

## Contents

- Editorial
- Guest Column: The Swiss Experiment
- Member profile: DERI at NUIG
- The Future of Force Protection
- ETTX'09
- Announcements

## Editorial

Welcome to the third 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 Prof. Karl Aberer (EPFL) about the use of large scale wireless sensor networks in environmental monitoring. In the "member profile" section we present DERI, the Digital Enterprise Research Institute at the National University of Ireland, Galway. An interesting article describing how cooperating objects can be used for insurgent detection in the British Forces is presented by our industrial partner SELEX. We also present a summary about the activities discussed on the First European TinyOS Technology Exchange (ETTX '09), an event with a resounding success organized by one of our members, the Technical University of Berlin (TUB).

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 ■

## The Swiss Experiment - Environmental Monitoring 2.0

By Karl Aberer (EPFL), Nicholas Dawes (SLF), Sebastian Michel (EPFL)<sup>1</sup>

**SwissEx is a collaboration of environmental science and technology research projects which will bring together field experiments and a common modern generic cyber-infrastructure on an unprecedented scale. This collaboration will allow common acquisition technologies to be shared and encourage data sharing and preservation of knowledge.**

In the environmental science domain, drawing accurate scientific conclusions, forecasting or validating models requires widespread temporal and spatial environmental monitoring. The overhead in collecting these observations is large and very often duplicated between projects and institutions as scientific projects have in the past been very isolated, data has seldom been reused within departments, opportunities for data sharing within institutions are missed and collaboration across institutions has generally only taken place when the expertise did not exist in-house. E-science is changing this and Swiss Experiment (SwissEx, <http://www.swiss-experiment.ch>) is one such e-science project. The Swiss Experiment collaboration will encourage data sharing and preservation of knowledge across projects and institutions through the use of a common, state-of-the-art database and data processing infrastructure. The addition of a spatially aware interface, combined with advanced querying tools is aimed at making scientists aware of what data exists and encouraging them to re-use data and/or collaborate on data acquisition. Through the re-use of data across projects, SwissEx aims to bridge the traditional scientific domains, broadening scientific knowledge on the interdisciplinary process interactions with the aim of eventually exploiting these links in large scale sensor deployments to improve environmental hazard forecasting and warning.

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The data collected may be more effectively used if it were shared between synergetic projects. Using these synergies also helps us to understand the links between interdisciplinary processes.

The challenge is threefold:

- **Scientific:** The use of a generic system for the collection of data (for a wide range of parameters, space and time scales) and for assistance in data validation and interpretation.
- **Technological:** The deployment of a large number of sensors with differing requirements for data rates, resolutions, embedded intelligence, cost, data acquisition, streaming, storage, security, authorization etc.
- **Knowledge Management:** Recording the collection scenario, methods, locations and times of data acquisition and post-processing alongside the real-time data and allowing scientists to effectively search for their required data.

The Swiss Experiment aims to provide a platform for large sensor network deployment and information retrieval, providing measurements of an unprecedented spatial and temporal resolution and simultaneous deployment of a wide range of sensor types. The aim of these types of deployments is to broaden scientific knowledge on the interdisciplinary process interactions, provide previously unavailable access to data required for extending and validating environmental models, to feed the broader community of environmental hazard prevention and to provide a platform for environmental education and public data access. It is hoped that SwissEx will help to build a new community of collaboration between the public, environmental scientists and administration. This should lead to a new and better way to conduct environmental science and environment-related decision making. To this end, a wide variety of environmental research projects have begun to collaborate through Swiss Experiment.

From the data management perspective within SwissEx we deal with the following tasks: data acquisition and processing, data visualization, and metadata management.

## Data Acquisition Sensor Networks (GSN)

GSN is a Java environment which runs on one or more computers composing the backbone of the acquisition network. A set of wrappers allow live data to be imported into the system. The data streams are processed according to XML specification files. The middleware system is built

upon a concept of sensors (real sensors or virtual sensors - new data sources created by processing or repeating live data in software) that are connected together in order to build the required processing path. For example, one can imagine an anemometer that would send its data into GSN through a wrapper (various wrappers are already available and writing new ones is quick), this data stream could then be sent to an averaging virtual sensor, the output of this virtual sensor could then be split and sent to a database for recording or to a visualization layer for displaying the average measured wind in real time. GSN obtains the data directly from sensor network deployments and provides the capability of replaying previously measured data, for demonstration or exploration purposes. For more information see also <http://gsn.sourceforge.net/>

## Data Visualization – Microsoft Research SensorMap

Once measurements about the physical world have been collected through GSN, it is advantageous to share the data, allowing multiple projects to share the instrumentation costs and deployment and maintenance effort. Sharing of large volumes of scientific data imposes challenges in data exploration techniques to efficiently discover a subset of data containing phenomena of interest to scientists. To tackle the challenges, an extensible infrastructure for data sharing (called SenseWeb) has been designed as well as a map-based front-end (called SensorMap, <http://atom.research.microsoft.com/sensormap/>) to visually explore the shared datasets on geocentric interfaces such as maps and 3D terrain topographies.

