CONET Newsletter

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Editorial

Welcome to the tenth 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 presents a guest column from Bence Pásztor, University of Cambridge, Andrew Markham and Stephen Ellwood, University of Oxford, about WildSensing – an interdisciplinary project and hybrid framework of mobile and sensor nodes for wildlife monitoring. The issue's "member profile" presents the Interdepartmental Research Center "E. Piaggio" of the University of Pisa together with an overview of several European research projects related to CONET in which they are involved. An interesting article describing IPAC – an Integrating Platform for Autonomic Computing is presented by Panayiotis Andreou, Networks Research Laboratory, University of Cyprus.

We also take the opportunity to announce 8th European Conference on Wireless Sensor Networks (EWSN 2011) and in particular the Master and PhD Thesis Award Competitions in the area of Cooperating Objects.

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 ■

WildSensing[1]

By Bence Pásztor, University of Cambridge, Networks and Operating Systems Group; Andrew Markham, University of Oxford, Computing Laboratory; Stephen Ellwood, University of Oxford, Department of Zoology

WildSensing is an interdisciplinary research project undertaken by the Computer Laboratory at the University of Cambridge, and the University of Oxford's Computing Laboratory and Wildlife Conservation Research Unit (Dept. Zoology), to monitor wild Eurasian badgers (Meles meles) in their natural habitat in the UK. Badgers (Figure 1) are nocturnal mammals that, in the UK, tend to live in communal burrow systems (called 'setts'), predominantly in woodland.

Figure 1: Eurasian badger

Current approaches to tracking badgers and other animals often use the manual location of animals wearing analogue VHF beaconing collars – a highly labour intensive and therefore expensive method. This system also risks disturbance as researchers follow animals at relatively close quarters. GPS tracking collars typically perform poorly under heavy tree cover, which precludes their use in this application. The WildSensing approach to animal tracking was to leverage the power of sensor network technology to provide continuous and long term monitoring of badger movements and potentially their sociobiology.

[1] Further involved in the project: Cecilia Mascolo (Univ. of Cambridge, Networks and Operating Systems Group), Salvatore Scellato (Univ. of Cambridge, Computer Lab), Niki Trigoni, Ricklef Wohlers (Univ. of Oxford, Computing Lab), David Macdonald (Univ. of Oxford, Dept. of Zoology), Vladimir Dyo (University of Bedfordshire, Dept of Computer Science)

Over 70 animals were equipped with tracking collars (Figure 2), which periodically emit radio beacons.

Figure 2: RFID tag on a collar

In order to rapidly deploy the devices, existing active RFID devices (Wavetrend Ltd) were used. RFID transmissions were detected by a network of 26 detection nodes (Figure 3) placed at strategic locations, such as at setts and latrines. Presence/absence data were therefore continually collected. In a one-year operational period, over 26 million transmissions were recorded and logged. Such a large quantity of badger location data has never been collected before.

Figure 3: Initial detection node

The deployment experience led to the development of algorithms to deliver data using a hierarchical delay tolerant approach where information was transferred to different locations depending on its priority. For example, high priority information (such as network health) was sent immediately to the 3-G backhaul link, whereas low priority information was stored at intermediate nodes for pickup by zoologists carrying mobile devices. During the deployment, it was found that the energy consumed by the RFID readers was prohibitively high, leading to a very short operational lifetime (one week). A static schedule could not be used, as badgers exhibit seasonal variation in behavior, due to changing night length. An adaptive learning approach was devised to turn the RFID readers on at times when badgers were more likely to be in the vicinity (e.g. at night). One of the contributions of this project was an investigation into the interplay between hardware and software advances and what effect and impact they had on the system as a whole. This was especially true as modifications and improvements had to be phased in so as to allow for continual operation, whilst maintaining backwards compatibility.

Although, the software enhancements described above reduced the energy consumption of the system, the hardware became the limiting factor. The first version of the detection node was built using off-the-shelf parts enabling rapid deployment; however it had a short radio range of about 50-100m and only 1 MB of on-board storage. Using our experiences from the first version of the node, a new board design was optimized for our application. The new 'V2' board (Figure 4) had a radio range of up to 2 km, a reduced power consumption and an on-board micro-SD card to provide an "unlimited" amount of storage. The new board reduced the necessary maintenance visits to the forest from once a week to less than once a month, while staying compatible with the initial system.

