CISTER
Research Center in
Real-Time & Embedded
Computing Systems

Annual Report

2011

isep Instituto Superior de Engenharia do Porto

POLITÉCNICO DO PORTO

INESCTEC
TECNOLOGIA E CIÊNCIA

Contents

Executive Summary

The CISTER Research Unit 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 both the 2003 and 2007 evaluations, the Unit was granted the classification of 'Excellent' from an international panel of experts. We firmly believe that ever since then, and particularly during 2009, we have been exceeding the expectations placed on us. 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.

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, and two Vice Directors. Together these form the Board of Directors (BoD).

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 yearly report (scientific and financial) to the Unit's Steering Committee and Executive Boards. The main responsibilities of the Vice Directors are to assist and replace the Director when necessary.

The BoD is assisted in governance by an Executive Board (ExecB), to manage day-to-day activities. The ExecB is structured by areas of responsibilities: (i) Finances, Quality & Procedures; (ii) Human Resources; (iii) Research Projects; (iv) Industry Contracts, IP-issues (v) Presentation & Image; (vi) Infrastructures & Facilities; (vii) IT Infrastructure and (viii) Administrative Support. These responsibilities are associated with individuals in the ExecB.

The Steering Committee (SC) supports the BoD in contributing to the medium to long term strategic planning of the CISTER Research Unit. This includes providing direct input to the half yearly budget planning process, as well as reviewing the resulting overall budget. It is also involved in planning the opening or closure of research areas. Additionally, the SC supports the BoD in the selection process and management of research staff and students. The SC includes the ExecB members and the research leaders.

The activities of the Unit are periodically reviewed by international top-ranked researchers. Annually, a number of on-site visits are performed by these researchers to discuss the Unit's activities and plans. Current members of the External Advisory Board are: Alan Burns (University of York, UK); Tarek Abdelzaher (UIUC, USA); Sanjoy Baruah (UNC, USA) and Raj Rajkumar (CMU, USA). 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 2011, the CISTER research team was composed by:

- Number of Researchers holding a PhD: 16
- Number of Researchers holding a MSc: 19

In 2011 the unit had around 562K EUR of competitive funding. During 2011 CISTER had 8 international and industrial driven projects, and 7 fundamental research projects (FCT supported) running.

In 2011 CISTER got approved a set of new projects, accounting for a budget of 192K EUR in the year, with a total budget of 577K EUR.

General Objectives

The CISTER Research Unit focuses its activity in the analysis, design and implementation of real-time and embedded computing systems (RTES). In RTES, correctness depends not only on the logical result of computation, but also on the time at which the results are produced. RTES is one of the ICT areas witnessing higher growth; over 98% of the current processors are embedded. RTES are everywhere, built into vehicles, roads, buildings, medical instruments, game consoles and mobile phones, usually interconnected in networks of many devices.

The strategy adopted by CISTER is the pursuit of excellence in research which is benchmarked against the best international groups in our research areas, in Europe (e.g. York, UK; SSSUP, IT; MdH and SICS, SE; TUW, AT; TUB, DE), U.S.A. (e.g. UNC-CH, UIUC, UVa, WUStL, CMU) and Asia (e.g. KAIST, KR).

There are five key strategic options that have been driving the research agenda of the Unit: (i) research focus; ii) sustained growing; (iii) selective publication efforts; (iv) selective and consistent participation in scientific service; (v) strong participation in international reputed academic/industrial research partnerships on both fundamental and applied research.

The continued focus and excellence of CISTER's research is supported through the Unit's definition of a few but strategic research areas: Wireless Sensor Networks (WSN); Cyber-Physical Systems (CPS); Multicore Systems (MCS); Adaptive Real-Time Systems (ARTS); Real-Time Software (RTS).

In WSNs, we will keep addressing strategic research topics such as Quality-of-Service (QoS) – timeliness/real-time, reliability, mobility and energy-efficiency, considering both standard COTS technology and cutting-edge new solutions. Some research will continue to be application-driven, such as for energy-efficiency in buildings.

In CPS, we will continue tackling challenges such as distributed programming paradigms and systems theory, holistically combining "physical concerns" (e.g. control systems, signal processing) and "computational concerns" (e.g. complexity, schedulability). Some research has been application-oriented e.g. smart skins for drag reduction in aircrafts and energy-efficiency of data centres via high resolution sensing/actuation.

The MCS area addresses new scheduling algorithms and proof techniques to enable design- and run-time timeliness guarantees, considering both identical and heterogeneous multiprocessor architectures, and considering an environment where exact information about service arrivals does not exist. The group is well-established and aims to continue its work, with an anticipated enlargement both in PhD members and PhD students.

ARTS addresses issues associated with systems requiring temporal isolation of components with different criticality, as well as systems being robust and reliable in the context of additional restrictions like available energy, changing environment or a dynamic set of services and their implementation in operating systems. We aim at an increased volume of journal publications and a small increase of the number of researchers.

RTS addresses the incorporation of advanced mechanisms (e.g. multicore programming, software transactional memory, real-time virtual machines, and component frameworks) in the software infrastructure (languages, operating systems, middleware) of RTES, enabling designers/programmers to manage increasing complexity and flexibility requirements.

In line with the strategy of research excellence, CISTER aim is to keep participating in national and international projects and networks of excellence and publishing in highly reputed journals & conferences (some with higher impact than top journals).

Main Achievements

CISTER research achievements in the last years (particularly in 2011) as simultaneously a cause and a consequence of the international leadership of the unit in its scientific areas.

CISTER has been consistently involved in the top scientific events and publications in the area, with a track record of over 1500 citations just for papers published in the last 6 years. Its senior researchers are renowned in their topics of expertise and consistently participate as chairs and PC members in top conferences such as IEEE RTSS, IEEE RTAS, IEEE RTCSA, ECRTS, Ada-Europe, ACM/IEEE ICCPS and EWSN, as well as in the editorial board of the IEEE TII, Springer RTSJ, Elsevier JSA and the Ada User Journal.