Besides the real-time view, a user can explore sensor data streams in historic or spatial views. Via SensorMap, they can select a list of sensors of interest and visualize their temporal distributions in a single comparison chart or in multiple side-by-side time series charts. A third feature of SensorMap is to generate map/image-overlaid contours of selected sensors in view, which can be zoomed or panned together with the underlying map/image. SensorMap is a central resource for SwissEx scientists to get a geo-spatial central data access point, where data from all instances can be accessed and increasingly complex tasks can be carried out on data from an assortment of hardware locations. In addition, metadata is simultaneously displayed to show the user the known status of the data that they are using.

## Metadata Management – The SwissEx Wiki

The SwissEx web portal (<http://www.swiss-experiment.ch>) is based on the media wiki platform and employs several extensions to ease its use. A wiki is a collaborative software platform which allows users to create, enter and modify pages using a simplified markup language in a browser based editor. Wikipedia is a very popular example of a wiki. Due to its flexibility and ease of use, this technology is ideal as a platform to enable and foster collaborative information sharing. In addition to the basic wiki functionality, we make use of semantic annotations which can model any process by meaningfully annotating the entities, connecting them semantically to each other. Transparently to the users, these annotations can be automatically generated based on templates. Doing so, we have set up a sensor metadata store, giving users from the environmental sciences the possibility to enter meta-information about their sensor hardware and deployed stations in field experiments. The sensor directory serves as a fundamental concept for gathering both basic and advanced sensor metadata. It has been successfully connected to SensorMap to enable browsing important meta-information such as data quality information together with the data.

In general, the data management infrastructure described above, aims at assisting throughout the life cycle of environmental monitoring.

## Outlook on Field Experiments in 2009

In addition to the tens of field sites across Switzerland involved in SwissEx, in fall 2009, the first SwissEx multidisciplinary deployment will take place, involving permanent sensors as well as a multitude of temporarily deployed wireless sensor networks, radars, etc.

## Acknowledgement

The main funding sources for the research described in this article come from Microsoft External Research, the National Competence Center in Research on Mobile Information and Communication Systems (NCCR-MICS), a center supported by the Swiss National Science Foundation under grant number 5005-67322, and the Competence Center Environment and Sustainability of the ETH Domain (CCES). ■

## Member Profile: DERI

The Digital Enterprise Research Institute (DERI) is a Centre for Science, Engineering and Technology (CSET) established in 2003 by funding from the Science Foundation Ireland. The first round of CSET funding, under which DERI was established, expired in May 2008. DERI has since been successful in acquiring funding for a further 5 year period to June 2013 following an international peer review in mid 2008. A critical aspect of DERI's SFI-funded activities is the strong alignment between the core research, and the research and development activities carried out by its industry partners. DERI's CSET partners are: Cisco, Nortel, Ericsson, Storm, Cyntelix, OpenLink, Celtrak and Fidelity.

## Enabling Networked Knowledge

DERI's core mission is *"to exploit semantics for people, organisations and systems to collaborate and interoperate on a global scale."*

Systematic and human-centric access to knowledge is critical for solving today's problems. To develop new solutions and enable innovation, it is essential to interlink people, organisations and information in a "network of knowledge". Although knowledge is inherently strongly interconnected, this interconnectedness is not reflected in the current structure of the Web and other information systems: the "information fabric" is not optimal for supporting the development of solutions and innovation. To develop the right tools and methods for enabling networked knowledge on a global scale is an enormous and extremely important challenge. Only by interconnecting this global knowledge and by creating the right collaboration methods can we hope to tackle current and future problems.

Gartner predicts that "By 2015, wirelessly networked sensors in everything we own will form a new Web. But it will only be of value if the 'terabyte torrent' of data it generates can be collected, analyzed and interpreted." Making sensor-generated information usable as a new and key source of knowledge will require its integration into the existing information space of the Web.

