CONET Newsletter

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Editorial

Welcome to the 8th issue of the CONET newsletter. CONET is the EU FP7 network of excellence on Cooperating Objects, merging the fields of embedded systems for robotics and control, pervasive computing and wireless sensor networks. CONET focuses on establishing the field of Cooperating Objects within the research and industrial community, thus strengthening the position of Europe in the research landscape.

This issue shows "Objects cooperating on land, sea and air" from the Underwater Systems and Technology Laboratory at Porto University, which is a CONET Associated Partner. With the member profile of UDE, the coordinator of CONET is presented. The guest column talks about the EcoSense project at the University of Castilla-La Mancha. A short report from the CONET 2010 Workshop is included as well.

If you are interested in obtaining up-to-date information about the CONET project please visit our website at: http://www.cooperating-objects.eu

We hope you will enjoy this issue. ■

Objects cooperating on land, sea and air

By LSTS – Underwater Systems and Technology Laboratory, Porto University, Portugal

Background

The Underwater Systems and Technologies Laboratory (LSTS) from Porto University has been designing, building and operating unmanned underwater, surface and air vehicle systems for innovative applications with strong societal impact since it was established in 1997. Currently the LSTS team has over 30 researchers, including faculty and students, with Electrical and Computer Engineering, Mechanical Engineering and Computer Science backgrounds. In 2006 the LSTS received the national BES Innovation National Award for the design of the *Light* Autonomous Underwater Vehicle (AUV).

In the last 15 years we have successfully fielded unmanned air, ground, surface and underwater vehicles in innovative operations in Europe and in the United States of America. These include some world firsts, such as the underwater rendezvous between the *Aries* and *Isurus* AUVs, respectively from the Naval Postgraduate School and Porto University, which took place in 2006 in Monterey, California, under a cooperation project between the two institutions.

Currently, LSTS is leading several national and EU projects concerning the development of unmanned vehicle systems. The LSTS is tasked, under the *Seacon* project funded by the Portuguese Ministry of Defence, to deliver three units of an advanced version of the award-winning *Light* AUV to the Portuguese Navy. The LSTS is leading, in cooperation with the Portuguese Air Force Academy, the *Pitvant* unmanned air vehicles program funded by the Portuguese Ministry of Defense. The LSTS is cooperating with the Portuguese Task Group for the Extension of the Continental Shelf in the operation of the Deep Sea Remotely Operated Vehicle Luso. The LSTS is developing tools and technologies for ocean observation under the *Raia* project funded by the EU Programa de Cooperação Transfronteiriça Espanha-Portugal. Under the Control for Coordination project, funded by the EU FP7, the LSTS is developing coordination & control strategies to be demonstrated with ocean-going vehicles in 2011.

Currently, the LSTS fleet includes two remotely operated submarines (rated for 200m and equipped with video cameras and side-scan sonar), two autonomous underwater vehicles (1.8m long, equipped with side-scan sonar, acoustic modem and ADCP), six *Light* autonomous underwater vehicles (1.5m long, which can be configured with CTD sensor, side-scan sonar and acoustic modem), one autonomous surface vehicle (can be used as a communications gateway for wireless and underwater communications), six autonomous air vehicles (wingspans ranging from 1.8m to 3.6m), gateway buoys (supporting wireless and underwater communications) and sixty *Telos* Motes with several sensor configurations.

Figure 1: LSTS unmanned vehicles

Research challenges

The LSTS is currently developing a scientific framework for the systematic design and deployment of cooperating networked vehicle and sensor systems in new applications with strong societal and scientific impact such as oceanographic or environmental surveys with high temporal and spatial resolution. These include persistent 24/7 operations. 24/7 system's level properties arise from the coordination and control of resources, which are not continuously available due to operational constraints (e.g. fuel limitations).

The idea of a system of systems captures the essential aspects of operation of these vehicle systems. In a system of systems, a significant part of the “system” is embodied not as physical devices, such as vehicles, sensors or communication networks, but as software applications which may be mobile. Moreover, mixed initiative interactions, where operators intervene in the planning and control loops, play a central role in operations thus making human factors an important consideration in the design of the system.

These challenges entail a shift in the focus of existing methodologies: from prescribing and commanding the behavior of isolated systems to prescribing and commanding the behavior of networked systems.

Approach

The LSTS has a three-fold approach to these challenges: 1) low cost modular vehicles; 2) a planning, command and control framework within which the interactions among heterogeneous vehicles, sensors and operators are standardized and mediated; and 3) a software tool set which implements the framework over inter-operated (possibly intermittent) communication networks.

