models of Computation and Communication (MoCC) at the ETH last year, the TU/e organized the MoCC2008 workhop. It took place in Eindhoven on July 3th and 4th. It brought together scientists from various areas, i.e. formal methods, hardware design and software architecture, http://www.artist-embedded.org/artist/MoCC-2008.html.

The ESI (TU/e) participated in the Quasimodo workshop (IST framework programme 7) and brought in a industrial case study to combine different quantitative analysis techniques. The workshop was held in Aachen on June 2nd and 3th.

TU Eindhoven and TU Braunschweig are guest editors of the ACM TECS special issue on Model-driven Embedded System Design (http://acmtecs.acm.org/mesd.htm).

Linköping has given an invited talk at the DATE 2008 Conference, as part of the special day on Dependable Embedded Systems. With this occasion several results obtained in the ARTIST context have been made accessible to an international audience. They are related, in particular, to fault tolerance aspects of distributed real-time systems like those used in automotive applications.

Linköping has organised the 6th IEEE Workshop on Embedded Systems for Real-Time Multimedia, as part of the ARTIST sponsored Embedded Systems Week 2008.

UNIBO has been very active in the Multi-core Systems-on-Chip community and in the computer architecture community which is now aggressively targeting multi-core systems. UNIBO has become active member of the HIPEAC2 network of excellence and participated to several events in this area. Prof. Benini has been an HIPEAC instructor at the ACACES summer school, in L'Acquila. Members of the UNIBO team have participated to the main HIPEAC events in 2008.

DTU has been organizing the DaNES Mini-Case Workshop on industrial case-studies at DTU on May 22-23, 2008.

TU Braunschweig has been organizing the Embedded Software Track at the major European conference on design automation DATE (Design Automation and Test in Europe) that took place March 10-14, 2007. The track was devoted to modelling, analysis, design and deployment of embedded software, including formal methods, tools, methodologies and development environments. Thereby, the emphasis was on embedded software platforms, software integration and portability issues.

9.5 Control for Embedded Systems (Control) cluster

Similar to previous years the main interaction ¨within Artist2 has been with the ART cluster and the RT-Components cluster. The interaction with the ART cluster has been performed through joint research work, and through joint proposals and projects.

Outside Artist2 the cluster has interacted with a number of other communities. Some examples are given below:

- The partners of the cluster have interacted with the partners in HYCON through joint participation.
- The partners of cluster have interacted with the partners in SOCRADES IP projects through joint participation.
- The partners of the cluster have interacted with the partners in numerous STREP projects. These include ATESST, ACTORS, DYSCAS, CHAT, AEOLUS, and FRESCOR.
- The partners of the cluster have interacted with the respective national research communities.
- The cluster has organized or co-organized a number of workshops and events, both with a research focus and with a dissemination focus. These includes:

- The Fourth Graduate School on Embedded Control Systems, Stockholm, May 2007.
- Zdenek Hanzalek was the General Chair for the 20th Euromicro Conference on Real-Time Systems (ECRTS 08) held in Prague, July 2-4, 2008.
- A one-day workshop on "Embedded Control Systems: From Design to Implementation" was held in association with the IFAC World Congress, Seoul, Korea, 6 July, 2008
- The cluster was among the presenters at the workshop "Complex Embedded and Networked Control Systems" organized by the HYCON community and held in association with the IFAC World Congress, Seoul, Korea, 5-6 July, 2008
- The cluster co-organized a workshop on "DataFlow Modeling for Embedded Systems" together with the ART cluster and the ACTORS project that was held in Pisa, 5 May, 2008
- An invited session on networked embedded control for the CDC 2008 conference was organized together with Albert Benveniste from the RT-Components cluster. The session was accepted and will take place in Cancun in parallel with the final Artist2 review in December 2008.
- Karl Henrik Johansson and Karl-Erik Årzén co-organized the EU-US'08 workshop held in Stockholm, 16 June 2008. The topic of the workshop was Networked Information and Control Systems.
- A workshop on "Model-based development of automotive embedded systems – The EAST-ADL approach" was co-organized with ATESST, Brussels, 3 March, 2008
- A workshop on harmonization of modeling languages was co-organized with ATESST in Paris, 25 October, 2007. The meeting gathered representatives from the EAST-ADL, AADL, and MARTE communities.
- A KTH/Industry seminar was organized on September 3 to mark the kick-off for the KTH Embedded Systems centre (ICES). Presentations were given among others by representatives from ABB, Ericsson, and Scania and by Edgar Brinksma from the Dutch Embedded Systems Institute.

- The partners of the cluster has given several keynote addresses, invited sessions, and invited lectures, see the respective activity reports.