In the CPS area, we have advanced the state-of-the-art in scalable data aggregation/processing [J2,FP8] and macroprogramming [FP9-11]. The SmartSkin project (CISTER leads + Embraer + Critical Materials) started, for reducing fuel consumption in aircrafts by reducing drag. In the SENODS project (CISTER leads + PT + CMU), for energy-optimized data centres, we successfully demonstrated some base functionalities at ISEP and PT data centres. A CPS researcher gave a talk at a school on ICT for future Energy Systems in Trento (IT).

The WSN area leads R&D in QoS, namely in within the leadership of the COTS4QoS cluster (CONET NoE). In 2011, we published seminal results on improving reliability in mobile WSN ([FP4], [SP4]) and on link quality estimation ([J3], [T1]) and interference modelling/generation ([J7], [FP6-7]) and consolidated the design, implementation and deployment of large-scale and dense WSNs for monitoring a building at SANJOTEC high tech park, under the EMMON project ([FP1-2], [SP1-2]).

The RTS area continued the work on middleware for cooperative and autonomic embedded systems, tackling in particular support to code mobility [J8,FP19,FP26,SP11], and analyzed the support for developing multicore applications, both at the language level [FP18,FP20], and at the operating system level (software transactional memory [FP17] and parallel tasks [FP22]). A joint activity was also realized with the CPS/ WSN areas in programmability of sensor networks [FP10]

ARTS further developed work in the area of energy management – an efficient algorithm for slack management to enable the use of sleep states was developed [FP15]. The management of preemptions and the associated cost in terms of loss of working set in the caches was investigated [SP10, FP23]. Also, we continued the work on the contention on implicitly shared resources, in particularly interconnect busses [SP12, SP9, FP25] and built a simulation framework for the real-time system community to test scheduling and resource management approaches [SP8, FP24].

During 2011, the MCS area had three main achievements: (i) an approach to achieve guaranteeable utilisation without inducing many preemptions [J1]; (ii) protocols for multi-mode systems deployed on multicores [SP7, FP16]; and iii) scheduling a tasks set on a specific type of heterogeneous multiprocessor [J8, FP13, FP21]. The work on resource sharing on multi-core systems received the best student paper award [FP14] at RTAS, one of the top events in the area.

Besides the other projects ongoing in 2011, we would like to highlight the start of the ENCOURAGE Artemis project on ICT support to energy-efficient buildings, lead by Intel Labs Europe (IE), and involving e.g. ENEL (IT), EnergiNord (DK), ISA (PT), U. Alborg (DK), UCD (IE) and Atos (ES).

In 2011, CISTER hosted several national and international events, of which we would like to highlight the 23rd Euromicro Conference on Real-Time Systems (5-8/JUL), the CONET WP4 (research clusters) meeting (15-16/DEC; 30 attendants), the RECOMP General Meeting (29/AUG-2/SEP; 67 attendants), a distinguished keynote talk (Ian Bate, U. York, UK, 20/SEP) and the 14th RTCM workshop (1/JUL). Eduardo Tovar was WSN track chair of the 17th IEEE RTAS.

Activities

Integrative/multidisciplinary activities

As the Unit is relatively small, its areas of research are by their nature multidisciplinary. The unit has strategically fostered the integration of researchers from different background areas with the goal of setting up a team with focused and complementary competencies.

This policy was continued during 2010, particularly by the strategic hiring of researchers in the area of multicore systems. CISTER includes researchers with diverse academic backgrounds, such as Electrical and Computer Engineering, Informatics Engineering, Computer Science and Applied Physics/Mathematics.

These complementary backgrounds allowed increasing the 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. Utilising this, the Unit leads international research in embedded real-time systems, attacking emerging challenges in a focused manner through its research areas.

Wireless Sensor Networks experience the transition from research to industrial deployment. During this transition new challenges appear in link quality management and general communication paradigms to scale small deployments to 1000s of nodes in a reliable and energy efficient manner. In Cyber-Physical Systems, the computer systems do not only compute quantities, but are also tightly integrated and interacting with their physical environment, by taking sensor readings and acting on it. Such systems require a rethinking in the usual computing and networking concepts, while the importance of timeliness is increasing steadily.

Another trend is towards massively networked embedded computing devices. Such extreme networking poses considerable technical challenges in terms of the distributed programming paradigms not reflected in current languages. Real-Time Software is concerned with languages, management of software concurrency, as well as decentralised middleware and operating system adaptation, which form fundamental building blocks of autonomic distributed systems.

Adaptive Real-Time Systems address the emergence of embedded devices exposed to different levels of criticality, reconfigurable and mobile systems. This is reflected in the work on server-based scheduling, adaptive service management, hierarchical systems, as well power management of energy constrained embedded systems. A final trend addressed by the group is the increased deployment of Multicore Systems and the inherent challenges in providing solutions, which are able to support real-time guarantees, considering both identical and heterogeneous multicores.

The research unit is involved in a number of national and international projects that are multi-site and multi-disciplinary; e.g. SENODs, RESCUE, EMMON and RECOMP, or the ArtistDesign and CONET networks of excellence.

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 organised 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.

Most of our fundamental research activities are supported by applied research vertices, which facilitates that CISTER scientific results are accessible to the general public through practical demonstrations with state-of-the-art technology and appealing application scenarios. Notable

examples are the RFieldbus manufacturing automation field-trial, the ART-WiSe search&rescue testbed or the developments being carried out in the scope of the EMMON project.

Also, during 2010 CISTER organized a series of seminar talks and distinguished lectures. The talks involved several senior researchers and PhD students from CISTER, and were well attended by not only students and faculty members of Instituto Superior de Engenharia do Porto, but also by members of the Faculdade de Engenharia of University do Porto (FEUP). During the year we organized distinguished lectures by highly reputed academics and industrial researchers like Professor Iain Bate Abdelzaher (University of York), CISTER researchers have also participated in similar initiatives of other institutions.

CISTER researchers have been consistently enrolled in supervising undergraduate, MSc and PhD students in collaboration with several national and international universities, either funder by CISTER or by these institutions or specific funding programs. Importantly, CISTER continued to consolidate its enrolment in the Doctoral Program in Electrical and Computer Engineering(PDEEC) at the University of Porto (FEUP). CISTER is responsible for the "Real-Time and Embedded Systems" stream, involving 4 courses (2 mandatories and 2 elective).

