Research Centre in Real-Time Computing Systems

FCT Research Unit 608

Annual Report

2007

isep

instituto
superior de
engenharia do
porto

INSTITUTO
POLITÉCNICO DO PORTO

CONTENTS

Executive Summary

www.cister.isep.ipp.pt

The Research Centre in Real-Time and Embedded Computing Systems (CISTER) is based upon the IPP-HURRAY Research Group (Hugging Real-time and Reliable Architectures for computing sYstems), which was created in 1997, and has since grown to become the most prominent research group of the School of Engineering (ISEP) of the Polytechnic Institute of Porto (IPP), and one of the leading International research groups in the area of real-time computing systems.

In 2004, CISTER was granted the classification of 'Excellent' from an international jury. We firmly believe that ever since then, and particularly during 2007, we have been exceeding the expectations placed on us.

The strategy set down by CISTER has been definitely towards top-quality research, able to compete with the best international groups in our research areas. The goal of the unit is to continue (and reinforce) to be one the International leaders of research in real-time embedded systems. This objective is aligned with the growing strategic importance of embedded systems in Europe, and the role that needs to be played in the international research landscape of the area.

MANAGEMENT STRUCTURE

The unit has a Director, the Unit leader, an Adjunct Director, a Scientific Board and an Advisory Committee. The main responsibilities of the Director are: to represent externally the Unit; to manage and co-ordinate the activities of the Unit; to co-ordinate the definition of the plan of activities and budget; and to present the plan of activities, budget and early report (scientific and financial) to the Scientific Board. The main responsibilities of the Adjunct Director are to assist and replace the Director when necessary. The Scientific Board, which includes all the members of the Unit with PhD degree, has the following main responsibilities: to appoint the Director and Adjunct Director; to define the scientific research areas and working strategies; to carry out research; and to approve the plan of activities, budget and early report.

The activities of CISTER are periodically reviewed by Advisory Committee (AC) members. Annually, a number of on-site visits are performed by top-ranked researchers to discuss the Unit's activities and plans. The Unit has also been actively endorsing and driving bilateral research workshops with top research centres. These have been extremely useful as well in providing inputs for research plans and strategy.

CISTER IN NUMBERS

In the year of 2007, the CISTER research team was composed by:

- Number of Researchers holding a PhD: 9
- Number of Researchers holding a MSc: 6

During 2007 CISTER had 2 international and industrial driven projects, 1 Network of Excellence and 2 fundamental research projects (FCT supported) running; also in 2007 CISTER got approved 2 more fundamental research projects and 2 Networks of Excellence. These new projects initiated in 2008, representing a total budget of 154K Euros and 372K Euros respectively.

GENERAL OBJECTIVES

The CISTER Research Unit focuses its activity in the analysis, design and implementation of real-time computing systems (RTS). In RTS, correctness depends not only on the logical result of computation, but also on the time at which the results are produced. This implies that, unlike more traditional information and communication systems, where there is a separation between correctness and performance, in RTS correctness and performance are very tightly interrelated.

Historically, RTS were an important, but narrow, niche of computer systems, consisting mainly of military systems, air traffic control and embedded systems for manufacturing and process control. This association caused that RTS problems did not attract widespread interest from the computer community. Meanwhile, the emergence of largescale distributed systems, enabled by advances in networking technology, has broaden real-time concerns into a mainstream enterprise, with clients in a wide variety of industries and academic disciplines. This tendency has been establishing RTS technology as a priority for commercial strategy and academic research for the foreseeable future and also for a wider number of applications.

The strategy set down by the Unit has been definitely towards top-quality research able to compete with the best international groups in our research areas. These include not only the most prestigious research groups in Europe (York, UK; SSSUP, Italy; MdH, Sweden; TUW, Austria) as well as a large number of research groups in the U.S., such as those from the UNC-CH, the UIUC, the UVa, the WUStL or the CMU, to mention just a few. This is just a sample of prestigious research/higher education institutions with whom we collaborate, but also with whom we compete in the advancement of the state-of-the-art in real-time computing systems. Even given our relatively small dimension, we have been able to compete internationally with cutting-edge and seminal research into a few, but strategically defined, research topics. And we have been tremendously successful.