9.6 Testing and Verification (TV) cluster

At the *scientific level* model checking technology forms the very basis for automatic verification with numerous applications. Its recognition in Computer Science as a core technology is clearly witnessed by the giving the Turing Award 2007 jointly to Edmund Clark, Allan Emerson and Joseph Sifakis for their original and continued research on model checking.

In the period of ARTIST2 model-checking has been successfully applied to the automatic generation of test suites (with guaranteed coverage), and is also increasingly applied successfully within and by other communities including hardware/software co-design, control theory, discrete event systems, fault-tolerance, planning and scheduling and performance evaluation.

Members of the cluster has published and given invited talks at main conferences and in journals of these neighbouring communities.

Similarly leading research groups within AI are finding applications of existing search heuristics from planning to the improved model-checking (e.g. Friburg University, Germany within the AVACS project and Trento University, Italy).

At the *organization* level, members of the cluster have been active in the European ARTEMIS initiative; in particular ESI is a member of ARTEMIS, and other partners of the cluster have been active in promoting ARTEMIS at national levels (e.g. Aalborg together with IMM/DTU have been initiators of the Danish D-ARTEMIS consortium).

10. Vision Beyond the Artist2 NoE

10.1 Real Time Components (RTC) cluster

Embedded real-time components are used in more and more application domains, which go clearly beyond avionics and automotive. Building automation is one of these domains, with a predictable growth in the next ten years. This growth is motivated by many factors. Two factors are of particular importance: energy saving and health care for the elderly. The increasing concerns about energy use and pollution has made energy conservation and use of renewable sources of energy a primary goal of the European Community. In this context, we believe that the overall activity of ARTIST 2 is essential since embedded control and monitoring will be a pillar to achieve possibly overambitious goals to have buildings that consume zero net energy by 2012.

The lines of work of the different RTC activities will be continued in many forms.

- As already mentioned in the previous section, the need for a good and effective connection between UML-RT related standardisation bodies and the active academic community still remain. This is the role currently played by the activity *Development of UML for Real-Time Embedded Systems.* This role should remain fulfilled even after the end of ARTIST2 and the effort to disseminate around the MARTE specification will be more and more effective in the incoming year. Both the ADAMS project and the Artist Design NoE will two of the most important support for achieving this purpose.
- The aim of the component platform activity is to show the feasibility of and possibly to improve the design approaches for component based heterogeneous systems in the cluster by providing tool support for it. To this aim, we have started to build a set of platforms or tool suites supporting such model-based design approaches based on user level modelling notations, notations supported in commercial tool suites, and new modelling paradigms being developed in this cluster. At a longer term, the today isolated tool suites showing partial solutions should be usable consistently also in a combined fashion due to the existence of semantically well-founded component frameworks flexible enough to represent and meaningfully combine models from different user tools and possibly different abstraction levels or view points and that can be exploited by back-end tools (analysis and code generation). Generally speaking, most of the activities of the platform activities will be continued in the modelling and validation cluster of the Artist Design NoE in some form, even if the platform will not be identified as such in the new NoE. T
- The challenge of putting model-based design of embedded systems on a firm scientific basis has met with further problems that should be addressed. Important problems include to bridge the dichotomy between operational and transformational modeling approaches. Operational means automata-based: these approaches work on a component level, and have been successful in model checking, protocol verification, and code generation. Transformational means stream-based: these approaches work on the system level, and have been successful in performance analysis. While operational approaches have difficulties to scale to systems, transformational approaches suffer a loss of precision. Further important topics include resource modeling, to permit the exploration of trade-offs between multiple dimensions, such as functionality, reliability, performance, and resource consumption. To overcome the problem that current models for modeling quantitative properties of systems systems (Markov processes; timed automata; hybrid automata) tend to be brittle and overly sensitive towards arbitrarily small numeric perturburances, we plan to develop robust models for stochastic, timed, and hybrid systems. On the tool side, we will continue to

study the integration of BIP and Metropolis as two frameworks that will allow the composition and the analysis of heterogeneous parts. The sequence of meetings in different industrial sectors will continue by considering the building, avionics, consumer electronics and automotive domains (a meeting is planned for November 12th and 13th, 2008 at PARADES to discuss these application domains and see how Artist Partners can contribute to solidify a design methogology and supporting tools for industry. A major focus of future work will be to establish well defined bridges between innovation potentials for component based design and industry standards, notably Autosar.

The above and other challenges will be addressed in current and to-be-initiated collaboration projects between Artist2 partners and others. Examples include ArtistDesign, and the omgoing projects SPEEDS, COMBEST, and GENESYS.

10.2 Adaptive Real Time (ART) cluster

The major result of the ART cluster has been to build a significant amount of knowledge on problems, methodologies, techniques, and tools for embedded systems with highly dynamic behavior. Such a knowledge is now available to be disseminated in the industry and in the academia to educate next generation engineers.