Organization of Conferences

CISTER organized the 23rd Euromicro Conference on Real-Time Systems (ECRTS'11) and its satellite workshops in Porto. ECRTS is one of the three flagship events in real-time embedded systems research. We had five satellite workshops that ran in parallel in the day before the main conference. This adds to a Work in Progress (WiP) session. The excellent technical program, with a total of 25 presentations (out of 119 high quality submissions), was complemented by a substantial social program covering many touristic aspects of the city and has drawn a new record for ECRTS of over 170 participants to the conference and its associated workshops. More info at http://www.cister.isep.ipp.pt/ecrts11/.

CISTER hosted the Artemis RECOMP project meeting week in ISEP, 29/AUG-2/SEP. RECOMP aims to reduce the certification cost of the deployment of multicore systems in safety critical settings. The week saw the participation of 67 researchers from top European universities (e.g. Danish Technical University in Kopenhagen, TU Braunschweig), SMEs (e.g. Symtavision GmBH, Saferiver) and larger corporations (e.g. Thales, EADS, Infineon, Honeywell, Danfoss, Kone, TÜV Süd). More info at http://www.recomp-project.eu/.

CISTER hosted the WP4 (research clusters) meetings of the FP7 European NoE in Cooperating Objects (CONET), 15-16/DEC/2011. The overall objective of this meeting was to make a status update on the research clusters activities and intra/inter-cluster collaborations, fostering technical discussions and leveraging future work within and between the 6 research clusters. CONET includes 16 core members, 11 from academia (e.g. TU Delft, TU Berlin, ETHZ, UCL, SICS and U. Pisa) and 5 from industry (SAP, Schneider, SELEX, Boeing R&T Europe and Telecom Italia. More info at http://www.cooperating-objects.eu.

Industry Contract Research

The unit has a track record of consistent participation in international industry-driven R&D projects, of which we outline the ones ongoing/started in 2011: EMMON, SENODS, RECOMP and ENCOURAGE.

EMMON (Embedded Monitoring), funded by FP7/ARTEMIS, aims at large-scale and dense embedded monitoring using wireless sensor networks. The EMMON architecture will enable to monitor different physical properties (e.g. temperature, humidity, pressure) of specific geographical areas at unprecedented scale and density, through the use of tiny low-cost low-power sensor nodes. CISTER leads WP4 on Protocols & Communication Systems.

The SENODs (Sustainable ENergy-Optimized Datacenters) project, funded by the Portugal-CMU Program, is lead by CISTER and involves Portugal Telecom as main industry driver. CISTER is using know-how and technologies developed in the Unit that offer integrated solutions to address both the

cyber and physical challenges posed by the large-scale energy consumption, cooling, and operational needs of data centres.

RECOMP (Reduced Certification Costs for Trusted Multi-core Platforms) is a FP7/ARTEMIS Embedded Computing Systems Initiative, that will establish methods, tools and platforms for enabling cost-efficient certification and re-certification of safety-critical as well as mixed-criticality software systems such as those present in automobiles and aircrafts. CISTER is focusing on aspects related to the certification and re-certification of timing guarantees in the system.

The ENCOURAGE (Embedded iNtelligent COntrols for bUildings with Renewable generAtion and storaGE) project, funded by FP7/ARTEMIS, aims at developing embedded intelligence and integration technologies for optimizing energy use in buildings with renewable energy and enabling active participation in the future smart grid environment. CISTER essentially addresses sensing technologies and the event-based middleware.

Internationalization

CISTER has been actively involved in international networks of excellence and R&D projects which naturally foster further collaborations, e.g., preparing projects, visiting scholars, joint papers, organization of joint events. CISTER is member of the FP7/ARTEMIS JTI Artemisia Association, the European Networks of Excellence on Embedded Systems Design (ArtistDesign) and Cooperating Objects (CONET), the IEEE Technical Committee on Real-Time Systems, the Euromicro Technical Committee on Real-Time Systems, the IFIP Working Group 10.2 on Embedded Systems, the Ada-Europe Board and the TinyOS 15.4 and Zigbee working groups.

During 2011 CISTER continued its participation in several international projects, namely EMMON (Artemis), RECOMP (Artemis) and SENODS (PT-CMU), and started yet another one - ENCOURAGE (Artemis), dealing with ICT support to energy-efficient buildings.

We would like also to note the two partnerships that CISTER has in terms of national and international graduate studies. PhD studies with CISTER are made within a specialized stream in Embedded and Real-Time Systems in Doctoral Programs of the School of Engineering of the University of Porto (where most of the students are foreigners) or within the Dual-degree Ph.D. Programs of the Portugal-CMU initiative, where CISTER is involved from the beginning (only research centre from the polytechnic to be invited to enroll in this program from the start).

CISTER has also been collaborating with other international institutions for interchanging (hosting theirs and sending ours) students at both undergraduate and graduate levels, such as with SICS (Sweden), UDE (Germany), UFSC (Brazil), SupCom (Tunisia), UCLM (Spain), CTU (Czech Republic), IITs (India), KAIST (South Korea).

CISTER has been consistently publishing papers in co-authorship with other international groups, as a natural consequence of its involvement in international partnerships. In 2011, we published around 10 full papers and 4 short papers and developed code, prototypes and toolsets with other reputed foreign groups.

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.

CONET

COOPERATING OBJECTS NETWORK OF EXCELLENCE
Project FP7-ICT-224053, EU-funded
CISTER funding: 250 KEUR

4 YEARS (JUN 2008 TO MAY 2012)

A number of different system concepts have gained a lot of relevance in the area of embedded systems over the past couple of years: Embedded systems, pervasive computing and wireless sensor networks. These three types of quite diverse systems share a lot of commonalities but also have some complementary aspects in common that make a combination into a coherent system vision promising.

The term "Cooperating Objects" was coined explicitly for the purpose of describing such systems by the Embedded WiSeNts Consortium, a Coordination Action funded by the EC in FP6. One of the main results was the publishing of the Embedded WiSeNts Research Roadmap that defines the concept of Cooperating Objects. The vision of Cooperating Objects is, therefore, quite new and needs to be understood in more detail and probably extended with inputs from the relevant individual communities that compose it. This will enable us to better understand the impact on the research landscape and to steer the available resources in a meaningful way.