Therefore, the general objectives of CISTER consists on developing cutting-edge research on real-time computing systems. The focus is on fundamental research issues, including PhD and MSc research works. But the Unit also cares on drawing the obtained cutting-edge results into applied research driven in the framework of international academic/industrial partnerships.

There are four key strategic options that have been driving the research agenda of the Unit: (i) sustained growing and research focus; (ii) selective and demanding publication efforts; as a consequence of the two previous, (iii) selective, demanding and consistent participation of key Unit's researchers in scientific service; and finally, as a consequence of the three previous, (iv) a strong participation in international reputed academic/industrial research partnerships with focus both on fundamental and applied research.

CISTER competes internationally with cutting-edge and seminal research into a few, but strategically defined, research topics, achieving outstanding results.

MAIN ACHIEVEMENTS

In the Wireless Sensor Networks (WSN) research area, in which both ART-WiSe and WiDom research frameworks have been leading international research on IEEE802.15.4/ZigBee and dominance-based protocols, respectively. These frameworks have been producing seminal results and best papers published in the proceedings of top-ranked conferences (e.g., [O4, O6, O9]) and journals [J2-J6], namely one Best Paper Award at ECRTS'07. Our web site holding an open-source toolset for the IEEE 802.15.4/ZigBee protocols had around 30000 visits and 1000 downloads during 2007.

We are among the best 5 groups in the world in the area of RT Multiprocessor Systems. Just an example, we created the first multiprocessor real-time scheduling algorithm with few preemptions and that can assure that at least 50% of the processing capacity can be requested without missing a deadline. In this domain, the RESCORE FCT project, led by CISTER, received the highest funding from FCT, in 2007.

Concerning QoS-Aware computing, we designed a novel QoS-aware collaborative framework for higher adaptation to changing conditions in dynamic environments, based on new anytime algorithms and new solutions for dynamic overload control. We devised a new architecture for language supported operating system behavioural reification and reflection, to support dynamic adaptation of applications.

Seminal results were also produced concerning distributed data aggregation, namely to support scalability (time complexity independent of number of nodes) while exacerbating the integration of physical dynamics with computations and communications. This framework is being further explored in a FCT-sponsored project, CooperatES.

The collaborative framework is also being used in another FCT-sponsored project (RESCUE), in consortium with other Portuguese universities, as the underlying infrastructure to support proof-carrying code in embedded systems.

CISTER's PhD researchers participated in 2007 as PC Chairs, PC members, Track Chairs in the most reputed scientific events the concerned research areas, e.g. IEEE RTSS, ECRTS, IEEE RTAS, IEEE RTCSA, IEEE ICDCS, Ada-Europe, IFIP DIPES, IEEE ETFA, OPODIS. One of CISTER's researchers was programme co-chair of the 11th International Conference On Principles Of Distributed Systems (OPODIS'07). Another researcher is since June 2007 Editor-in-chief of the Ada User Journal.

CISTER participates in several consortia involving reputed academic and industrial partners. The Unit has been deeply involved the Real-Time and Embedded Systems (ARTIST2) European NoE in and its follow up – ARTISTDesign. 2007 also witnessed the genesis of the CONET NoE on Cooperating Objects and Wireless Sensor Networks (kick-off in June 2008). CISTER also participated in or even leaded several joint RTD project proposals involving international consortiums, as well as in a European-wide Cyber-Physical Systems programme.

In 2007, the Unit fostered its participation in the CMU-Portugal programme, involving a dual ECE PhD programme, joint research projects with the CMU (namely under the Sensor Andrew framework) and with several Portuguese end-user and technology providers companies.