The vision beyond the ARTIST2 NoE is to organize such a huge amount of knowledge and make it available in different forms to help the development of embedded systems that are more robust, more efficient, more flexible, and more predictable than what is possible today.

Part of this cluster will continue to work within the ArtistDesign NoE, both in the OS and Networks domain, and in the transversal Design for Adaptivity activity. A lot of the work will also continue in the different existing and new IP and STREP projects that the core partners are members, e.g., FRESCOR, ACTORS, PREDATORS and INTERESTED, as well as in different national projects.

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

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

10.3 Compilers and Timing Analysis (CTA) cluster

Fortunately, the successful cooperation within the ARTIST2 NoE will be continued in the ArtistDesign NoE. For ArtistDesign, the scope has been extended. There is now the focus on multiprocessor systems, due to the needs of the industry in this area. This includes the integration of the single-task-on-uniprocessor methods. Also, this includes the integration of tools into design flows considering distributed and communication-centric systems. This new direction is considered by both subclusters, as multiprocessor systems generate new problems for compilation and for timing analysis. The subclusters are also cooperating on this issue. A first workshop has been held. Also, code generation beyond compilers receives more attention. Work on compiler platforms, timing analysis, and resource aware design continues.

New projects extending the cooperation between the partners include the following:

- AbsInt, Mälardalen, York spinoff Rapita Systems, and TU Vienna are partners in the FP7 STREP ALL-TIMES (ICT-215068, duration Dec. 2007 – Feb. 2009). Their work on tool integration and analysis of C code will be continued within ALL-TIMES.
- AbsInt, Saarland University, and TU Dortmund are partners in the FP7 project PREDATOR (Ref. 216008, duration Feb. 2008 – Jan. 2011) aiming at reconciling predictability and efficiency. Joint work on the WCET-aware compiler will continue in that framework.
- IMEC, TU Eindhoven and ICD (a spin-off of TU Dortmund) are partners in the FP7 Mnemee (IST-216224, duration Jan. 2008-Dec. 2010) project.

Timing Analysis: code-level timing analysis is now in a state where it is being applied in industry for the analysis of time- and safety-critical systems. Still, many challenges remain. Code-level analysis tools and techniques must be integrated into tool chains and development processes, interacting with system-level tools. The usability can be improved, increasing the level of automation. Early, approximate estimates of timing properties are needed for the dimensioning of systems. As computer architecture develops, the timing models become more complex and the subsequent analysis becomes harder. In particular, the introduction of explicitly parallel multicore and MPSoC architectures is very problematic from a timing analysis point of view since shared resources, like buses and memories, easily can cause very unpredictable timing behaviour.

What is needed is a new design discipline, Design for Predictability, that deals with resource handling in general and cuts across several disciplines such as timing analysis (as well as other resource analyses), computer architecture, software design, system software, compilers, and HW/SW codesign/synthesis..

The ultimate vision is a fully integrated development process with resource needs and safely and precisely determined resource consumption communicated between components and layers through resource interfaces. The PREDATOR project addresses these issues.

Compilers: multiprocessor systems challenge compiler technology. Significant progress is required to support the forthcoming parallel architectures. Significant investments into compiler technology are needed to meet the continuing trend towards more performance hungry applications. The lack of adequate compiler technology could potentially inhibit new applications in a large variety of domains. In many cases, required technologies can use available compilers as backends. Hence, fortunately, there is a decreasing need to integrate all new optimizations into a single monolithic compiler.

The generation of embedded systems from specifications in standard von-Neumann languages comes with a number of problems, like potential deadlocks, priority inversion etc. Therefore, new models of computation are being tried out. New code generation techniques are needed for such new models.

Research along the lines of the ARTIST2 project continues to be needed. New optimization engines are required. Resource aware design will be an important topic in the future. This includes memory-architecture aware compilation in particular. Due to the obvious impact of the memory-wall problem, embedded systems will become memory-speed limited and all techniques easing the problem can be expected to find a major attention. Also, optimization engines for SIMD architectures must be improved. Energy efficiency of embedded systems will become even more important than it was in the past. The required high levels of optimization will need to be supported by advanced code analysis techniques. Code correctness is urgently needed. Hence, techniques for code verification are also needed.

Synergies between compilers and timing analysis: Linking compilers and timing analysis can be expected to be an area of further research. Improved availability of timing information in compilers is certainly overdue. It can be expected that this will be recognized outside this

consortium as well and that timing issues will be given more attention. It is unknown, how quickly this will be taken up by the industry.

10.4 Execution Platforms (EP) cluster

As a result of the activities of the execution platforms cluster, a number of powerfull analyses, design and exploration methods are available today. An important direction for future activities within ArtistDesign is to make a step towards large-scale industrial applications by applying these methods to industrial applications in different domains, analyse their strengths and weaknesses, categorize them, integrate them and fit them in industrial design trajectories.