The main goal of CONET is to build a strong community in the area of Cooperating Objects capable of conducting the needed research to achieve, in the long run, the vision of Mark Weiser.

Research Projects

EMMON

EMBEDDED MONITORING
Project Artemis 100036
CISTER Funding: 250 KEUR

3 YEARS (SEP 2007 TO SEP 2010)

EMMON goal is to allow monitoring huge geographical extensions in real time, obtaining information from the field of observation as variations occur, using Wireless Sensor Network (WSN) devices – small communicating & cooperative nodes with sensors.

ENCOURAGE

EMBEDDED INTELLIGENT CONTROLS FOR BUILDINGS WITH RENEWABLE GENERATION AND STORAGE
JU grant nr. 269354 ARTEMIS/0002/2010
Funding: 6.37MEUR (CISTER Funding: 266KEUR)

42 MONTHS (JUN 2011 TO NOV 2014)

The ENCOURAGE project aims to develop embedded intelligence and integration technologies that will directly optimize energy use in buildings and enable active participation in the future smart grid environment. The desired energy savings will be achieved in three complementary ways:

I. by developing supervisory control strategies that will be able to coordinate larger subsystems and orchestrate operation of the numerous devices in such systems.
II. through an intelligent gateway with embedded logic supporting inter-building energy exchange.
III. by developing novel virtual sub-metering technologies and event-based middleware applications that will support advanced monitoring and diagnostics concepts.

The primary application domains are non-residential buildings and campuses, but the project has relevancy also to residential buildings and neighbourhoods. This will be expressed through several demonstrators comprising public and private office buildings, campus buildings, and private homes. ENCOURAGE aims to achieve 20% of energy savings through the improved interoperability between various types of energy generation, consumption and storage devices; inter-building energy exchange; and systematic performance monitoring.

Partners of the ENCOURAGE consortium include, among others:

PT-CMU

CMU PORTUGAL

CISTER Funding: 350 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.

MASQOTS

MOBILITY MANAGEMENT IN WIRELESS SENSOR NETWORKS UNDER QOS CONSTRAINTS USING STANDARD AND OFF-THE-SHELF TECHNOLOGIES
FCOMP-01-0124-FEDER-014922 PTDC/EEA-TEL/112220/2009
CISTER Funding: 94.8 KEUR

42 MONTHS (FEB 2011 TO JUL 2014)

MASQOTS aims at real-time and reliable communications in IEEE 802.15.4/ZigBee (15.4/ZigBee, for short) Wireless Sensor Networks (WSNs) supporting physical mobility. Physical mobility concerns mobile sensor/actuator nodes and node groups (e.g. body sensor networks (BSNs), robots), and also mobile sinks (e.g. gateways, user-interface equipment).

The main objective of this project is to design a real-time and reliable mobility management mechanism for IEEE 802.15.4/ZigBee-based WSNs.

We will build upon the most widespread WSN technologies – the 15.4 and ZigBee protocols and the TinyOS operating system (OS) – for which the research team in this proposal is international leader. OnWorld predicts that in 2012, 88.3% of the WSN units will be standards-based. Freescale reports over 7 million 15.4/ZigBee units sold in 2008 and In-Stat forecasts 292 million units in 2012. TinyOS is the most used OS for WSNs.

MASQOTS will also address some fundamental (not yet solved) problems, such as the ones related to reliable Radio Link Quality Estimation (LQE), efficient and dynamic resource management, reliable and time-bounded handoff and re-association mechanisms and the provision of (simulation, analytical) models/tools for WSN analysis and dimensioning.

RECOMP

REDUCED CERTIFICATION COSTS FOR TRUSTED MULTI-CORE PLATFORMS

Artemis 100202
CISTER Funding: 456 KEUR

3 YEARS (APR 2010 TO MAR 2013)

RECOMP recognizes the fact that the increasing processing power of embedded systems is mainly provided by increasing the number of processing cores. The increased numbers of cores is commonly regarded as a design challenge in the safety-critical area, as there are no established approaches to achieve certification. At the same time there is an increased need for flexibility in the products in the safety-critical market. This need for flexibility puts new requirements on the customization and the upgradability of both the non-safety and safety-critical critical part. The difficulty with this is the large cost in both effort and money of the re-certification of the modified software, which means that companies cannot fully leverage the advantages of modular software system. RECOMP will provide reference designs and platform architectures together with the required design methods and tools for achieving cost-effective certification and re-certification of mixed-criticality, component based, multi-core systems. The aim of RECOMP is to define a European standard reference technology for mixed-criticality multi-core systems supported by the European tool vendors participating in RECOMP.

Partners of the RECOMP consortium include, among others:

REHEAT

REAL-TIME SCHEDULING ON HETEROGENEOUS MULTICORE ARCHITECTURES

FCOMP-01-0124-FEDER-010045 PTDC/EIA-CCO/105716/2008
CISTER Funding: 130 KEUR

3 YEARS (FEB 2010 TO JAN 2013)

Parallel processing platforms are spreading at an unprecedented rate. Traditionally, parallel processing platforms were used to reduce the execution time of a large computational job such as predicting the weather but now they are also used in low-end systems and embedded real-time systems thanks to the availability of multicore processors. And those systems are often comprised of a large number of independent tasks. Designers are well-aware that processing units specialized for a specific function can offer a significant performance boost. Consequently, heterogeneous multicores now enjoy a period of widespread use. Virtually all major semiconductor companies are offering or have declared plans to offer heterogeneous multicores.

This project aims to create provable good real-time scheduling algorithms for heterogeneous multicores.

REJOIN

REAL-TIME SCHEDULING ON MULTICORE PROCESSORS: ADDRESSING TWO OPEN PROBLEMS JOINTLY

FLAD/NSF 91-02/10
CISTER Funding: 7 KEUR

11 MONTHS (JUN 2010 TO MAY 2011)

The objectives of this project is to study the following two problems:

P1. Multiprocessor Global Feasibility Analysis - Arbitrary-Deadline Tasks;
P2. Resource sharing on Multiprocessor Systems.