ACTIVITIES

INTEGRATIVE/MULTIDISCIPLINARY ACTIVITIES

Although the relatively small dimension of the unit, its areas of research are by their nature multidisciplinary. The unit has fostered the integration of researchers from different background areas with the goal of setting up a team with complementary, but nevertheless focused, competences.

Of particular relevancy, was the strategy to involve researchers from different institutions and countries, with different yet complementary experience, allowing attaining a comprehensive spectrum of knowledge. This policy was strictly continued and even amplified during 2007. CISTER includes researchers with diverse academic backgrounds, such as Electrical and Computer Engineering, Informatics Engineering, Computer Science and Applied Physics/Mathematics.

These complementary competences allowed increasing the research capabilities of the unit, through research initiatives that encompassed hardware and software integration, vertical frameworks, ranging from lower level issues such as hardware platforms for sensor network communication to higher level design, such as applications and test-beds.

For instance, within the WiDOM research framework, we have specified and implemented a new hardware communication board for sensor networks, the associated dominance-based WiDOM protocol and several applications for which WiDOM brings unprecedented benefits in terms of scalability. Examples of these include determining the maximum/minimum value of a certain physical parameter among cents of sensor nodes with only one message or accurately identifying the shape of a physical parameter in a certain region by interpolation with only a few messages.

In another area, the unit was involved in a multi-site, multidisciplinary project, which was accepted by FCT in 2007. This project (RESCUE) involves researchers from several institutions in Portugal: CISTER at ISEP, the Artificial Intelligence and Computer Science Laboratory and the Computer Science Department at the School of Sciences of the University of Porto, the Department of Informatics of the University of Beira Interior, and the Departments of Informatics and Mathematics of the University of Minho). The goal of this project is providing innovative, efficient and expressive mechanisms for the secure implementation and execution of code, in embedded systems.

In this context, the project brings together a significant team of researchers from 5 different groups, comprising mathematicians, theoretical computer scientists, and experts in Embedded Systems, with the purpose of setting up a scientific network in the area of Program Verification, with applications to Embedded Systems.

OUTREACH ACTIVITIES

The CISTER Research Unit has been devoting a special attention to outreach activities, trying to leverage synergies between our scientific achievements and society, both in a broader sense (public in general) as well as in more specific niches (e.g. Portuguese industrial community and secondary school students). Visits from secondary schools or universities to our applied research

labs are very frequent. The Unit also regularly participates in workshops organized by its hosting institutions ISEP and IPP, which aim at disseminating ongoing education and research to all ISEP/IPP but also the general public, namely to potential candidates to our engineering degrees.

In this sense, most of our fundamental research activities are supported by applied research vertices. We are aware that CISTER scientific results are much better assimilated by the general public through practical demonstrations with state-of-the-art technology and appealing (yet realistic) application scenarios. This approach has been common practice in CISTER (e.g. RFieldbus manufacturing automation field-trial, http://www.cister.isep.ipp.pt/rfpilot), and was also instantiated during 2007 (e.g. ARTWiSe search&rescue testbed (http://www.cister.isep.ipp.pt/ART-WiSe/testbed.php). These real application demonstrators have proven to shorten the gap between industrials (and even the general public) and the research community.

CISTER strategy has been also to reinforce collaborations with the Portuguese industrial tissue, namely with some of the most predominant companies actuating in our areas. Companies such as Microsoft Portugal, Critical Software, MRA/CrossBow or EFACEC are following or even collaborating with us within some of our research lines.

ORGANIZATION OF CONFERENCES

By integrating the top-ranked scientific community in the real-time and embedded systems area, the Unit regularly organizes scientific events related to those scientific topics.

In 2007, several senior researchers of the unit were PC Members of world-reputed events such as IEEE RTSS, ECRTS, IEEE RTAS, IEEE RTCSA, WPDRTS, IEEE SRDS, IEEE ICDCS, ACM EMSOFT, OPODIS, Ada-Europe, IFIP DIPES, ACM SAC, IRTAW IEEE ETFA, IEEE WFCS, IFAC FET.

