IST-004527 ARTIST2
Network of Excellence
on Embedded Systems Design

Activity Progress Report for Year 4

JPRA-Cluster Integration

Dynamic and Pervasive Networking

Clusters:

Adaptive Real-Time

Activity Leader:

Professor Eduardo Tovar, Polytechnic Institute of Porto, Portugal

http://www.dei.isep.ipp.pt/~emt

Policy Objective (abstract)

There is a consistently growing role of networking in various fields of applications of embedded computing, such as the provision of pervasive access to multimedia and telecommunication networks, the deployment and operation of large-scale sensor networks or even the construction of vehicles, industrial machinery, medical equipment, etc. This activity looks at platforms, communication protocols, quality-of-service provision, efficiency, etc, of these networks. Both COTS and research-based technologies are considered. Current efforts have been essentially devoted to various aspects related to wireless sensor networks, to re-configurability and on-line adaptation mechanisms in networked embedded systems and to deeply-embedded systems where the actual physical dynamics is tightly tied with computations and communications.

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1. Overview of the Activity

1.1 ARTIST Participants and Roles

Professor Eduardo Tovar – Polytechnic Institute of Porto (Portugal)
Wireless Sensor Networks (WSN); dynamic Medium Access Control (MAC) protocols; deeply-embedded networked systems with emphasis on the integration of physical dynamics with computations and communications.

Professor Luís Almeida – University of Aveiro (Portugal)
Dynamic reconfiguration in distributed embedded systems.

Professor Giorgio Buttazzo – University of Pisa (Italy)
Advanced scheduling methodologies and overload management.

Professor Alan Burns – University of York (UK)
QoS in networks of embedded systems, modelling knowledge in sensor networks.

1.2 Affiliated Participants and Roles

Professor Lucia Lo Bello – University of Catania (Italy)
Real-time networks in factory communication and automotive environments; Soft real-time communication and QoS support over wireless networks, in particular, IEEE 802.11, IEEE 802.15.4 and Bluetooth; Energy-aware real-time protocols for wireless sensor networks.

Professor Pau Martí – Polytechnic University of Catalonia (Spain)
Network-based control systems; feedback control of communication systems.

Professor Marisol García-Valls – Universidad Carlos III de Madrid (Spain)
Dynamic reconfiguration architectures in networked embedded applications.

Professor Julián Proenza – University of Balearic Islands (Spain)
System-wide integration of fault tolerance mechanisms in distributed embedded systems with dynamic reconfiguration.

Professor Wilfried Elmenreich – Technical University of Vienna (Austria)
Sensor fusion; time-triggered architectures.

Professor José Maria Giron – Complutense University of Madrid (Spain)
Dynamic reconfiguration in distributed computer control systems based on smart components.

1.3 Starting Date, and Expected Ending Date

This activity officially started on September 2006. It is planned to develop to the end of the project in August 2008.

1.4 Baseline

Looking at the current scenario in embedded systems we see a *consistently* growing role of networking, ranging from the interconnection of autonomous devices such as cellular phones, personal digital assistants (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 activity on Dynamic and Pervasive Networks of the ARTIST2 Adaptive Real-Time Systems (ART) cluster focuses on **Wireless Sensor Networks** (WSNs) and **Networked Embedded Systems** (NESs), areas in which many open challenges remain, and many new problems arose in the past few years. From *energy-aware communication* to *efficient data aggregation*, *real-time routing* and *operation under severe resource constraints* in WSN, to *dynamic topology tracking and management* and *dynamic team composition* in MANETs, to *Quality-of-Service (QoS) adaptation* and *higher software integration* in NES, these are all open issues in which further advances will impact the embedded systems community at large, from the way systems are designed to the way they interact with users and the way they are immersed in the environment.