The main challenge with respect to P1 is that optimal scheduling for the problem P1 requires knowledge of future job arrivals. It has recently been shown [1] that no optimal solution exists for problem P1 even for the slightly more restricted model of sporadic tasks. Creating non-optimal algorithms is worthwhile though.

Problem P2 is non-trivial because normal uniprocessor solutions, Priority-Inheritance Protocol (PIP) and Priority Ceiling Protocol (PCP, perform poorly. The former (PIP) allows a large degree of parallel execution but there are many situations when a lower priority task inherits a much higher priority and this can happen multiple times and this cause delays to a medium priority task. The latter (PCP) severely limits parallel execution. Because of the poor performance PIP and PCP, new solutions to P2 must be devised.

REPOMUC

REAL-TIME POWER MANAGEMENT ON PARTITIONED MULTICORES

FCOMP-01-0124-FEDER-015050 PTDC/EIA-EIA/112599/2009
CISTER Funding: 106 KEUR

3 YEARS (FEB 2011 TO JAN 2014)

The fundamental objective of the RePoMuC project to provide a methodology for real-time power-management in Multicores, considering:
1. the non-linear behaviour of dynamic frequency and voltage scaling (DVFS) on execution-time and energy,
2. pre-emption delays, and
3. memory bus contention Particular focus will be given to demonstrate with a real-world implementation the practicality and limitations of the proposed methodology.

The approach we intend to take is to build on successful experience of the group in the areas of DVFS power management, real-time multiprocessor scheduling and temporal isolation. The issues of DVFS behaviour, pre-emption delays, and memory bus contention have a fundamental communality in the sense that they are all tightly coupled to the amount of memory traffic.

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.

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.

REWIN

Real-Time Guarantees in Wireless Sensor Networks

FCOMP-01-0124-FEDER-010050 PTDC/EIA-CCO/109027/2008
CISTER Funding: 68 KEUR

3 years (Feb 2010 to Jan 2013)

A class of WSN applications require timely response to events. For example, in a smart nursing home WSN scenario, it is necessary to guarantee that life-threatening events such as heart-attacks are communicated to doctors within a bounded time. The ability to support real-time applications is fundamental to the advancement of capabilities of WSN, and is the motivation for this proposed research. Since communication is an integral part of WSN, the performance of WSN is mainly determined by the quality and capacity of the wireless channel. The limited previous research that exists is insufficient to guarantee (with mathematical proofs) a low delay for disseminating the occurrence of rare but critical events, such as the heart-attack mentioned above. This project, we will develop methods to offer hard real-time guarantees to individual real-time flows over multi-hop WSN of arbitrary node deployments and arbitrary traffic pattern. These methods will guarantee a small delay for disseminating the occurrence of critical events.

SENODs

Sustainable ENergy-Optimized Datacenters

FCOMP-01-0124-FEDER-012988 CMU-PT/SIA/0045/2009
CISTER Funding: 219KEUR

39 months (Oct 2010 to Dec 2013)

Data centres increasingly constitute a critical backbone of the worldwide information technology (IT) infrastructure, forming the server infrastructure for search engines, mail servers, e-commerce, data warehousing and other cloud computing functions.

Thousands of data centres operate across the world occupying various millions of square meters. While such data centres generally target large-scale virtual IT services, the design, construction and operation of data centres (i) depend on cyber-physical infrastructure with major power and cooling requirements, (ii) incur significant energy costs, and (iii) can lead to significant economic and societal impact from the failures of physical subsystems. In fact, power and cooling in a data centre cost more than the IT equipment supported. As a result, data centres face an emerging crisis.

The SENODs (Sustainable ENergy-Optimized Datacenters) project will rectify that by:

(i) using ultimate distributed sensing technologies to provide fine-grained monitoring of power consumption, cooling and data centre environmental variables to identify, model, analyse and optimize energy costs;
(ii) developing intelligent layout optimization algorithms that offer recommendations regarding placement of new servers so as to minimize local hotspots and improve energy efficiency;
(iii) providing support for alerts and notifications of actual or pending failures in cooling and other infrastructure equipment to gracefully shut down some or all of centre operations;
(iv) online capacity and workload management that allows dynamic reallocation of computing loads driven by energy and cost minimization.

Partners of the SENODs consortium include:

VIPCORE

VIRTUAL PROCESSOR-BASED MULTICORE SCHEDULING

FCOMP-01-0124-FEDER-015006 PTDC/EIA-CCO/111799/2009
CISTER Funding: 111KEUR

40 MONTHS (FEB 2011 TO JUN 2014)

Scheduling on multicores is a much harder problem than those studied under single processor scheduling theories, largely because of the inherent non-parallelism in workload tasks. Although a multicore platform may execute different tasks from a workload at the same time, it is typically not allowed to execute the same task on more than one core simultaneously. This project plans to research multiprocessor frameworks and platforms to tackle these issues.

One important concept is the notion of virtual processors, which allow to use a three-step scheduling strategy: partitioning of workload tasks and assigning virtual processors to each partition, scheduling of tasks on virtual processors within each cluster, and scheduling of virtual processors on the physical cores. Another important concept is the notion of pJobs, which allow tasks to be executed in parallel in the physical cores, increasing the potential parallelism of applications. The project will also research into architectures and platforms for supporting these concepts, and the underlying resource sharing paradigms.

SMARTSKIN

DENSELY INSTRUMENTED PHYSICAL INFRASTRUCTURES

FCOMP-01-0124-FEDER-020312 PTDC/EEA-ELC/121753/2010
CISTER Funding: 141KEUR

3 YEARS (MAR 2012 TO FEB 2015)

Although the information technology transformation of the 20th century appeared revolutionary, a bigger change is on the horizon. The term Cyber-Physical Systems (CPS) has come to describe the research and technological effort that will ultimately allow the interlinking of the real-world physical objects and the cyberspace efficiently. The integration of physical processes and computing is not new.