Importantly, one CISTER researcher was PC Co-Chair of the 11th International Conference On Principles Of Distributed Systems (OPODIS'07), December 2007. Another researcher is since June 2007 Editor-in-chief of the Ada User Journal.

INDUSTRY CONTRACT RESEARCH

In the context of industry-driven research, the Unit has been steadily increasing its efforts to integrate research results in existent and new technologies.

The investment the Unit has recently been performing in specific areas such as Wireless Sensor Networks, has been important in attracting attention from industry which have demonstrated interest in fostering the research and jointly provide new and improved solutions in the area.

In this context, several initiatives have been triggered in 2007, leading to collaborations with companies such as Critical Software (Portugal), ATMEL (Norway), among others.

There were a number of contacts and meetings in the framework of the critical infrastructures and risk assessment consortium of the PT-CMU program with key Portuguese end user companies

and technology providers. It is foreseen that these efforts will lead to industry-funded research contracts as well.

INTERNATIONALIZATION

While bilateral and multilateral collaborations with Portuguese academic, research and industrial parties were not neglected, CISTER mostly plays at the international arena, collaborating with top level institutions on several strategic topics and at different levels.

As already referred, the Unit has been collaborating with the most prestigious research groups in Europe (e.g. York, UK; SSSUP, Italy; MdH, Sweden; TUW, Austria) and in the U.S. (e.g. UNC-CH, UIUC, UVa, WUStL, CMU, USC).

During 2007, the Unit was deeply involved in triggering industry-driven EU project proposals, involving reputed companies such as Critical Software, Siemens, Schneider and SAP. The Unit has also been deeply involved in the ARTIST2 European NoE in the area of distributed real-time and embedded systems. Two of those, namely the ARTISTDesign and CONET NoEs are officially starting in 2008.

The PhD researchers of CISTER have been consecutively participating in the most reputed international scientific events, as PC Chairs, General Chairs, PC members, Track Chairs, WiP Chairs, Industry Chairs or Publicity Chairs. We highlight the 2007 edition of the following series of top-ranked scientific events: IEEE RTSS, Euromicro ECRTS, IEEE RTAS, IEEE RTCSA, IEEE ICDCS, ACM EMSOFT, IEEE SRDS, Ada-Europe, IEEE ETFA, IEEE WFCS. Notably, an Unit member was Program Co-Chair of OPODIS'07.

CISTER researchers were invited to and actively participating in standardization committees and international organizations, e.g. the IFIP Working Group 10.2 on Embedded Systems, the board of the Ada-Europe Organization and the TinyOS 2.0 Network working Group, and participated in the "EU-US Workshop on Wirelessly Networked Embedded Systems Cyber-Physical Systems and Beyond", where a European-wide Cyber-Physical Systems program started preparation.

The research excellence attained by the Unit has been leveraging the invitation to join several consortiums for driving new long-term research initiatives. Since 2006, we have engaged a long-term research framework with the CMU, under the CMU-Portugal program.

Some of our ongoing collaborations lead to joint publications with researchers from the CMU [O9], Technical University of Prague [O7] and Technical University of Vienna [J6].

RESEARCH PROJECTS

EUROPEAN NETWORKS OF EXCELLENCE

ARTIST2

NETWORK OF EXCELLENCE ON EMBEDDED SYSTEM DESIGN
Project IST-004527, EU-funded
CISTER funding: 150 KEUR

4 years (Oct 2004 to Sep 2008)
The objective of ARTIST2 is to strengthen European research in Embedded Systems Design, and promote the emergence of this new multi-disciplinary area. We gather together the best European teams from the composing disciplines, and will work to forge a scientific community.

FUNDAMENTAL RESEARCH PROJECTS

PT-CMU

CMU PORTUGAL

CISTER Funding: 500 KEUR

6 years (Jan 2007 to Dec 2012)
The CMU-Portugal Program is a partnership between the Carnegie Mellon University (CMU, Pittsburgh, USA) and the Portuguese Government, aiming at creating top level and internationally recognized education and research programs in Information and Communication Technologies (ICT).