1.5 Problems Tackled in Year 4

a) Use of standard protocols and COTS technologies in WSNs

This problem has been addressed within the ART-WiSe framework (http://www.hurray.isep.ipp.pt/ART-WiSe), involving researchers from **Porto, Catania, Pisa** and **Prague**. Main focus on how to use IEEE 802.15.4 and ZigBee as federating communication protocols for WSN applications with QoS requirements (e.g. real-time, reliability, energy-efficiency, scalability, mobility). Research includes the provision of timeliness guarantees, evaluation models, simulation tools, energy-efficiency, cluster tree topologies, network dimensioning and admission control. The objective is to use not only standard communication protocols (IEEE 802.15.4/ZigBee), but also COTS technologies such as operating systems (e.g. TinyOS and ERIKA) and hardware platforms (e.g. MICAz, TelosB, Stargate SBC).

b) Scalable data aggregation in WSNs

WiDom (Wireless Dominance protocol) and WiSe-CAN (Wireless Sensor Networks protocol based on the Controller Area Network protocol) are two related research efforts that have evolved through this year involving researchers from **Porto** and **Vienna**. We have (i) shown how to deal with sensor faults, (ii) shown how the approach can be used to perform localization and (iii) how the approach can be used with the CAN bus.

c) Robust communication with star topologies

In wired networks, star topologies are known to provide a high level of robustness in the sense that the start hub is a natural point for error containment, be it in the value or time domains. However, typical wired networked embedded systems use either bus topologies or star topologies that have limited confinement capabilities. For example, CAN buses, which are commonly found in embedded systems due to their low cost and simplification of cabling, present low error confinement capabilities and thus a simple fault in the medium or in a transceiver may render the network useless.

On the other hand, current COTS Ethernet switches also have relatively poor traffic scheduling capabilities (FIFO queues and very few priority leves) and poor protection against misbehaving nodes, namely in the time domain. Therefore, it is possible that a node suffering from a time domain fault, such as a babbling idiot, can cause a substantial negative impact system wide. Improving this aspect by including more protection capabilities in the switches, mainly in the time domain, was considered an important aspect. Both the stars for CAN and Ethernet were addressed by **Aveiro** and **Mallorca** with support from **CMU** in the case of Ethernet.

d) Schedulability analysis for specific traffic types

In the last decade, there has been a strong advance in schedulability analysis in terms of the computing models considered and efficiency of the tests. However, there are always specific models that lack adequate analysis. This was the case of non-preemptive multi-frame transmission in CAN networks. This model is useful when there are multi-packet messages that require a prompt transfer. This problem was tackled by **Pisa** and **Aveiro**.

e) Real-time network support to middleware layers.

The development of complex distributed applications requires appropriate support from a middleware layer that provides an adequate abstraction level. There are nowadays several types of middleware that abstract away certain properties of the underlying platforms and facilitate application development. Service-oriented middleware is one such case that improves functional flexibility at run-time. However, existing service-oriented middlewares do not support real-time guarantees. Improving this situation and bringing Service-oriented Architectures to the real-time applications domain has been tackled by **Madrid** (UC3M) and **Aveiro**. **Cantabria** and **Aveiro** addressed a similar issue but using a contract-based middleware that guarantees the availability of resources that applications need at run-time. Finally, **Madrid** (UC3M) and **Aveiro** also tackled the problem of improving the timeliness of Distributed Real-time Specification for Java by means of specific architectural solutions.

1.6 Comments From Year 3 Review

1.6.1 Reviewers' Comments

The deliverable D11-ART-Y3 on Dynamic and Pervasive Networks was accepted upon revision. The comment on the updated version follows "*The initial document was very verbose and unclear and was missing a global picture of activities. In the updated version, Section 1.5 has been slightly re-organised to show the articulation of various activities. Section 2.3.1 has been drastically reduced, replacing details by references to articles and better spotting the results.*"

1.6.2 How These Have Been Addressed

We maintained the recommendations for improved articulation of the problems addressed and the use of a compact form in the identification of the results achieved.

2. Summary of Activity Progress

2.1 Previous Work in Year 1

Not applicable

2.2 Previous Work in Year 2

Not applicable

2.3 Previous Work in Year 3

Year 4 results are a natural continuation of the effort carried out during the first year (Year 3) of the DPN activity, so most of the research frameworks span over these two years.

In Year 3, we devoted main research efforts to aspects related to *wireless sensor networks*, to *re-configurability and on-line adaptation* mechanisms in networked embedded systems and to the use and improvements in standard and COTS communication technologies for WSNs, MANETs and NESs. A substantial part of this work was based on the IEEE 802.3/Ethernet, IEEE 802.11/WiFi and IEEE 802.15.4/ZigBee wireless protocol standards, which were analysed, improved, engineered, implemented and tested to be used in time-sensitive applications.