Figure 4: V2 detection node

The initial data have revealed some interesting badger behaviors which had previously only been speculative due to the difficulties of observation, such as frequent badger movements between social groups. Social network analysis tools have also been used to elucidate social groupings and potential relationships.

Another avenue of research that has been recently explored is localizing badgers when they are underground. Radio signals are unable to penetrate soil, and thus conventional tracking modalities cannot be used. Instead, a novel method using low frequency magnetic fields was developed. As a byproduct of localizing animals over time, the tunnel structure itself can be revealed. This new research area is likely to lead to some interesting discoveries about badger social structure underground, something which has been impossible to do until now.

Figure 5: WildSensing in action

As a measure of the success of the WildSensing project, two papers have been accepted for the highly rated ACM SenSys 2010 conference. This is impressive, considering that only 25 papers in total were accepted from over 145 submissions.

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http://www.cl.cam.ac.uk/research/srg/netos/wildsensing

References

Evolution and Sustainability of a Wildlife Monitoring Sensor Network, Vladimir Dyo, Stephen A. Ellwood, David W. Macdonald, Andrew Markham, Cecilia Mascolo, Bence Pásztor, Salvatore Scellato, Niki Trigoni, Ricklef Wohlers, Kharsim Yousef. In 8th ACM Conference on Embedded Networked Sensor Systems (SenSys 2010), Zurich, Switzerland, 2010.

Revealing the hidden lives of underground animals using magneto-inductive tracking, Andrew Markham, Niki Trigoni, Stephen A. Ellwood and David W. Macdonald, In 8th ACM Conference on Embedded Networked Sensor Systems (SenSys 2010), Zurich, Switzerland, 2010. ■

Member Profile: UNIPI

ⓘ http://www.piaggio.ing.unipi.it

The University of Pisa was founded in 1343. It is one of the oldest Universities in Europe. It has around 56000 students in 83 Fist level undergraduate (corsi di laurea) and 86 masters.

The Interdepartmental Research Center "E. Piaggio" of the University of Pisa is characterized by a multidisciplinary research in Automation, Bioengineering, and Robotics. Staff and students are mechanical, chemical, and computer engineers, mathematicians, physicists, chemists and biologists. The Center contributes in training PhD students and Post-Doctoral fellows.

One of the research topics of "E. Piaggio" robotics group is the management and control of large systems of autonomous agents. Indeed, large systems of many autonomous but networked units, capable of acting in and on the environment will soon be a reality. Robots will be many, autonomous, possibly fast, and very heterogeneous. One possibility is that robots are organized in teams, flocks or swarms, to more effectively and robustly pursue a goal which is shared by all members (i.e. ``emergent behaviors''). We are interested in the case of robots that do not share the same goals, rather have independent and possibly conflicting purposes, but are supposed to coexist and behave so that the accomplishment of their mission does not jeopardize the chances of others. In other words, we are concerned with the organization of a society of Robots.

Scalability, heterogeneity, reconfigurability, safety are fundamental requirements for a system of behaviors for a society of robots. A very effective way of achieving some of these features is decentralization, i.e. decisions and coordination should be made by each agent autonomously, and should be based on information limited to a local neighborhood of each robot, reducing the role of a central authority to the minimum necessary.

A system that relies on social behaviors to mitigate the excess of individualism is intrinsically very sensitive to the possibility that misbehaviors occur, due either to faults in some robots, or because of malicious programming of agents. Thus, security requirements are crucial for a society of robots, which imply the capability to detect, isolate, and neutralize the threat posed by misbehaving robots. In a society of autonomous robots, intrusion detection also has to rely on information

available locally, and on limited knowledge of a model for the behavior of other robots.

The center is and has been involved in several European research projects related to CONET:

1. Real-Time Embedded Control of Mobile Systems with Distributed Sensing (**RECSYS**), IST-2001-37170, 2002-2005.

In collaboration with: Padova University, KTH, EPFL, INTECS HRT S.p.A.

The goal of the project was the development of new paradigms and methods for control design of embedded systems with distributed sensing and limited communication and computational resources. This included rigorous methods for modeling, analysis, design and verification of control systems with heterogeneous sensors. Although such systems are omnipresent, the project was focused on mobile systems, which provide a particularly challenging benchmark since they operate in an uncertain and changing environment. The proposed methodologies dealt with the control design under various constraints, such as signal quantization, bandwidth limitation, distributed sensing and computation, and real-time scheduling.