Within the CMU-Portugal Program, CISTER/IPP-HURRAY is involved in a collaborative scientific program that integrates the capabilities of the Carnegie Mellon University, in particular the Electrical and Computer Engineering Department and CenSCIR, and the following Portuguese research institutions: ISR-Lisbon and INESC-ID (affiliated with IST/UTL), CISTER/IPP-HURRAY (affiliated with ISEP/IPP) and the ISQ Group.

This collaborative scientific program includes a dual doctoral program in the area of Electrical and Computer Engineering. The main focus of this doctoral program is on Sensing Technologies and Networks for Risk Minimization Systems, with an additional emphasis on their application to Cyber-Physical Systems such as critical infrastructures. This wide area of research includes communication infrastructures (e.g., wireless sensor and ad-hoc networks), hardware/software platforms (embedded real-time and distributed computing systems), sensing and decision

systems (signal/video processing, surveillance, robotics and distributed decision systems) and risk assessment.

Students will be supervised by two faculty advisors, one from Carnegie Mellon and the other from one of the Portuguese partners. The dual doctoral program is structured so that students spend part of their time at CMU and at one of the Portuguese partner Institutions.

This PhD is to be offered by the Department of Electrical and Computer Engineering at the Carnegie Mellon University (CMU), Pittsburgh, USA and by the Department of Electrical and Computer Engineering at Instituto Superior Técnico (IST), Universidade Técnica de Lisboa (UTL), Lisbon, Portugal.

This research partnership has been launched in Portugal between CISTER/IPP-HURRAY, ISR-Lisbon, INESC-ID and ISQ, but it is expected to bring together other leading Portuguese institutions. The following CMU Units are involved: Center for Sensed Critical Infrastructure Research (CenSCIR), Electrical and Computer Engineering (ECE) Department, Computer Science (CS) Department, Engineering and Public Policy (EPP) Department, and Tepper, the CMU Business School.

COOPERATES

QOS-AWARE COOPERATIVE EMBEDDED SYSTEMS
PTDC/EIA/71624/2006
CISTER Funding: 80 KEUR

3 years (Sep 2007 to Sep 2010)
Quality of Service (QoS) is considered an important user demand, receiving wide attention in real-time research. However, in most systems, users do not have any real influence over the QoS they can obtain, since service characteristics are fixed when the systems are initiated.

Furthermore, applications (and their users) can differ enormously in their service requirements as well as in the resources which need to be available to them. These applications present increasingly complex demands on quality of service, reflected in multiple attributes over multiple quality dimensions.

At the same time, the use of embedded devices with wireless network interfaces is growing rapidly. The increasing pervasiveness of these devices in the everyday life is changing the way computing systems are used and interact, creating a new, highly dynamic and decentralized environment.

RESCUE

RELIABLE AND SAFE CODE EXECUTION FOR EMBEDDED SYSTEMS

PTDC/EIA/65862/2006
CISTER Funding: 80 KEUR

3 years (Sep 2007 to Sep 2010)

This project looks at an important requirement in safety critical systems -- that of supporting verifiability of software components. The project partners focus on embedded systems, thereby making the approach more manageable. This also provides a more significant challenge, in that the device in which the verification is being undertaken is resource constrained. The approach is clearly applicable to a variety of different contexts and scenarios.

The use of certificates in Proof Carrying Codes provides a useful basis to support such verifiability provides a useful first step for the research being proposed here. The authors advocate the use of: (i) Type-based; (ii) Language-based; and (iii) Logic-based security enforcement mechanisms.

RESCORE

REAL-TIME SCHEDULING ON MULTICORES

PTDC/EIA/78141/2006
CISTER Funding: 156 KEUR

3 years (Sep 2007 to Sep 2010)

Multiprocessors have already made the transition from high-end computing to desktops and laptops. This was possible because of the miniaturization of integrated electronics system which allowed the implementation of multiprocessors on a single chip, called multicores.