This is an inter-disciplinary effort that builds on advances in (1) dynamic networks of hybrid automata; (2) hierarchical architecture design for semi-automated, distributed teams of agents; (3) incorporating human intervention in mission planning and execution; and (4) models of systems with evolving structure.

Planning and execution control

The LSTS has a layered approach to planning and execution control. We use the concept of manoeuvre – a prototype of an action/motion description for a vehicle – as the atomic component of all execution concepts. A mission plan is a graph of manoeuvres with guard conditions for transitions between manoeuvres. The concepts of plan and manoeuvre play a unifying role in our control architecture, starting with the process of mission specification, when the mission plan is written by a mission specialist, to execution, where vehicles have manoeuvre controllers to execute them.

Tools and technologies

We developed a *toolchain* composed of the following tools for the implementation of our planning, command and control framework.

Neptus is a distributed command, control, communications and intelligence framework for operations with networked vehicles, systems, and human operators. *Neptus* supports all the phases of a mission life cycle: world representation; planning; simulation; execution and post-mission analysis. *Neptus* supports concurrent operations: vehicles, operators, and operator consoles come and go; operators are able to plan and supervise missions concurrently.

IMC is a communications protocol that defines a common control message set understood by all types of LSTS nodes (vehicles, consoles or sensors) in networked environments. This provides for standard coupling of heterogeneous components in terms of data interchange.

DUNE is the system for vehicle on-board software. It is used to write generic embedded software at the heart of the vehicle, e.g. code for control, navigation, or to access sensors and actuators. It provides an operating-system and architecture independent C++ programming environment for writing efficient real-time reactive tasks in modular fashion.

DFO (Data Flow Objects) is a coordination language for the specification of supervision control software, deployed on top of DUNE. It is used for supervision of mission execution, vehicle state, and embedding manoeuvre controllers. In conjunction with the *toolchain*, it is being extended to accommodate for more expressive notions of autonomous vehicle execution that provide support for: cooperative vehicle missions, dynamic exchange of control links between network entities, or on-the-fly mission re-programming.

Seaware is an interface for publish-subscribe messaging, deployed on top of the Real-Time Innovations DDS tool. It supports dynamic coupling of network nodes and configurable network QOS.

Operations

The fleet of the LSTS has seen action at least twice a month since 2007. We have been operating aquatic vehicles in the Atlantic and Pacific oceans and also in Portuguese and American rivers. Figure 2 depicts a representation of the setup for a demonstration which took place in 2008 at the Porto harbor in Portugal. In this demonstration we operated several autonomous underwater and surface vehicles under the control of our software *toolchain* operating over inter-operated communication networks.

Figure 2: Deployment with aquatic vehicles[1]

Figure 3 presents photographs of operations with unmanned air vehicles which took place at the Ota Air Base from the Portuguese Air Force. These were part of experiments carried out under the *Pitvant* project, a major collaborative effort between the Portuguese Air Force Academy and Porto University. In 2009 we accumulated over 100 autonomous flights with 6 different UAV platforms. In 2010 we have already performed night operations at the Sintra Air Force base. In 2010 new operations are already planned with additional developments to be tested and certified. These missions include control hand-over between operators, target tracking and vision based control. Again, we have been using, and developing, our software *toolchain* for command and control with mixed initiative interactions.

Figure 3: Air operations

Future developments

We are planning demonstrations of cooperating air and ocean going vehicle systems which will take place in July in Portugal in collaboration with the Portuguese Navy and Air Force.

Cooperation with other CONET members is key to develop a system of systems of cooperating objects. Come experiment with us! ■

ⓘ http://whale.fe.up.pt/lsts/

Member Profile: UDE

The University of Duisburg-Essen (UDE) is located in the European region with the highest density of institutions of higher learning. Created in 2003 by the merger of the universities of Duisburg and Essen, the UDE is the youngest university in North Rhine-Westphalia and one of the ten largest universities in Germany. Currently, around 31,000 students from 130 countries are enrolled at the UDE.

In research the University of Duisburg-Essen occupies a respectable high-ranking position among the forty German universities known for their re-

[1] Superimposed on a map of the Porto Harbor from Google Maps.

search – as measured by the amount of financial support granted by the German Research Foundation (DFG).

Networked Embedded Systems Group

The "Networked Embedded Systems" (NES) group was founded in 2009 with the change in position of Pedro Marrón, the head of the group, from the University of Bonn to the University of Duisburg-Essen. Scientists at NES have worked on research and development projects for government agencies, associations and industry during their work at the University of Bonn and Fraunhofer IAIS.