2.4 Current Results

2.4.1 Technical Achievements

a) Worst-case analysis and dimensioning of cluster-tree wireless sensor networks

Modeling the fundamental performance limits of Wireless Sensor Networks (WSNs) is of paramount importance to understand their behavior under worst-case conditions and to make the appropriate design choices. This is of particular importance for time-sensitive WSN applications, where the timing behavior of the operating system (task execution must respect deadlines) and of the network protocols (message transmission must respect deadlines) impacts on the correct operation of these applications. In that direction, researchers from **Porto and Prague** have proposed a methodology for modeling cluster-tree WSNs where the sink can either be static or mobile [PO14, PO15]. This methodology enables the computation of the worst-case end-to-end delays, buffering and bandwidth requirements across any source-destination path in a cluster-tree WSN. This generic methodology was instantiated for the particular case of IEEE 802.15.4/ZigBee cluster-tree WSNs and validated through a comprehensive experimental study using commercially available technology, namely TelosB motes running TinyOS.

Catania addressed the limitations of the cluster tree topology [CT1], namely, low scalability and unbalanced energy consumption through simulation results obtained using the Omnet++ tool, and proposes viable alternatives to address these problems.

b) QoS add-ons to the IEEE 802.15.4 and ZigBee protocols

Porto has continued the ART-WiSe research framework around the use of IEEE 802.15.4 and ZigBee as federating communication protocols for WSN applications with QoS requirements (energy-efficiency, timeliness, throughput, reliability). In this context in this reporting period,

several mechanisms were proposed in order to improve QoS, such as a Hidden-Node Avoidance Mechanism for wireless sensor networks [PO1], a Time Division Beacon Scheduling mechanism for ZigBee cluster-tree networks [PO2], a mechanism for improving bandwidth usage of Guaranteed Time Slot (GTS) /in IEEE 802.15.4 [PO3] and the outline of a gateway between IEEE 802.15.4/ZigBee and IEEE 802.11/WiFi [PO08].

Notably, the open-ZB open-source toolset (http://www.open-ZB.net) for the IEEE 802.15.4 and ZigBee protocols [PO5, PO9, PO16] witnessed an outstanding number of visits (over 53000) and downloads (over 3000) since December 2006.

Another issue that has been addressed by **Catania** is cross-channel interference in co-located IEEE 802.15.4 industrial networks [CT2]. The problem is tackled from two different perspectives and provides both analytical and experimental results. The latter were obtained through an extensive series of measurements run in order to assess the performance of IEEE 802.15.4 networks under different critical operating conditions. The analytical results are based on the properties of the coding used at the Physical layer of the IEEE 802.15.4 protocol, in particular the power spectral density of the signal.

c) Supporting real-time communications in wireless sensor networks over the ERIKA real-time operating system

IEEE 802.15.4/ZigBee and TinyOS have been playing an important role in leveraging a new generation of large-scale networked embedded systems. However, based on previous experience (from **Porto** and **Prague**) on the implementation and use of the IEEE 802.15.4/ZigBee protocols over TinyOS (http://www.open-ZB.net), several problems (producing loss of synchronization and even network crashes) emerge due to some limitations of TinyOS, namely related to the lack of task pre-emption and prioritization [PO10]. This unreliability is not a major concern for non-critical environments where the nodes are supposed to guarantee best-effort services. However, when real-time guarantees are required, different software solutions must be used to support real-time services in such networked applications. In this context, researchers from **Porto** and **Pisa** have been working [PO17] towards the implementation of the IEEE 802.15.4/ZigBee protocol stack over ERIKA, a real-time operating system for resourceconstrained embedded systems.

d) Keeping low the time-complexity of distributed computations of physical quantities in large-scale and very dense sensor systems.