Now, the next step is about to begin. These multicores are targeting embedded real-time systems as witnessed by (i) the commercial availability of multicore PowerPC and ARM processors and (ii) Intel's and AMD's recent marketing of the use of multicores in embedded systems. Today, more than 99% of all computers are embedded systems. These computers operate within products to improve their functionality.

Often human beings are not aware of the existence of these computers - as long as they are working as intended. Pace makers, cars, electronic pianos, vacuum cleaners and walking robots, all represent examples of embedded computers. In fact, virtually every product developed in the future will host an embedded computer. For this reason, they constitute an enabling technology for most goals in our life, our society and the economy.

REFLECT

REFLECTION MECHANISMS IN REAL-TIME EMBEDDED SYSTEMS

PTDC/EIA/60797/2004
CISTER Funding: 50 KEUR

30 months (Jan 2005 to Oct 2007)

The main goal of this project is to provide real-time systems with a generic framework for dynamic application monitoring and control, which uses the advantages offered by advanced programming paradigms, with a particular focus on reflection technologies. The correct use of this technology will allow building systems where the functional aspects are guaranteed to be reliable and deterministic, whilst providing the required flexibility.

The main target of this framework is to support online resource consumption feedback for systems with dynamic QoS requirements.

PUBLICATIONS

THESIS

[T1] Paulo Baltarejo Sousa, "Performance Analysis of Wireless-enabled PROFIBUS Networks", MSc Thesis, Instituto Superior Técnico da Universidade Nova de Lisboa, June 2007.

[T2] André Cunha, "On the use of IEEE 802.15.4/ZigBee as federating communication protocols for wireless sensor networks", MSc Thesis, Faculdade de Engenharia da Universidade do Porto, September 2007.

[T3] Veríssimo Lima, "Arquitecturas de Comunicação Industriais para Suporte a Sistemas Computacionais Móveis", MSc Thesis, Faculdade de Engenharia da Universidade do Porto, December 2007.

JOURNAL PAPERS

[J1] Bjorn Andersson and Cecilia Ekelin, "Exact Admission-Control for Integrated Aperiodic and Periodic Tasks", Journal of Computer and System Sciences, Elsevier, Vol. 73, Issue 2, pp. 225-241, March 2007.

[J2] Nuno Pereira, Bjorn Andersson, Eduardo Tovar, "WiDom: A Dominance Protocol for Wireless Medium Access", IEEE Transactions on Industrial Informatics, Vol. 3, No. 2, pp. 120-130, May 2007.

[J3] Anis Koubaa, Mário Alves, Eduardo Tovar, "Energy/Delay Trade-off of the GTS Allocation Mechanism in IEEE 802.15.4 for Wireless Sensor Networks", International Journal on Communication Systems, John Wiley & Sons, Vol. 20, No. 7, pp. 791-808, July 2007.

[J4] Mário Alves, Eduardo Tovar, "Real-time communications over wired/wireless PROFIBUS networks supporting inter-cell mobility", Computer Networks Journal, Elsevier, Vol. 51, No. 11, pp. 2994-3012, August 2007.

[J5] Anis Koubaa, Mário Alves, Eduardo Tovar, André Cunha, "An Implicit GTS Allocation Mechanism in IEEE 802.15.4: theory and practice", (ECRTS'06 Best Papers), Real-Time Systems Journal, Springer. Numbers 1-3, pp 169 - 204, Springer, August 2008.

[J6] 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) (accepted in 2007).

OTHER PUBLICATIONS

[O1] A. Koubaa, M. Alves, E. Tovar, "IEEE 802.15.4: a Federating Communication Protocol for Time-Sensitive Wireless Sensor Networks", chapter of the book "Sensor Networks and Configurations: Fundamentals, Techniques, Platforms, and Experiments", Springer-Verlag, Germany, pp. 19-49, January 2007.