2. Reconfigurable Ubiquitous Networked Embedded Systems (**RUNES**), IST-004536, 2004-2008.

In collaboration with: Ericsson, Kodak, ConnectBlue, UCL, KTH, University of Berkely.

The vision of the RUNES project was to enable the creation of large scale, widely distributed, heterogeneous networked embedded systems that interoperate and adapt to their environments. It was belief of the RUNES partners that the vision of networked embedded systems everywhere could only be realized if the architecture on which they were built was standardized and could self-organize to suit the environment as it happens to be from moment to moment. A final demo, as a tunnel accident with fire emergency, to demonstrate the project results has been carried out successfully.

3. Hybrid Control: Taming Heterogeneity and Complexity of Networked Embedded Systems (**Hycon**),Network of Excellence, 511368, 2004-2008.

In collaboration with: CNRS, INRIA, ETHK, DLR, UCL, KTH.

The objective of the NoE HYCON was to establishing a durable community of leading researchers and practitioners who developed and applied the hybrid systems approach to the design of networked embedded control systems as found, e.g., in industrial production, transportation systems, generation and distribution of energy, communication systems. The interaction of digital controllers, communication systems and physical plants originates complex dynamic behaviors that cannot be understood intuitively.
HYCON aimed at a major advancement of the methodology for the design of such systems and their application in power management, industrial controls, automotive control and communication networks.
The long-lasting result has been a European Embedded Control Institute (EECI).

4. Control of Heterogeneous Automation Systems: Technologies for scalability, reconfigurability and security (**CHAT**), 224428, 2008-2011,

In collaboration with: Siemens, Lund University, Università di Trento, UCL, SELEX, SOFIDEL, Università del Salento, MIT.

CHAT aims at developing the next-generation of distributed control systems, able to effectively tackle the supervision and control of larger and more complex automated industrial plants, while drastically reducing their infrastructure, maintenance and reconfiguration costs. The ambition of the project is to provide a unified approach and a set of specific tools and technologies that will enable this transition in the broad area of industrial automation, while also providing foundations for advanced applications in less structured environments.

5. Underwater Acoustic Network (**UAN**), 225669, 2009-2012.

In collaboration with: INTAL (Portugal), SINTEF-ICT (Norway), ISME (Italy), KongsBerg Maritime (Norway), Selex (Italy), FOI - Swedish Defense Research Agency (Sweden)

The project aims at conceiving, developing and testing at sea an innovative and operational concept for integrating in a unique system submerged, surface and aerial sensors with the objective of protecting critical infrastructures, such as off-shore platforms and energy plants. The security of such economically vital infrastructures requires an integrated approach involving underwater and land/air sensors and actuators for surveillance, monitoring and deterrence. In particular UAN focuses on a security oriented underwater wireless network infrastructure, realized by hydroacoustic communication. The UAN concept is to gather environmental information during the acoustic transmission and use it to predict the acoustic propagation conditions and the optimal obtainable performance at any given time. The UAN project builds on a multidisciplinary consortium of technologically advanced industries, field experienced university labs and governmental

agencies, thus grouping the required knowledge and experience.

6. Highly-complex and networked control systems (**HYCON2**), ICT-2009.3.5, 2010-2014.

In collaboration with: CNRS, INRIA, ETHK, DLR, UCL, KTH.

The main HYCON2 ideas that go beyond the HYCON NoE ones are the following: 1) The analysis and control design of networked systems are essential technologies for improving robustness, safety, performance, predictability and cost of large-scale networked systems (increasingly distributed & immersed in hostile environments). 2) The new discipline merging the disciplines of control, computer, and communication with physical or biological systems is facing new very interesting challenges. A considerable focused research effort by the best complementary teams is needed. 3) Research on networked control systems has major strategic relevance for the European industry and society and is essential to ensuring a leading position for Europe in numerous key industrial sectors and in the biological and medical word. HYCON2 will address engineering technologies for *highly-complex and networked control systems* that is large scale, distributed and cooperating systems for monitoring and control, including wireless sensor networks.

7. PLAtform for the deployment and operation of heterogeneous NETworked cooperating objects (**PLANET**), 257649, 2010-2013.