Embedded systems have been in place for a long time and these systems often combine physical processes with computing. The revolution will come from massively networked embedded computing devices, which will allow instrumenting the physical world with pervasive networks of sensor-rich embedded computation.

In this project we intend to develop techniques and technologies that allow performing scalable and efficient data processing in large-scale dense cyber-physical systems. This is yet an unsolved problem. The major novelty of this proposal is effectively in the co-design of distributed algorithms for sensor data processing and underlying networked distributed computing systems with corresponding resource management schemes such that the utilization of resources is low.

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Publications

Thesis

[T1] (EWSN/CONET 2011 MSc award): Maissa Ben Jamaa, “An Experimental Study for the Performance Evaluation and Optimization of Link Quality Estimators in Wireless Sensor Networks, MSc Thesis in Information Systems and New Technologies, University of Sfax, Tunisia, July 2010.

[T2] Maia, C., "Cooperative Framework for Open Real-Time Systems", Master Thesis, Instituto Superior de Engenharia do Porto.

Journal Papers

[J1] Bletsas, K., Andersson, B., "Preemption-light multiprocessor scheduling of sporadic tasks with high utilisation bound", Real-Time Systems Journal (Springer), Volume 47, Number 4, January 2011, pp. 319-355.

[J2] Andersson, B., Pereira, N., Tovar, E., Gomes, R., "Using a Prioritized Medium Access Control Protocol for Incrementally Obtaining an Interpolation of Sensor Readings", M. Conti et al. (eds.), “Solutions on Embedded Systems”, Lecture Notes in Electrical Engineering (LNEE), February, 2011, pp. 17-31.

[J3] Baccour, N., Koubaa, A., Jamâa, M., Rosário, D., Youssef, H., Alves, M., Becker, L., "RadiaLE: a Framework for Designing and Assessing Link Quality Estimators in Wireless Sensor Networks", Ad Hoc Networks Journal (Elsevier), Volume 9, Issue 7, September 2011, pp. 1165–1185.

[J4] A. Belghith, A. Koubaa, E. Shakshuki, “EDITORIAL: Challenges and trends in wireless ubiquitous computing systems”, Personal and Ubiquitous Computing Journal (Springer), Volume 15, Issue 8, December 2011, pp. 781-782.

[J5] O. Cheikhrouhou, A. Koubaa, G. Dini, M. Abid, “RiSeG: a ring based secure group communication protocol for resource-constrained wireless sensor networks”, Personal and Ubiquitous Computing Journal (Springer), Volume 15, Issue 8, December 2011, pp. 783-797.

[J6] Raravi, G., Andersson, B., Bletsas, K., "Provably good task assignment on heterogeneous multiprocessor platforms for a restricted case but with a stronger adversary", ACM SIGBED Review – Special issue on the Work-in-Progress (WiP) Session of the 23rd Euromicro Conference on Real-Time Systems (ECRTS 2011), Volume 8 Issue 3, September 2011 , ACM New York, NY, USA, pp. 19-22.

[J7] Noda, C., Prabh, S., Alves, M., Boano, C., Voigt, T., "Quantifying the Channel Quality for Interference-Aware Wireless Sensor Networks", ACM SIGBED Review - Special Issue on the 10th International Workshop on Real-time Networks (RTN 2011), Volume 8, Issue 4, December 2011, ACM New York, NY, USA, pp. 43-48.

[J8] Ferreira, L., Nogueira, L., "On the Use of Code Mobility Mechanisms in Real-Time Systems", ACM SIGBED Review - Special Issue on the 10th International Workshop on Real-time Networks (RTN 2011), Volume 8, Issue 4, December 2011, ACM New York, NY, USA, pp. 16-21.

Full Papers (Conferences & Workshops)

[FP1] Tennina, S., Gomes, R., Alves, M., Ciriello, V., Carrozza, G., "The Dark Side Of DEMMON: What Is Behind The Scene In Engineering Large-Scale Wireless Sensor Networks", 14th ACM MSWiM 2011.

[FP2] Tennina, S., Bouroche, M., Braga, P., Gomes, R., Alves, M., Mirza, F., Ciriello, V., Carrozza, G., Oliveira, P., Cahill, V., "EMMON: A WSN System Architecture for Large Scale and Dense Real-Time Embedded Monitoring", 9th IEEE/IFIP EUC 2011.

[FP3] Tennina, S., Valletta, M., Santucci, F., Renzo, M., Graziosi, F., Minutolo, R., "Entity Localization and Tracking: A Sensor Fusion-based Mechanism in WSNs", 4th MELT 2011.

[FP4] Prabh, S., Hauer, J., "Opportunistic Packet Scheduling in Body Area Networks", 8th EWSN 2011.

[FP5] Prabh, S., "Bandwidth Allocation in Hexagonal Wireless Sensor Networks for Real-Time Communications", IEEE ICNSC 2011.

[FP6] Noda, C., Prabh, S., Alves, M., Voigt, T., Boano, C., "Quantifying the Channel Quality for Interference-Aware Wireless Sensor Networks", 10th RTN 2011.

[FP7] (Best Paper Nominee) Boano, C.A.; Voigt, T.; Noda, C.; Romer, K.; Zuniga, M., "JamLab: Augmenting sensornet testbeds with realistic and controlled interference generation", 10th ACM IPSN 2011.

[FP8] Ehyaei, A., Tovar, E., Pereira, N., Andersson, B., "Scalable Data Acquisition for Densely Instrumented Cyber-Physical Systems", 2nd ACM/IEEE ICCPS 2011.

[FP9] Gupta, V., Kim, J., Pandya, A., Lakshmanan, K., Rajkumar, R., Tovar, E., "Nano-CF: A Coordination Framework for Macro-programming in Wireless Sensor Networks", 8th IEEE SECON 2011.

[FP10] Gupta, V., Tovar, E., Pinho, L., Kim, J., Lakshmanan, K., Rajkumar, R., "sMapReduce: A Programming Pattern for Wireless Sensor Networks", 2nd SESENA 2011.

[FP11] Gupta, V., Tovar, E., Lakshmanan, K., Rajkumar, R., "A Framework for Programming Sensor Networks with Scheduling and Resource-Sharing Optimizations", Invited paper 1st CPSNA 2011.