In ArtistDesign we will continue our work on analysis and optimisation of distributed embedded systems, fault tolerance, and energy efficiency. The focus will be on systems with a dynamic nature where we do not assume that a certain worst case constellation is known at design time, but certain decisions regarding resource allocation have to be taken dynamically, at run-time, by still satisfying certain safety and QoS constraints.

ARTIST2 has inspired work on several topics that could not be fully pursued within its lifetime, but have sparked research into directions that now continue within other projects.

- The integration of different levels of Quality-of-Service will be investigated in the AIS Project (http://www.edacentrum.de/ais/)
- In particular, mixing real-time and non-real time processing in a multi-core system is the focus of the Compose project (http://www.ida.ing.tubs.de/en/research/projects/compose/)
- In the scope of the Combest project (http://www.combest.eu), TUBS and ETHZ build on the foundations of hierarchical event models and scheduling.
- Organic computing has become a Schwerpunktprogramm of the DFG (http://www.organic-computing.de/spp)
- Intertask communication and synchronization in multi-core systems.

10.5 Control for Embedded Systems (Control) cluster

The general vision for the research work that is coordinated within the cluster is summarized in the following two statements:

Development of methods, tools and theory that allow faster and more efficient development of networked embedded control systems that are safer, more flexible, more predictable, have higher degree of resource utilization, and better performance than what is possible today

and

Advance the state of the art in applying control methods for providing flexibility and robustness and manage uncertainty in embedded computing and communication systems.

This cluster as a whole will be discontinued after the end of Artist2. However, in spite of this, a lot of the work will still be continued in the ArtistDesign network, both in the OS and Networks cluster and in the transversal Design for Adaptivity activity. A lot of the work will also continue in the different existing and new IP and STREP projects that the core partners are members, e.g., SOCRADES, FRESCOR, DYSCAS, ACTORS, and ATESST, as well as in different national projects.

There are strong indications that control implementation techniques will continue to be important for the embedded systems community. Control is and will without doubt continue to

be one of the largest application areas for embedded system, in particular for ubiquitous networked embedded systems. The current multi-core trend that both makes traditional static implementation techniques more difficult and generates new requirements on programming models and implementation techniques is one sign of this. Another sign is the focus on small ubiquitous networked devices in the form of, e.g., sensor networks, where there are severely limited computing resources, but still a desire to perform as much of the computations (incl. control computations) locally in order to save communication bandwidth and battery power.

The use of feedback to provide performance and robustness in networked embedded computer 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 dynamic feedback-based resource management will be increasingly important for the future.

10.6 Testing and Verification (TV) cluster

As clearly observed by the many industrial contacts of the two national embedded systems centers, ESI (The Netherlands) and CISS (Denmark), testing is *by far* the most used and important validation technique applied by industry today. It is estimated that some *30-70% of the total development cost* for embedded systems is spent on testing at various stages. It is also a general observation that current testing practice is very ad-hoc often with manual construction and even execution of test-scripts. There is clearly a gap between current industrial practice and existing academic state-of-the art technology. It is important that continued effort is made towards bridging this gap though collaborative projects attempting to make industry take-up existing state-of-the-art testing and verification techniques.

To focus on aspects such as performance, timeliness, and efficient resource-usage, the testing and verification techniques should be based on models with *quantitative information.* To provide a coherent model-based testing and verification methodology with a well-integrated chain of tools applied in industrial practice is a long-term vision beyond the ARTIST2 NoE. In addition to modelling, this will require a strong focus on analytical techniques that address the combination of non-determinism, real-time and stochastic information. Here we foresee the need for techniques that will combine Abstract Interpretation and Model Checker. Also support for high abstraction levels must be provided to overcome the inherent complexity of modern embedded systems. Finally, (semi-)automatic generation of code that preserves the relevant design properties will be essential to ensure industrial impact. These challenges on quantitative modelling and verification will be key activities within the ARTIST Design NoE.

The momentum and willingness of the partners of the cluster to continue working together is very strong. This is witnessed by the two newly started EU FP7 STREP projects *Quasimodo* and *Multiform*. Here *Quasimodo* is targeted towards quantitative modelling formalisms and tool plug-ins for the use in specification, analysis, implementation of embedded systems, and *Multiform* focuses on tool-integration of academic tools (e.g. PHAVer and UPPAAL) and commercial tools (e.g. Simulink). Other partners of the cluster are active in the SPEEDS project where formats for tool exchange are becoming available.

The partners of the cluster also intend to play an active role in the forth-coming Joint Technology Initiative ARTEMIS' research priority on Design Methods and Tools. Here ESI already play a leading role.