Examples of European projects, where current members of NES have worked on, are the Embedded WiSeNts coordination action and the research projects AWARE and EMMA. The goal of the Embedded WiSeNts coordination action was to formulate a common vision as well as a roadmap towards wireless sensor networks and cooperating embedded systems. In AWARE, the capabilities of UAVs, robots, cameras and sensor networks were combined to fight the spread of fire in indoor scenarios (see Figure 4). The members of NES were responsible for the design and implementation of a publish/subscribe middleware that allows for the seamless communication of entities in the system. The goal of the EMMA project was the development of a novel communication middleware for wireless cooperating objects in automotive applications.

Figure 4: AWARE experiment

Moreover, NES has participated in a bilateral project with Siemens AG for the development of robust self-management concepts for the operational maintenance in wireless sensor network deployments.

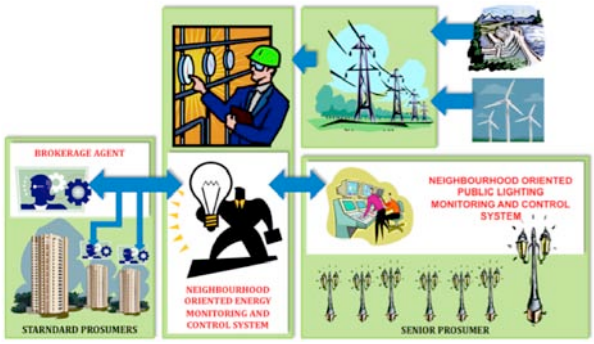

Figure 5: NOBEL project overview

Currently, NES is participating as a founding member in the projects PECES, NOBEL and PLANET, all of them funded by the EC. In the PECES project, techniques for the secure communication and interaction of smart spaces in local and remote environments are developed. The NOBEL project will build an energy brokerage system with which individual energy consumers can communicate their energy needs directly with both large-scale and small-scale energy producers, thereby making energy use more efficient (see Figure 5). The brokerage system will use a middleware developed by UDE to communicate relevant data and IPv6 technology to interconnect the middleware with sensors and energy meters on individual devices.

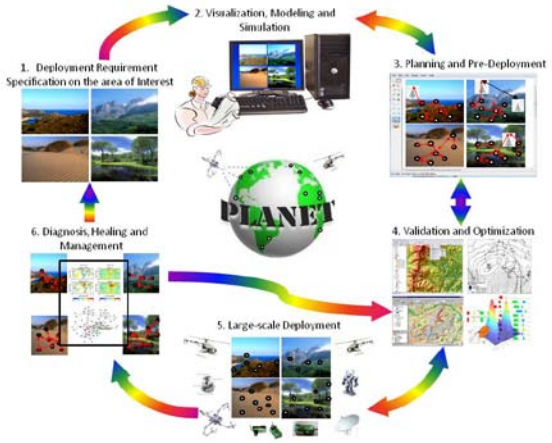

Figure 6: PLANET project overview

The PLANET project (see Figure 6) aims to provide an integrated planning and maintenance platform that enables the deployment, operation and maintenance of heterogeneous networked COs in an efficient way. The main objective of the project particularly emphasizes the capability of the platform to support deployment and operation

strategies for large-scale systems composed of unmanned ground and aerial vehicles cooperating with wireless sensors and actuators.

Apart from these European projects, the NES group is also participating in the WebDA project funded by the German Federal Ministry for Education and Research. Its goal is to enable elderly people suffering from dementia to stay at home independently for a longer period of time. The primary task of NES is the development of new and the optimization of existing localization algorithms. Finally, NES is working on middleware systems that enable the efficient utilization of sensor networks in Ubiquitous Computing applications with a specific focus on home and office automation. ■

ⓘ http://www.nes.uni-due.de/

The EcoSense Project: an intelligent wireless sensor and actuator network for indoor energy management systems

By Teresa Olivares and Luis Orozco-Barbosa, University of Castilla-La Mancha

Energy efficiency has been identified as a priority area by the European Commission. The main of the EcoSense project is to develop a methodology for the design and deployment of monitoring and control environmental indoor systems built around wireless sensor and actuator networks. During the first phase of the project, the research efforts are being focused on the monitoring capabilities of a collaborative set of environmental monitoring devices. The results of this first phase should set the basis towards the understanding of the capabilities and main issues to be addressed for the effective deployment and operation of a set of sensors and actuators in indoor infrastructures. In a second phase, the system will be equipped with intelligent actuators enabling the optimal configuration and operation of energy consumption control systems. These actuators will be agents with capabilities including goal management and task execution. These agents will be able to communicate and negotiate services to achieve the required functionality.