DERI's hypothesis is that networked knowledge can assist with individual as well as collective problem solving, enabling innovation and increased productivity and also helping to bridge the gap between the physical and virtual worlds through the inclusion of emerging sensor technologies as an additional source of knowledge about the real world. For example, an application in the healthcare domain is remote

patient monitoring where the integration of sensor measurements into a patient's health records enables their use and interpretation anywhere in the world.

## Semantic Reality

Web and sensor technologies facilitate the building of very large infrastructures which for the first time facilitate the information-driven real-time integration of the physical world and computers on a global scale, i.e, cooperating objects at a technical level but additionally taking the Internet and the user into the loop.

A cornerstone to enabling Semantic Reality is flexible middleware technology which abstracts from heterogeneous sensor network technologies to higher-level functionalities to enable interconnected sensor networks and processing of sensor data (Sensor Internet). The sheer size of this system poses quite novel and unique challenges, as it can only be engineered and deployed if a large degree of self-organisation and automation capabilities are being built into the system and its constituents, enabling simple deployment (plug-and-play), dynamic (re-) configuration, flexible component and information integration, and tailored information delivery based on user context and needs in a service-oriented way. This requires semantic descriptions of the user needs and contexts, and of the system's constituents, the data streams they produce, their functionalities and their requirements to enable a machine-understandable information space of real-world entities and their dynamic communication processes on a scale which is beyond the current size of the Internet. The ultimate goal of Semantic Reality is *"to deliver the right knowledge to the right people at the right time."*

To enable this goal DERI's research efforts focus around the following areas:

- Large-scale and open semantic infrastructures and flexible abstractions to enable the large-scale design, deployment and integration of sensor/actuator networks and their data.
- Query processing, reasoning, and planning based on real-world sensor information.
- Cross-layer integration and optimization specifically focusing on the mutual influences between network and data processing layers (both at intra-network and inter-network level).
- Semantic description and annotation of sensors, sensor data and other data

streams will enable the flexible integration of information and (distributed) discovery of information.

- Vertical integration of business processes ↔ middleware ↔ sensor networks.
- Development support and tools along with experimental platforms and simulation tools.

## Statistics

DERI was established in June 2003 and currently has 119 members. Overall, DERI has published over 200 conference papers and more than 55 journal articles. In terms of funding, DERI has been awarded €27M by SFI (Science Foundation Ireland) through two CSETS. DERI has also been involved in over 20 EU projects past and present, 12 Enterprise Ireland projects, other smaller SFI funded projects and has received direct industry funding. ■

## The Future of Force Protection

By SELEX

**British Forces could soon be using autonomous vehicles which automatically detect insurgents and Improvised Explosive Devices after a competition held by the Ministry of Defence (MoD).**

SELEX Galileo joined industry experts and academics to form Team Stellar to compete in the Grand Challenge in a bid to develop technology to protect troops in an urban environment.

With the grand finale at Copehill Down, an MoD training centre of a mock East German Village, Team Stellar demonstrated a system with a high degree of autonomy that out-performed their competitors, winning the RJ Mitchell Trophy.

Protecting troops in the modern urban warfare environment requires up-to-the-minute intelligence. The aim of the Grand Challenge was to create a system with a high degree of autonomy that can detect, identify, monitor and report a comprehensive range of military threats in an urban environment. This includes technical vehicles (civilian vehicles modified for combat), armed personnel, Improvised Explosive Devices (IEDs), and marksmen.

## A Networked Battlefield

Team Stellar's entry to the Grand Challenge was called SATURN (Sensing & Autonomous Tactical

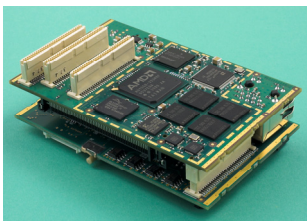
Urban Reconnaissance Network). The system comprises a Medium Level Unmanned Air Vehicle (MLUAV), a Low Level Air Vehicle (LLAV), an Unmanned Ground Vehicle (UGV) and a Ground Control Station (GCS). The aircraft and ground vehicles autonomously reconnoitre a chosen area using intelligent routing, data fusion and threat data processing algorithms hosted on the ground station.

The land and air assets carry different combinations of visual, thermal and radar threat detection sensors in addition to sensor suites for autonomous navigation.

At the heart of this networked system is a module called CISP. The Compact Integrated Sensor Processor (CISP) was developed to easily integrate new and existing sensor products into a secure self forming Ad-hoc communication network. The unit is compact and modular, enabling on-board processing of sensor data as well as advanced networking features.