WiDom (Wireless Dominance protocol) and WiSe-CAN (Wireless Sensor Networks protocol based on the Controller Area Network protocol) are two related research efforts that have evolved through this year involving researchers from **Porto** and **Vienna**. We have (i) shown how to deal with sensor faults [PO11], (ii) shown how the approach can be used to perform localization [PO12] and (iii) how the approach can be used with the CAN bus [PO18].

e) Robust communication with star topologies

When considering wired communication, star topologies present several advantages in robustness with respect to other topologies such as the typical buses, e.g., in terms of error confinement. This lead to two different developments, one with CAN networks carried out by **Mallorca** and **Aveiro**, and another with switched Ethernet, by **Aveiro**, with collaboration from **CMU**. In the former case, two star topologies were developed for CAN, namely CANcentrate, which is a simplex star, and ReCANcentrate, which is replicated. As a consequence of this work a book chapter [AVc1] was produced as well as a paper that has been accepted for publication in IEEE Computer [AVc2]. This year in particular, special attention was devoted to data consistency issues in ReCANcentrate, during dynamic phenomena associated to transient errors [AVc3] [AVc4].

Concerning switched Ethernet, current COTS switches do not include protection against faults in the time domain, or even overloads. This is particularly important in dynamic systems in

which the current configuration can change at run-time. However, to provide such policing and protection, the switch must know the properties of the streams currently crossing it. Therefore, the team at **Aveiro**, with the collaboration from **CMU**, designed a new switch that carries out traffic scheduling with resource reservation, controlling the transmissions, and verifying compliance of the incoming streams with their negociated properties at the input. Non-compliant packets can be promptly eliminated, thus not interfering with the remaining system. A preliminary version of such switch is presented in [AV1].

f) Schedulability analysis for specific traffic types

The transmission of long messages in CAN requires fragmentation but the medium access control still operates on a packet basis. In some applications it was found that it could be convenient to transfer such messages at once, overriding the packet level MAC. A specific schedulability analysis was developed by **Pisa** and **Aveiro** for such cases [PIc1]

g) real-time support to middleware layers

Providing real-time support to existing middlewares requires appropriate infrastructures. In this case, **Aveiro** has provided the FTT-SE platform that has been used in **Madrid** (UC3M) to support composition of service-based applications [AVc5]. **Cantabria** has provided the FRESCOR contracting middleware and Aveiro supported it on FTT-SE to allow centralized contract management and facilitate contract run-time adaptation [AVc6]. Finally, Madrid (UC3M) has also developed different enhancements for RTSJ, especially in memory management [MA1] [MA2] that introduce higher predictability and efficiency towards implementing the Distributed RTSJ. These extensions have been implemented in their DRTSJ prototype named DREQUIEMI.

h) Educational Testbed supporting teaching of industrial wired/wireless networks

In order to enable students to understand how to properly design hybrid wired/wireless industrial communication networks, the adoption of new concepts and paradigms is needed. The work [CT3] describes the design and implementation of an educational testbed for a course in industrial communication, via a remotely accessible platform emulating various network configurations based on user configured network conditions, also providing the user with monitoring capability.

Scheduling inside the routers is one main focus of the testbed. When the network is being configured, students can choose the scheduling policy they want to investigate and even assign the various routers different policies in order to evaluate the effect of each of them on the router behaviour. In addition to the First-In–First-Out (FIFO) policy, which is present in all traditional routers, the testbed also uses some scheduling techniques which adapt the Earliest Deadline First (EDF) algorithm for use in a packet-switched multihop network.

2.4.2 Individual Publications Resulting from these Achievements

Porto (available to download from http://www.hurray.isep.ipp.pt/asp/list_docs2.asp)

[PO1] A. Koubâa, R. Severino, M. Alves, E. Tovar, “H-NAMe: A Hidden-Node Avoidance Mechanism for Wireless Sensor Networks”, submitted to an international journal.

[PO2] A. Koubâa, A. Cunha, M. Alves, E. Tovar, “TDBS: A Time Division Beacon Scheduling Mechanism for ZigBee Cluster-Tree Wireless Sensor Networks”, to be published in the Real-Time Systems Journal, Springer.

[PO3] A. Koubaa, M. Alves, E. Tovar, A. Cunha, “An Implicit GTS Allocation Mechanism in IEEE 802.15.4: theory and practice”, Real-Time Systems Journal, Volume 39, Numbers 1-3, pp. 169-204, Springer, August 2008. Published on-line: 21/NOV/2007.

[PO4] E. Tovar, B. Andersson, N. Pereira, M. Alves, S. Prabh and F. Pacheco, "Highly Scalable Aggregate Computations in Cyber-Physical Systems", 7th International Workshop on Real Time Networks (RTN'08), Prague, Czech Republic, 2/JUL/2008 (http://www.hurray.isep.ipp.pt/rtn08/index.php).