[O2] Andersson, B., Tovar, E., "Competitive Analysis of Partitioned Scheduling on Uniform Multiprocessors", 15th International Workshop on Parallel and Distributed Real-Time Systems

(WPDRTS'07), within the 21st IEEE International Parallel and Distributed Processing Symposium (IPDPS 2007), March 2007, Long Beach, California, USA.

[O3] L. Nogueira, L. Pinho, "Capacity Sharing and Stealing in Dynamic Server-based Real-Time Systems", 15th International Workshop on Parallel and Distributed Real-Time Systems (WPDRTS'07), within the 21st IEEE International Parallel and Distributed Processing Symposium (IPDPS 2007), March 2007, Long Beach, California, USA.

[O4] *(Best Paper Award)* A. Koubaa, A. Cunha, M. Alves, "A Time Division Beacon Scheduling Mechanism for IEEE 802.15.4/Zigbee Cluster-Tree Wireless Sensor Networks", in the 19th Euromicro Conference on Real-Time Systems (ECRTS´07), Pisa, Italy, July 2007.

[O5] B. Andersson, E. Tovar, "Competitive Analysis of Static-Priority Partitioned Scheduling on Uniform Multiprocessors", 13th IEEE International Conference on Embedded and Real-Time Computing Systems and Applications (RTCSA'07), August 2007, Daegu, Korea.

[O6] B. Andersson, N. Pereira, E. Tovar, "Exact Analysis of TDMA with Slot Skipping", 13th IEEE International Conference on Embedded and Real-Time Computing Systems and Applications (RTCSA'07), August 2007, Daegu, Korea.

[O7] P. Jurcik, A. Koubaa, M. Alves, E. Tovar, Z. Hanzalek, "A Simulation Model for the IEEE 802.15.4 protocol: Delay/Throughput Evaluation of the GTS Mechanism", 15th IEEE International Symposium on Modelling, Analysis, and Simulation of Computer and Telecommunication Systems (MASCOTS´07), Istanbul, Turkey, October 2007.

[O8] A. Cunha, A. Koubaa, R. Severino, M. Alves, "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, October 2007.

[O9] A. Rowe, B. Andersson, N. Pereira, E. Tovar, "Static-Priority Scheduling over Wireless Networks with Multiple Broadcast Domains", 28th IEEE Real-Time Systems Symposium (RTSS'07), Tucson, Arizona, USA, December 2007.

[O10] Andersson, B., Pereira, N., Tovar, E., "Delay-Bounded Medium Access for Unidirectional Wireless Links", Published in proceedings of the 15th International Conference on Real-Time and Network Systems (RTNS'07), Nancy, France, March 2007

Patents/Prototypes

In accordance with the Unit strategy, in 2007 we produced a significant set of prototypes, field trials and test-beds.

In the context of the ART-WiSe framework, the open-source toolset for the IEEE 802.15.4/ZigBee protocols has been further developed in 2007. This toolset features: (i) implementation of the IEEE 802.15.4 protocol in TinyOS, for both the MICAz and TelosB motes; (ii) implementation of the ZigBee Network Layer for supporting synchronized multiple cluster topologies in TinyOS, for the TelosB motes; (iii) a simulation model of the IEEE 802.15.4 protocol in OPNET; (iv) software tools (based on MATLAB and MS Excel) for timing analysis and network dimensioning. This toolset has been downloaded more than 1000 times and triggered several relevant collaborations.

Within the WiDOM framework, several prototypes and tools have been provided, such as: (i) a nano-RK implementation of WiDOM for the MICAz and FireFly motes; (ii) a TinyOS implementation of WiDOM for the MICAz motes; (iii) a simulation model of WiDom for Multiple Broadcast Domains (MBD) in the OMNet++ simulator; (iv) a simulation model to compute an estimation of the number of nodes, designed to exploit WiDOM.

Within the Hydra framework, we have mainly the following prototypes: (i) a TinyOS Implementation of HYDRA; (ii) a simulation model of HYDRA in the OMNet++ simulator.