[FP12] Sousa, P., Andersson, B., Tovar, E., "Implementing Slot-Based Task-Splitting Multiprocessor Scheduling", 6th IEEE SIES 11.

[FP13] Raravi, G., Andersson, B., Bletsas, K., "Intra-Type Migrative Scheduling of Implicit-Deadline Sporadic Tasks on Two-Type Heterogeneous Multiprocessor", 10th MAPSP 2011.

[FP14] Lee, J., Easwaran, A., Shin, I., "Maximizing Contention-Free Executions in Multiprocessor Scheduling", 17th IEEE RTAS 2011.

[FP15] Awan, M., Petters, S., "Enhanced Race-To-Halt: A Leakage-Aware Energy Management Approach for Dynamic Priority Systems", 23rd ECRTS 2011.

[FP16] Nelis, V., Marinho, J., Andersson, B., Petters, S., "Global-EDF Scheduling of Multimode Real-Time Systems Considering Mode Independent Tasks", 23rd ECRTS 2011.

[FP17] Barros, A., Pinho, L., "Software transactional memory as a building block for parallel embedded real-time systems", 37th SEAA 2011.

[FP18] Barros, A., Pinho, L., "Revisiting Transactions in Ada", 15th IRTAW 2011.

[FP19] Ferreira, L., Silva, G., Pinho, L., "Service offloading in Adaptive Real-Time Systems", 6th IEEE SOCNE2011.

[FP20] Ali, H., Pinho, L., "A Parallel Programming Model for Ada", ACM SIGAda 2011.

[FP21] Raravi, G., Andersson, B., Bletsas, K., "Provably Good Scheduling of Sporadic Tasks with Resource Sharing on a Two-type Heterogeneous Multiprocessor Platform (Corrected version)", 15th OPODIS 2011.

[FP22] Maia, C., Nogueira, L., Pinho, L., "Combining RTSJ with Fork/Join: A Priority-based Model", Published in Proceedings of the 9th JTRES 2011.

[FP23] Marinho, J., Petters, S., "Job Phasing Aware Preemption Deferral", 9th IEEE/IFIP EUC 2011.

[FP24] Nikolic, B., Awan, M., Petters, S., "SPARTS: Simulator for Power Aware and Real-Time Systems", 8th IEEE ICESS 2011.

[FP25] Dasari, D., Andersson, B., Nelis, V., Petters, S., Easwaran, A., Lee, J., "Response Time Analysis of COTS-Based Multicores Considering The Contention On The Shared Memory Bus", 8th IEEE ICESS 2011.

[FP26] Ferreira, L., Nogueira, L., "On the Use of Code Mobility Mechanisms in Real-Time Systems", 10th RTN 2011 (also published at ACM SIGBED Review, December 2011).

Short Papers (Demos, Posters & WiP)

[SP1] Tennina, S., Gomes, R., Alves, M., Bouroche, M., Mirza, F., Carrozza, G., Santos, M., Ciriello, V., Braga, P., Oliveira, P., Cahill, V., "Poster: EMMON - A WSN System Architecture and Toolset for Large-Scale and Dense Real-Time Embedded Monitoring", 9th ACM SenSys 2011.

[SP2] Tennina, S., Bouroche, M., Braga, P., Gomes, R., Alves, M., Mirza, F., Ciriello, V., Carrozza, G., Santos, M., Garg, A., Cahill, V., "Poster: EMMON: A System Architecture for Large-Scale, Dense and Real-Time WSNs", 8th EWSN 2011.

[SP3] Tennina, S., Renzo, M., Pomante, L., Alesii, R., Santucci, F., Graziosi, F., "Demo: Automatic Personal Identification System for Security in Critical Services - A Case Study", 9th ACM SenSys 2011.

[SP4] Fotouhi, H., Alves, M., Koubaa, A., Zuniga, M., "Poster: Smart-HOP: A Reliable Handoff Procedure for Supporting Mobility in Wireless Sensor Networks", 8th EWSN 2011.

[SP5] Raravi, G., Andersson, B., Bletsas, K., "A conjecture about provably good task assignment on heterogeneous multiprocessor platforms but with a stronger adversary", WiP 23rd ECRTS 2011.

[SP6] Raravi, G., Andersson, B., Bletsas, K., "Two-type Heterogeneous Multiprocessor Scheduling: Is there a Phase Transition?" 2nd RTSOPS 2011.

[SP7] Marinho, J., Raravi, G., Nelis, V., Petters, S., "Partitioned Scheduling of Multimode Systems on Multiprocessor Platforms: when to do the Mode Transition?", 2nd RTSOPS 2011.

[SP8] Awan, M., Nikolic, B., Petters, S., "Comparing the Schedulers and Power Saving Strategies with SPARTS", RTSS@Work, Demo at 32nd IEEE RTSS 2011.

[SP9] Nelis, V., Dasari, D., Nikolic, B., Petters, S., "A Tighter Analysis of the Worst-Case End-to-End Communication Delay in Massive Multicores", WiP 32nd IEEE RTSS 2011.

[FP10] Awan, M., Petters, S., "The Roman Conquered by Delay: Reducing the Number of Preemptions using Sleep States", WiP 17th IEEE RTAS 2011.

[SP11] Maia, C., Silva, G., Ferreira, L., Pinho, L., Nogueira, L., Gonçalves, J., "A Framework for Offloading Real-Time Applications in a Distributed Environment", Demo at 32nd IEEE RTSS 2011.

[SP12] Dasari, D., Nelis, V., Andersson, B., "WCET Analysis Considering Contention on Memory Bus in COTS-Based Multicores", WiP 6th IEEE ETFA 2011

Patents/Prototypes

The patent “Using a Prioritized Medium Access Control for Incrementally Obtaining an Interpolation of Sensor Readings”. was submitted to the US patent office in May 6, 2010. The inventors where CISTER researchers Björn Andersson, Nuno Pereira, Eduardo Tovar and Ricardo Gomes. The invention was related to communication and processing techniques for efficient data processing in wireless sensor networks.