[PO5] Cunha, A., Koubaa, A., Severino, R., Alves, M., "Open-ZB: an open-source implementation of the IEEE 802.15.4/ZigBee protocol stack on TinyOS", to be published in the 4th IEEE International Conference on Mobile Ad-hoc and Sensor Systems (MASS´07), Pisa, Italy, Oct. 2007.

[PO6] Andersson, B., Pereira, N., Tovar, E., "A Two-Competitive Approximate Schedulability Analysis of CAN", to be published in the 12th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA'07), Patras, Greece, Oct. 2007.

[PO7] Andersson, B., Pereira, N., Tovar, E., "Exploiting a Prioritized MAC Protocol to Efficiently Compute Interpolations", to be published in the 12th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA'07), Patras, Greece, Oct. 2007.

[PO8] J. Leal, A. Cunha, M. Alves, A. Koubaa, "On a IEEE 802.15.4/ZigBee to IEEE 802.11 Gateway for the ART-WiSe Architecture", Work-in-Progress session of the 12th IEEE Conference on Emerging Technologies and Factory Automation (ETFA07), Patras, Greece, September 2007.

[PO9] André Cunha, "On the use of IEEE 802.15.4/ZigBee as federating communication protocols for Wireless Sensor Networks", MSc Thesis, University of Porto, SEP/2007.

[PO10] A. Cunha, R. Severino, N. Pereira, A. Koubâa, M. Alves, "ZigBee over TinyOS: implementation and experimental challenges", 8th Portuguese Conference on Automatic Control (CONTROLO'2008), Invited Session on "Real-Time Communications: from theory to applications", 21-23/JUL/2008, Vila Real, Portugal.

[PO11] B. Andersson, N. Pereira and E. Tovar, "How a Cyber-Physical System can Efficiently Obtain a Snapshot of Physical Information Even in the Presence of Sensor Faults", in Proceedings of Sixth Workshop on Intelligent Solutions in Embedded Systems, Regensburg, Germany, July 10-11, 2007.

[PO12] B. Andersson and S. Prabh, "Localizing an Object in Large-Scale Cyber-Physical Systems", in International Workshop on Cyber-Physical Systems Challenges and Applications (CPS-CA'08)}, Santorini Island, Greece, June 11, 2008, in conjunction with the 4th IEEE International Conference on Distributed Computing in Sensor Systems (DCOSS'08), invited paper.

[PO13] B. Andersson, N. Pereira, N. Cruz, W. Elmenreich and E. Tovar, "A Scalable and Efficient Approach to Obtain Measurements in CAN-based Control Systems", in IEEE Transactions on Industrial Informatics, Vol 4, No 2, May 2008. (this publication is also listed in Section 2.4.4)

Aveiro

[AV1] Rui Santos, Ricardo Marau, Arnaldo Oliveira, Paulo Pedreiras, Luis Almeida. Designing a Costumized Ethernet Switch for Safe Hard Real-Time Communication. WFCS 2008 – 7th IEEE Workshop on Factory Communication Systems. Dresden, Germany. 21-23 May 2008.

Catania

[CT1] E. Toscano, L. Lo Bello, "On the Use of IEEE 802.15.4 for Real-Time Wireless Sensor Networks", In Proceedings of the 7th International Workshop on Real-Time Networks, RTN'08, Prague, Cech Republic, July 2008, pages 47-52.

[CT2] E. Toscano, L. Lo Bello, "Cross-Channel Interference in IEEE 802.15.4 Networks". In Proceedings of the 7th IEEE International Workshop on Factory Communication Systems, WFCS'08, Dresden, Germany, May 2008, pp. 139-148, IEEE 2008, ISBN 978-1-4244-2349-1.

[CT3] L. Lo Bello, O. Mirabella, A. Raucea, "Design and Implementation of an Educational Testbed for Experiencing with Industrial Communication Networks", *IEEE Transactions on Industrial Electronics*, Vol.54, N.6, ISSN: 0278-0046, IEEE Industrial Electronics Society, Piscataway, USA, Dec. 2007.