On the design of energy saving systems, there are several factors that have to be considered and studied carefully: temperature outdoors and indoors, luminosity, electrical consumption and presence detectors (passive infrared detectors, door and window opening sensors). The main variable in energy control is room temperature, since a comfortable working environment, and the energy consumed by the air conditioning in cooling the room, or by the heaters, depends to a great extent on this factor. The correct monitoring of the room temperature as perceived by the workers requires a wise layout of the monitoring devices. It is well known that measuring the temperature at one point within a room may not provide a representative view of the environmental conditions. However, the simple replication of multiple monitoring temperature sensors may neither overcome this issue. Furthermore, the monitoring of the outdoor environmental conditions may also play a major role on the optimization of an energy-aware monitoring and control system. Who has not suffered of being in a room at hot temperature while the outdoor temperature may be comfortable enough? These situations may be simply corrected by opening the windows instead of turning the air conditioning.

The EcoSense project is a joint initiative of the i3A, the Albacete Research Institute of Informatics and AGECAM, the regional Energy Agency of Castilla- La Mancha funded by the Council of Science and Innovation of Castilla La Mancha. ■

CONET 2010 Workshop Report

By Pedro José Marrón, UDE

The First International Workshop on Networks of Cooperating Objects took place on April 12th, 2010 in Stockholm, Sweden, co-located with CPSWeek 2010. More than 40 people participated actively in the workshop and discussed important problems in the area of Cooperating Objects.

The workshop started with a keynote on “Human-centric Sensing” given by Prof. Tarek F. Abdelzaher from the University of Illinois at Urbana Champaign. Thereafter, 5 full papers and 6 short papers were presented in three technical sessions on “Architectural issues” and “Systems and Applications” in Wireless Sensor Networks and “Control and Mobile Cooperating Objects”.

Overall, the workshop has been a great success, given its resonance in the community, and will find its continuation next year. ■

Announcements

COST2100 / CONET / NEWCOM++ Training School and Workshop on "Cooperating Objects and Wireless Sensor Networks"

May 10 – 13, 2010, Bologna, Italy

ⓘ **http://www.cost2100.org/index.php?page=2010-3**

Important dates:
Registration Deadline: May 2nd, 2010

International Workshop on Data Management for Sensor Networks (DMSN'10)

in conjunction with VLDB 2010

September 13th, 2010, Singapore

ⓘ **http://www.cs.ucy.ac.cy/~dmsn10/**

Important dates:
Abstract Submission Deadline: May 3rd, 2010
Acceptance Notification: July 26th, 2010
Final Paper Submission Deadline: Aug 9th, 2010

Real-Time Systems Symposium (RTSS 2010)

November 30 - December 3, 2010, San Diego, CA, USA

ⓘ **http://www.rtss.org/**

Important dates:
Paper Submission Deadline: May 16th, 2010
Acceptance Notification: Aug 8th, 2010
Final Paper Submission Deadline: Sep 12th, 2010

CONET Summer School 2010: "Act-Control-Move: Beyond Networked Sensors"

August 15 – 21, 2010, Schloss Dagstuhl, Germany

ⓘ **http://www.cooperating-objects.eu/school/2010/**

Important dates:
Application Deadline: May 31st, 2010
Admittance Notification: June 15th, 2010

Internet of Things 2010 Conference (IoT 2010)

November 29 - December 1, 2010, Tokyo, Japan

ⓘ **http://www.iot2010.org/**

Important dates:
Paper Submission Deadline: Jun 1st, 2010
Acceptance Notification: Jul 1st, 2010
Final Paper Submission Deadline: Aug 1st, 2010

Workshop on Real-World Wireless Sensor Networks (REALWSN'10)

December 16 – 17, 2010, Colombo, Sri Lanka

ⓘ **http://www.ucsc.cmb.ac.lk/realwsn10/**

Important dates:
Paper Submission Deadline: mid-July, 2010
Acceptance Notification: Sep, 2010
Final Paper Submission Deadline: Oct, 2010

Latest News

EWSN 2011 will take place on February 15-17, 2011 in Bonn, Germany. General chair will be the coordinator of CONET, Pedro José Marrón. We are looking forward to your paper submission until October 1st, 2010. Details will follow in future newsletters.