CISTER is leading worldwide research on IEEE 802.15.4 and ZigBee technologies, the most widespread technologies for Wireless Sensor Networks (WSNs). Within this line, CISTER has been developing cutting edge tools that have been widely used by the international community (http://www.open-zb.net) and have been involved in the TinyOS 15.4 and ZigBee Working Groups (http://www.tinyos.net) since their foundation (early 2009). In 2011, "official" implementations of the standard 15.4 and ZigBee cluster-tree protocols have been made available in the TinyOS repository. This work has been mainly performed within the COTS4QoS research cluster (http://www.cooperating-objects.eu/research-clusters/cots4qos/), under the CONET NoE.

In 2011, CISTER continued its collaboration within the RadiaLE framework – a benchmarking toolset for the performance evaluation and design of radio link quality estimators [J3, T1], available as an open-source (http://www.open-LQE.net), as well as within the Z-Monitor framework – monitoring and analysis tool for IEEE 802.15.4-based Wireless Sensor Networks, available at http://www.z-monitor.org.

In 2010, CISTER played a key role on putting together the first integrated system prototype (coined "DEMMON1"), a monitoring application encompassing all system components, ranging from hardware, communication architecture, middleware and command and control GUI. During 2011, the consortium has been developing DEMMON2 (the second EMMON demonstrator), for validating EMMON WSN technologies in a real-world environment (http://www.sanjotec.com/), allowing a fine-grained real-time monitoring of a building with over 400 wireless sensor nodes. More info at http://www.artemis-emmon.eu.

Future Research

Objectives

The research group is one of the leading European research groups in the area, contributing with seminal research works. We will continue to pursue research excellence in the coming years, by structuring our strategic research plans around our five research areas:

Highly Scalable Aggregate Computations in Cyber-Physical Systems (CPS)

One of our main continuing efforts is tackling the problem of scalable and efficient information processing in large-scale and dense systems. As discussed in the group objectives we will continue work on (PD)2 and advocate its use in industry. One initiative that we have been driving together with Portuguese Critical Materials and Brazilian Aircraft manufacturer Embraer aims at exploiting these results (the SmartSkin project). It relates to the environmental concerns in the industry by developing technologies to allow sustained air travel growth while minimizing carbon footprint. Local modulation of aircraft surfaces is a form of active flow control, which will be explored in term of its potential to offer significant reduction of fuel consumption and emissions. Implementing such a flow control system requires thousands of sensor/controller/actuator systems to be embedded across the aircraft wings and fuselage to create an active aircraft. New challenges will come from the recently started projects SENODs and ENCOURAGE.

Multicore Systems

During 2011, researchers in the multicore area of CISTER will continue the successful ongoing research. We expect to create even better algorithms for assigning tasks on heterogeneous multiprocessors and we expect to allow resource sharing with provably good performance (resource sharing with provably good performance has already been achieved for identical multiprocessors but not for a heterogeneous multiprocessor).

Researchers will also explore practical aspects (i) implementation of scheduling algorithms in real operating systems and (ii) analysis of shared low-level hardware resources.

Adaptive Real-Time Systems

We will develop a novel technique, which allows temporal isolation in multicore systems by developing metrics to estimate memory-bus and cache contention. Furthermore, we will explore power and thermal management in densely packed multicore systems.

We will continue the successful work in hierarchical systems scheduling, tackling hierarchical slack time management, as well as the development of component interfaces exploiting results obtained for flat uniprocessors and furthermore drive it into a multicore context, exploiting current research on cache and bus contention mentioned before.

Further efforts will explore mode changes in multicore systems, to ensure system stability in the face of environmental changes.

The efforts described are supported by a number of project proposals under evaluation (FCT SMARTS and MoMu), in negotiation (ARTEMIS SYMBEOSE), starting (FCT RePoMuC and ViPCore) and active (ARTEMIS RECOMP). Additionally, all of the above work aims to be implemented on commercial grade operating systems.

Real-Time Software

In this area work will continue in the current efforts of the cooperative embedded system middleware and the use of software verification tools with concurrent embedded programming models. The cooperative embedded platform will also be explored for mobile middleware, targeting commercial operating systems such as Android or Symbian.

We will continue the work on the autonomic behaviour of interdependent nodes in dynamic distributed environments with QoS constraints, partly supported by the ARES project proposal, with issues such as the non-linear nature of nodes' interactions and mechanisms to control their autonomic adaptation.

We will also continue to work on the specification of advanced concurrency models and mechanism within languages and operating systems, to support the raised abstraction level required by the more complex modern systems. In particular work will be developed in software transactional memory and parallel support of real-time tasks at the operating system and virtual machines levels.

Continuing the active participation in the standardization activities of the Ada language, we will foster the introduction of native support in the Ada language for multicore and multiprocessor architectures.

Wireless Sensor Networks (WSNs)

We will continue our strategy for excellence in collaborative R&D sustained by analytical, simulation and experimental models, as well as validating and consolidating of our findings through real-world applications.

Continuing our work in the area of QoS in WSNs, we will focus on real-time/timeliness, reliability/robustness, mobility support and energy-efficiency aspects within the scope of both national (e.g. REWIN, MASQOTS) and international (e.g. EMMON, CONET) projects. This will be based both on off-the-shelf technologies, as well as on novel solutions designed from scratch (e.g. hexagonal WSNs or BANMAC).

We will continue to contribute to the TinyOS 15.4 and ZigBee WGs, aiming developing platform-independent, standard-compliant, IEEE 802.15.4 Medium Access Control and ZigBee Network Layer protocols. We are also looking into emerging technologies and standards such as the IETF 6loWPAN for pervasive Internet and IEEE 802.15.6 for body sensor network applications.

We will consolidate the EMMON WSN architecture for large-scale and dense real-time monitoring with several QoS add-ons such as in what concerns reliability and data aggregation, as well as completing the supporting set of tools for system planning, worst-case dimensioning and simulation. The EMMON project will be complemented by the design of real-time and reliable mobility support in WSNs, through hand-off heuristics, radio diversity, interference modelling and link quality estimation.

Within the context of the ARTEMIS ENCOURAGE project (about to start), we will design a WSN architecture to enable more energy-efficient buildings.