Madrid

[MA1] P. Basanta-Val, M. García-Valls, and I. Estévez-Ayres. Simplifying the Dualized Threading Model of RTSJ Proc. of the 11th IEEE International Symposium on Object/component/service-oriented Real-time distributed Computing, ISORC 2008. May 5 - May 7, 2008. Orlando, Florida, USA.

[MA2] P. Basanta-Val, M. García-Valls, I. Estévez-Ayres y J. Fernández-González. Integración de capacidades de multiplexación en el conjunto de subprotocolos JRMP. IEEE América Latina, ISSN 1548-0992. In Spanish. (to appear)

2.4.3 Interaction and Building Excellence between Partners

Petr Jurcik, a PhD student at the Department of Control Engineering, Czech Technical University, Prague, has been in Porto (as a research fellowship) collaborating in the ART-WiSe and Open-ZB frameworks since the beginning of 2007. He has been addressing the implementation of a simulation model for the IEEE 802.15.4 GTS (Guaranteed Time Slot) MAC mechanism and the worst-case dimensioning of ZigBee cluster-tree wireless sensor networks.

Porto has also been involving other DPN partners in the collaboration with the TinyOS community, for developing implementations of the IEEE 802.15.4 and ZigBee protocols over TinyOS for commercially available mote platforms.

Porto and Pisa have been collaborating since late 2007 on the provision of technologies and tools for achieving real-time communications in wireless sensor networks. Particularly, Porto and Pisa have been working on the migration of the open-ZB IEEE 802.15.4/ZigBee protocol stack (http://www.open-ZB.net) to the ERIKA (http://erika.sssup.it/) real-time operating system.

Madrid and Aveiro have been collaborating for a couple of years in the provision of real-time networking support to service-oriented middleware, opening the way to use this kind of technology with its inherent functional flexibility in real-time applications [UC3M1]. In this year, Aveiro hosted for one month Iria Estevez, a professor from Madrid (UC3M), to develop a working prototype of her dynamic service composition framework based on the FTT-SE protocol. Further collaboration is beeing carried out in the scope of the DEREQUIEMI framework developed at UC3M to support distributed real-time Java applications, using principles from the FTT framework.

Aveiro and Cantabria carried out joint work toward supporting dynamic contracts in a distributed real-time contracting framework, namely the one developed within the FRESCOR project [AV7]. This work combined the FRESCOR and FTT frameworks in which the latter provided centralized contract management to the former, facilitating run-time contract (re)negotiation and adaptation.

Mallorca (UIB) and Aveiro continued their collaboration towards the definition of flexible yet dependable mechanisms for distributed real-time systems and on the use of star topologies to boost robustness [UIB2]. During this year the collaboration focused on the dependability analysis of ReCANcentrate, a replicated star system for CAN networks and on consistency issues in the replicated domains [UIB1].

2.4.4 Joint Publications Resulting from these Achievements

Porto and Prague

[PO14] P. Jurcik, A. Koubâa, R. Severino, M. Alves, E. Tovar, Real-Time Communications over Cluster-Tree Sensor Networks", submitted to an international journal.

[PO15] P. Jurcik, R. Severino, A. Koubâa, M. Alves, E. Tovar, "Real-Time Communications over Cluster-Tree Sensor Networks with Mobile Sink Behaviour", 14th IEEE International Conference on Embedded and Real-Time Computing Systems and Applications (RTCSA 2008), Kaohsiung, Taiwan, 25-27/AUG/2008.

[PO16] Jurcik, P., Koubâa, A., Alves, M., Tovar, E., Hanzalek, Z., "A Simulation Model for the IEEE 802.15.4 protocol: Delay/Throughput Evaluation of the GTS Mechanism", to be published in the 15th IEEE International Symposium on Modeling, Analysis, and Simulation of Computer and Telecommunication Systems (MASCOTS´07), Istanbul, Turkey, October 2007.

Porto and Pisa

[PO17] P. Pagano, M. Chitnis, A. Romano, G. Lipari, R. Severino, M. Alves, P. Sousa, E. Tovar, "ERIKA and OpenZB: a tool suite for realtime wireless networked applications", submitted to an international conference.

