ARTIST Newsletter n°4
September 2007

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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.

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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.

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 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 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.rtss.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

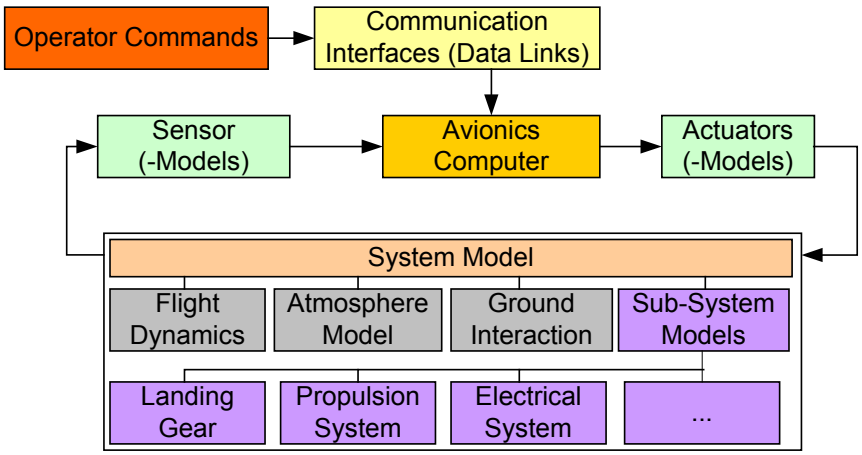
The development of modern aircraft and avionics systems has reached a degree of complexity where a highly integrated design process between various disciplines, such as electrical engineering, computer science, and control theory is necessary.

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).

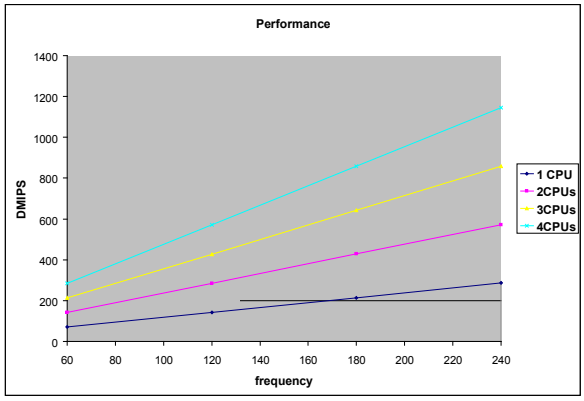


figure 1

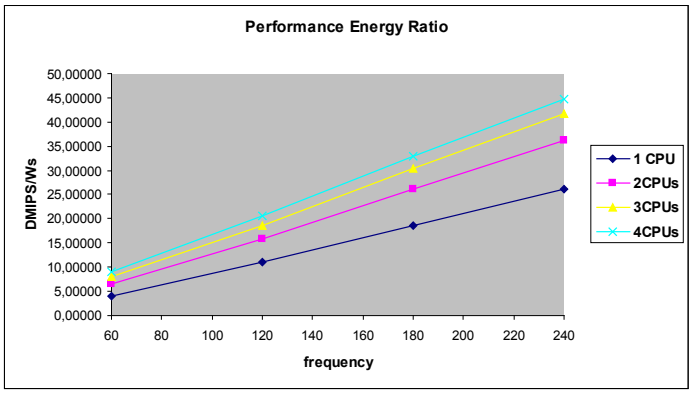


figure 2

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

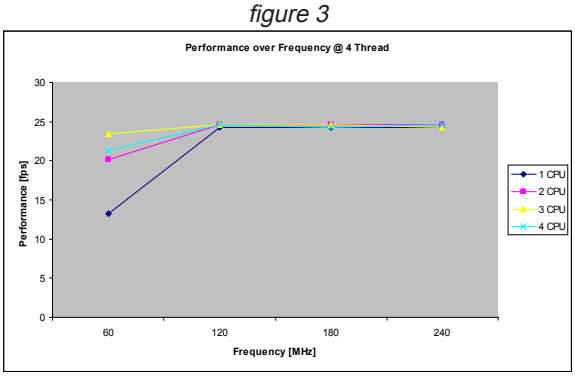


figure 4

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

ARTIST Newsletter n°4
September 2007

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

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.

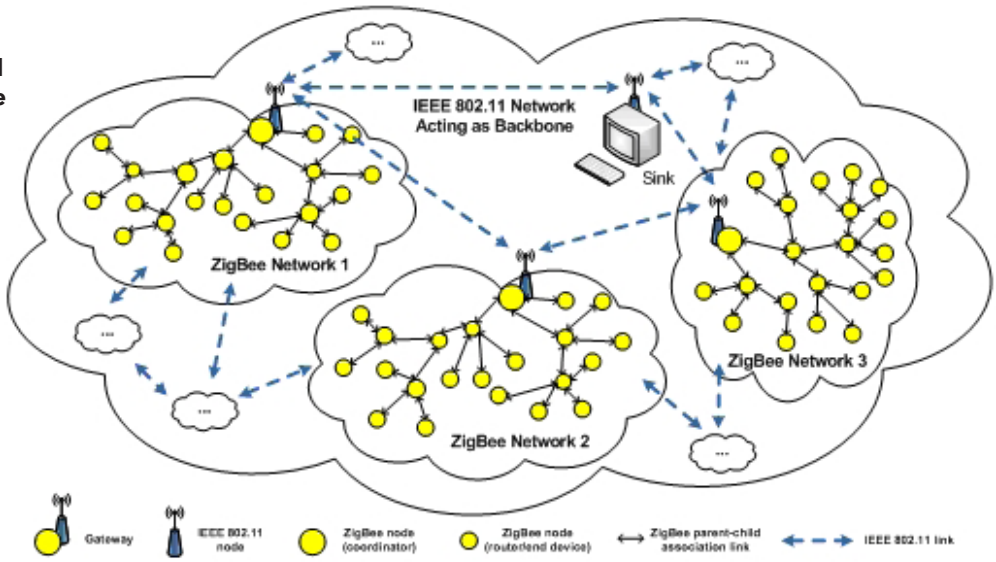


Figure 1: Example of the ART-WiSe two-tiered network architecture