In collaboration with: UDE CATEC/AICIA, SELEX, DLR, Boeing, University of Edinburgh, CSIC, Flying-Cam, ETRA.

Efficient deployment has been identified as one of the main problems for the acceptance of new technologies based on Cooperating Objects (COs). The goal of PLANET is 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. ■

IPAC: Integrated Platform for Autonomic Computing

By Panayiotis Andreou, Christophoros Panayiotou, George Samaras, University of Cyprus[2]

The lightweight and flexible IPAC middleware provides all services required for the deployment and execution of diverse applications in a collaborative nomadic environment. These services are supported by novel knowledge and ontology engineering techniques, dealing with interoperability, integration, and reconfiguration/adaptation problems encountered in contemporary embedded platforms. Being collaborative, IPAC relies on short-range communications (e.g., ZigBee, DSRC and Bluetooth) for the ad hoc realization of dialogs between nodes. Being context-aware, IPAC relies on advanced sensing components thus, delivering highly innovative application architecture.

Figure 1: IPAC application scenarios

IPAC is based on sophisticated information dissemination algorithms. Specifically, it relies on rumor spreading techniques. Rumor spreading involves the propagation of information within a certain network. Information is ducted only to immediate neighbors that are interested in specific content (rumor). Therefore, IPAC incorporates recent research advances in the area of bio-inspired computing systems.

[2] In collaboration with Siemens A.E. Electrotechnical Projects and Products (GR), National and Kapodistrian University of Athens (GR), Centre Suisse d' Electronique et de Microtechnique SA (CH), Centro Ricerche Fiat S.C.p.A. (IT), Hellenic Ministry of Defence (GR).

Mobile nodes in IPAC are specified and developed to be non-selfish with respect to information dissemination (a mobile incarnation of a peer-to-peer system). Specifically, the IPAC nodes operate in a collaborative fashion in order to diffuse contextual information and broader knowledge in their environment. A node propagates an information message received by another node across the network. In case that such message appears to be usable for the node, it can process it. An information message that is of no interest to an IPAC node has to be forwarded across the network for further processing. The same path is followed for the dissemination of new applications or application components after their development thus contributing to the deployment and use of new embedded applications. IPAC integrates techniques and algorithms for energy-efficient, autonomic node behavior, advanced context awareness, embedded service/application modeling and efficient information dissemination.

Technical Approach

IPAC pursues the development of a middleware platform for embedded devices with specific characteristics. IPAC also aims at the delivery of an application creation and runtime environment for autonomic computing. Autonomic nodes enter in the proximity of other nodes and relay relevant information in the form of “rumor spreading”. Target applications include traffic management, in-building guidance, industrial environment control, as well as crisis management. For instance, vehicles equipped with an IPAC device may forward information to one another regarding the road conditions (e.g., congestion, accidents, etc.) so as to improve circulation, and avoid potential accidents. Another potential application domain of IPAC is road advertising, or advertising in large commercial centers. Individuals in a shopping centre obtain useful and timely information (e.g., where a specific product may be found, discounts, special offers, etc) through the autonomous information exchanging of their IPAC devices.

The platform is supplemented by an application creation environment. Applications may be preinstalled on the node or deployed on demand by the user. Nodes may be considered as sources of information stemming from various sensors mounted on them or from human user input. Such information may be disseminated from one node to another in the network, thus, catering for a distributed, autonomic information propagation platform. In order to have meaningful and controlled information dissemination, the spreading of information is governed by space-time validity rules (directives). For instance, a message concerning congestion at a crossroad would be valid for less than one hour and within a radius of some kilometers.

The IPAC uses the Short Range Communication (SRC) technology for achieving communication between autonomic entities, thus, enhancing bandwidth and reducing latency in the communication link. Contrary to other wireless technologies (e.g., GSM) SRC operates in short distances, thus, enabling the formation of relatively small and isolated communication zones. In addition, IPAC explores the possibility of applying wireless sensor network technologies for implementing short-short-range communications. An indicative example of such a technology is the 802.15.4 protocol (ZigBee) targeting to devices with low battery consumption constraints that need to continuously transmit information.