Porto and Vienna

[PO18] B. Andersson, N. Pereira, W. Elmenreich, E. Tovar, F. Pacheco, N. Cruz, "A Scalable and Efficient Approach to Obtain Measurements in CAN-based Control Systems", accepted for publication in IEEE Transactions on Industrial Informatics (TII) (revised in November 2007 and January 2008).

Mallorca and Aveiro

[AVc1] J.Pimentel, J.Proenza, L.Almeida, G.Rodríguez-Navas, M.Barranco, J.Ferreira. Dependable Automotive CAN Networks. in Automotive Embedded Systems Handbook, N. Navet and F. Simonot-Lion (ed). CRC Press / Taylor and Francis, ISBN: 9780849380266, November 2008.

[AVc2] Manuel Barranco, Julian Proenza, Luis Almeida. Boosting robustness in CAN systems with new star topologies: CANcentrate and ReCANcentrate, IEEE Computer. (to appear)

[AVc3] Manuel Barranco, Julián Proenza, Luís Almeida. Maintaining data consistency in ReCANcentrate during hub decouplings. Work-in-Progress Session of WFCS 2008 – 7th IEEE Workshop on Factory Communication Systems. Dresden, Germany. 21-23 May 2008.

[AVc4] Manuel Barranco, Julián Proenza, Luis Almeida. Management of Media Replication in ReCANcentrate. ICC 2008, International CAN Conference, Barcelona, Spain, March 2008.

Pisa and Aveiro

[PIc1] Bartolini, C., Almeida, L., Lipari, G., "Using priority inheritance techniques to override the size limit of CAN messages", to be published at the 7th IFAC Conf on Fieldbuses and Networks for Industrial and Embedded Systems (FET 2007), Toulouse, France, Nov 2007.

Madrid and Aveiro

[AVc5] Iria Estevez-Ayres, Marisol Garcia-Valls, Luis Almeida, Pablo Basanta-Val. Solutions for Supporting Composition of Service-Based Real-Time Applications. 11th IEEE Symp. on Object/component/service-oriented Real-time distributed Computing, ISORC 2008. Orlando, USA. May 2008.

Aveiro and Cantabria

[AVc6] R. Marau, L. Almeida, P. Pedreiras, M. González-Harbour, D. Sangorrín, J. L. Medina. Integration of a flexible time-triggered network in the FRESCOR resource contracting framework. ETFA 2007, 12th IEEE International Conference on Emerging Technologies and Factory Automation. Patras, Greece, September 2007.

2.4.5 Keynotes, Workshops, Tutorials

Workshop: 1st International Workshop on Cyber-Physical Systems Challenges and Applications (CPS-CA'08)
Workshop Chair: Eduardo Tovar (Polytechnic Institute of Porto)
Santorini, Greece – 11/JUN/2008
This workshop was held in conjunction with the 4th IEEE International Conference on Distributed Computing in Sensor Systems (DCOSS'08). http://www.hurray.isep.ipp.pt/cps-ca08

Workshop: 7th International Workshop on Real Time Networks (RTN'08)
Workshop Chair: Anis Koubaa (Polytechnic Institute of Porto)
Prague, Czech Republic – 2/JUL/2008
This workshop was held in conjunction with the 20th Euromicro International Conference on Real-Time Systems (ECRTS'08). HomePage: http://www.hurray.isep.ipp.pt/rtn08/index.php

Seminar: Mobility Issues in Cyber-Physical Systems
Lecturer: Luis Almeida (U. Aveiro)
Stockholm, Sweden – 16/JUN/2008
Seminar given at the EU-US Workshop on Networked Information and Control Systems (http://www.access.ee.kth.se/EU-US08/)

Seminar: Networks for Embedded Control Systems
Lecturer: Luis Almeida (U. Aveiro)
Shanghai, China– 15/JUL/2008
Seminar given at the ARTIST2 Summer School 2008 in China (http://www.artist-embedded.org/artist/Artist2-Summer-School-in-China.html)

Keynote: Time for Cyber-Physical Systems
Lecturer: Alan Burns (University of York)
Santorini, Greece – 4/SEP/ 2008
Keynote talk at the International Workshop on Cyber-Physical Systems Challenges and Applications (CPS-CA'08). http://www.hurray.isep.ipp.pt/cps-ca08