Key Issues

IPAC develops embedded middleware technology for the realization of innovative context-aware services by autonomous nodes. Supported by ad-hoc network infrastructures, IPAC proceeds to the study of situation and context-aware services deployed by numerous and mostly dynamic network groups and communities. Context-awareness allows autonomic nodes to sense and adapt to their environment, not only at the network level but also at the application plane. This adaptive behavior will be supported by knowledge-based methods and technologies, in a highly innovative manner. Therefore, the key contribution of IPAC is a novel embedded middleware and service provision platform that brings considerable intelligence to the device. None of the existing research projects or products, in the academic or industrial context, has implemented all the self-CHOP characteristics (self-configuration, self-healing, self-optimizing and self-protecting), and additionally offer self-awareness and context-awareness, which are of major importance in many environments. IPAC addresses all the self-CHOP requirements and thus provides a solid, efficient and future-proof platform.

Expected Impact

The expected impact of IPAC spreads beyond the strict limits of the embedded devices sector. The applications developed have a profound impact on multiple human activities. Some example applications are: road safety (through embedded sensor networks both in vehicles and public roads), manufacturing (both through quality control checks and improved feedback to the actual manufacturing robots), energy conservation (through power-efficiency mechanisms for energy consumption), monitoring of core and metropolitan power, tar-

geted applications (advertising) and crisis management (through the creation of ad hoc communication infrastructure).

If you are interested in obtaining up-to-date information about IPAC visit http://ipac.di.uoa.gr/ ■

Announcements

The Embedded Software Group, TU Delft, is looking for a PostDoc in the Bird Tracking project.

ⓘ http://www.st.ewi.tudelft.nl/~koen/postdoc-flyer.pdf

EWSN - 8th European Conference on Wireless Sensor Networks

Feb 23-25, 2011, University of Bonn, Germany

ⓘ http://www.nes.uni-due.de/ewsn2011

EWSN 2011 Important dates

Posters and demos:

ⓘ http://www.nes.uni-due.de/ewsn2011/call-for-poster/

Submission: Dec 17, 2010
Notification: Jan 7, 2011
Camera Ready: Jan 14, 2011

Industrial demos:

ⓘ http://www.nes.uni-due.de/ewsn2011/industrial-demos/

Submission: Dec 17, 2010
Notification: Jan 7, 2011

WISENET Nordic Darkness School 2010

November 8-9, 2010, Uppsala, Sweden

ⓘ http://www.wisenet.uu.se

The objective of WISENET Nordic Darkness School is to offer foundational tutorials accompanied by a selection of exciting new and emerging technologies as well as industrial applications in the areas covered by WISENET, all given by leading scientific and industrial experts of the community. WISENET Nordic Darkness School 2010 is free of charge.

REALWSN 2010 – 4th Workshop on Real-World Wireless Sensor Networks

16-17 December, 2010, **Colombo**, Sri Lanka

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

Registration is now open.

1st European Teletraffic Seminar (ETS)

February 14-16, 2011, Poznań, Poland

ⓘ http://ets2011.et.put.poznan.pl/

Important dates

Extended abstracts due: Nov 15, 2010
Notification of acceptance: Dec12, 2010
Final camera-ready manuscript due: Jan 15, 2011
Tutorial submission: Dec 1, 2010

RTAS 2011 - 17th IEEE Real-Time and Embedded Technology and Applications Symposium

April 11 - 14, 2011, Chicago, IL, USA

ⓘ http://www.rtas.org

Co-located with the International Conference on Information Processing in Sensor Networks (IPSN), the International Conference on Hybrid Systems (HSCC), the International Conference on Cyber-Physical Systems (ICCPS), and the Conference on Languages, Compilers, and Tools for Embedded Systems (LCTES) as part of the Cyber-Physical Systems Week (CPSWEEK) April 11-14, 2011

Future Network & MobileSummit 2011

June 15 – 17, 2011, Warsaw, Poland

ⓘ http://www.futurenetworksummit.eu

Important dates

Online Submission Deadline: December 10, 2010
Provisional Acceptance: February 11, 2011
Submission of Final Paper: March 11, 2011
Presenter Registration: March 31, 2011

Latest News

- **CONET Master and PhD Thesis Awards** The Chairs of the EWSN 2011 and the CONET Consortium are pleased to announce the Master and PhD Thesis Award Competitions in the area of Cooperating Objects.

  Deadline for applications: **Dec 15th, 2010**

  ⓘ http://www.cooperating-objects.eu

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