Seminar: Challenges of Flexible Real-Time Communication
Lecturer: Luis Almeida (U. Aveiro)
Autrans, France – 8-12/SEP/2008
Seminar given at the ARTIST2 Summer School 2008 in Europe (http://www.artist-embedded.org/artist/ARTIST2-Summer-School-2008.html)

Seminar: Enabling ubiquitous computing and cyber-physical systems with wireless sensor/actuator networks: what is at stake?
Lecturer: Mário Alves (Polytechnic Institute of Porto)
L'Aquila, Italy – 4/SEP/2008
Seminar given in a doctoral school for PhD students in Computer Engineering (http://gii2008.dei.polimi.it)

Seminar: Guaranteeing QoS in large-scale distributed embedded systems using standard and COTS technologies: ongoing research at IPP-HURRAY
Lecturer: Mário Alves (Polytechnic Institute of Porto)
L'Aquila, Italy – 4/SEP/2008
Seminar given in a doctoral school for PhD students in Computer Engineering (http://gii2008.dei.polimi.it)

Seminar: Open-ZB: an open-source implementation of the IEEE 802.15.4/ZigBee protocol stack for TinyOS
Lecturer: André Cunha (Polytechnic Institute of Porto)
Pisa, Italy – 26/FEB/2008
Seminar given to a diverse audience in the SSSUP (http://retis.sssup.it/lab_events/openzb1).

2.5 Milestones

Year 4 Milestones

• ***Organize a summer school on Real-Time Networks, involving key players from industry and academia, possibly focusing on specific topics such as WSN, MANETs and reconfigurability issues.***

Achieved (upon adaptation). Given the strong involvement of activity elements in several similar events, it was decided not to organize one specific event since it would compete with other events orgnized within the NoE. On the contrary, there was a participation in two Artist2 Summer Schools, one in Shanghai, China, and another in Autrans, France, and in one doctoral school in L'Aquila, Italy, which covered several Dynamic and Pervasive Networking related topics. Moreover, elements of this activity organized two workshops collocated with relevant conferences, namely DCoSS 2008 and ECRTS 2008.

• ***Contributions to the Zigbee specification.***

Achieved. Important scientific and technological achievements within the ART-WiSe and open-ZB frameworks have lead to a leap forward in the use of IEEE 802.15.4 and ZigBee protocols for Wireless Sensor Networks (WSNs), particularly concerning the worst-case analysis, dimensioning and real engineering of multiple cluster (cluster-tree) WSNs as well as the improvement of their Quality-of-Service (e.g. throughput, energy-efficiency). Importantly, these efforts have been developed in close synergy with the participation in the TinyOS Net2 Working Group. Note that TinyOS is the most widely used operating system for wireless sensor nodes.

• ***Educational tools supporting teaching of industrial wired/wireless networks.***

Achieved. The knowhow, toolsets and test-beds emerging from the ART-WiSe and open-ZB frameworks (see 2.4.1 a, b and c), enabled and leveraged many academic courses and projects, ranging from hands-on lectures, short-term projects and MSc, PhD and post-doc studies. Also Catania developed an educational testbed for a course in industrial communication (see Section 2.4.1 h).

• ***A SOTA report on Dynamic and Pervasive Networks, with web publishing.***

Partially achieved. Despite the initial plan, the SOTA report was not produced due to lack of availability among the activity participants. Nevertheless, there were several seminars in the scope of summer/doctoral schools delivered by activity elements, which are available on the Internet and which address the state of the art in the field of Dynamic and Pervasive Networks.

2.6 Indicators for Integration

This second year witnessed a strong and coordinated integrative work between DPN partners. This was both reflected by the number of joint publications (either core or affiliate) and by their joint involvement in the organization and/or participation in very successful events such as the APRES'08, RTN'08 and CPS-CA (outlined in Section 2.4).

We strongly believe that this activity helped research performed by ARTIST2 partners on various aspects of networked embedded systems, wireless sensor networks and cyber-physical systems to gain visibility worldwide and in that way improve its impact and influence within research communities typically more competitive in those aspects such as those from the USA.

3. Internal Reviewers for this Deliverable

Mário Alves (Polytechnic Institute of Porto, Portugal)

Luis Almeida (University of Aveiro, Portugal)

Bjorn Andersson (Polytechnic Institute of Porto, Portugal)