CISP allows the SATURN system to operate as a network of sensors and vehicles, with data being passed between platforms to the Ground Control Station. A single human operator can then see the prioritised threats that the system has recognised and pass this intelligence onto friendly forces.

The CISP node network is primarily formed though its wireless interface, which is capable of digital communications at high data rates. CISP based networks can pick also up any new sensors that enter the network range and can reroute data if one of the network modules is damaged.



Compact Integrated Sensor Processor

## SATURN Components

The eyes and ears of the SATURN system are the autonomous vehicles. The MLUAV can circle over the operational area and provide situational awareness through its high sensitivity optical and thermal imaging capabilities. This not only allows instantaneous mapping of the terrain, but also identification of threats such as technical vehicles and groups of armed personnel.

The LLAV and UGV both act as threat confirmation vehicles, giving higher confidence as to the nature of potential threats as detected by

the MLUAV. EO or IR sensors can be fitted to the LLAV.

The UGV also has on-board image processing capabilities that allow it to autonomously avoid a wide range of obstacles. Sensors on the UGV include thermal and optical imaging, along with an obstacle avoidance radar system.

The UGV has the ability to detect snipers and IEDs by using its wide range of sensors. Particularly useful is the ability of the UGV to determine if a thermal signature in a window is a civilian, or a person with a weapon, as this reduces the system false alarms.

The GCS interprets all of the image classification and mission planning. A map of the terrain is generated from images from the MLUAV, which may include intelligence such as temporary road-blocks that may have been placed since the last intelligence of the area. The GCS can then automatically create paths for the SATURN vehicles by setting waypoints. Real-time video is fed back from each vehicle and displayed to a human operator including details of potential threats.

## Preparing for the Challenge

The SELEX Galileo Synthetic Environment facilitated hardware in-the-loop concept evaluations prior to full system implementation. This permitted simulated trials in a safe controlled environment at a fraction of the cost and set-up time of real trials.



A Technical vehicle, classified by GCS algorithms

## The Grand Finale

Team Stellar were able to accrue the most points in the set tasks and the integrated mixed-vehicle autonomous system impressed the judges. SATURN was able to give the best situational awareness for the given threat types with no false alarms.

Through Grand Challenge SELEX Galileo has demonstrated its ability to cooperate closely with partners from Small and Medium Sized Enterprises and Academia. Although the MoD

Grand Challenge was a very public display of SELEX Galileo's expertise, it is merely one example of the sort of novel and exciting ideas that SELEX Galileo puts into everything it does. For further information on CISP please contact [graham.bourdon@selexgalileo.com](mailto:graham.bourdon@selexgalileo.com). ■

## The First European TinyOS Technology exchange ETTX'09

by Vlado Handziski, Technische Universität Berlin.

The TinyOS Technology Exchange (TTX) is a yearly venue where developers, users, and companies involved in low-power wireless sensing, get together to talk about recent developments and future directions of the TinyOS platform and the related technologies. The TTX has traditionally been held in the USA. In order to foster a broader European TinyOS community, this year we launched a companion event in Europe with the same format.

The CONET sponsored First European TinyOS Technology Exchange (ETTX 2009) took place in Cork, Ireland, on February 10, 2009, collocated with EWSN 2009. With 70 delegates and a packed technical program it has been a resounding success. The highlights of the event included a provocative keynote by David Culler on migrating TinyOS towards an IPv6-based communication stack using the 6LoWPAN architecture, as well as a tutorial by Phil Levis on the design philosophy and major new features in TinyOS 2.x.

The technical program started with the Working Group Reports Session, a forum where TinyOS developers report back to the wider user community on the current activities and solicit feedback. In addition to the traditional report from the Core WG, this year the session featured two introductory talks by Jan-Hinrich Hauer and Anis Koubâa, about the newly formed 15.4 WG and Zigbee WG. The working groups aim at developing compliant implementations of the IEEE 802.15.4 and Zigbee standards in TinyOS. Both groups are chaired by CONET researchers.

The focus of each TTX is ultimately on the TinyOS user community and the event provided ample opportunity for active participation by the delegates. In the Community Contributions

Session, several users from academia and industry presented their work developed using TinyOS technologies. In one of the talks, Roberta Giannantonio from Telecom Italia introduced the latest version of their SPINE signal processing framework, a core technology used in the CONET Recognition of Emotions with Wireless Sensor Networks (REWSN) research cluster. Finally, in the Demo and Poster Session we had engaging demonstrations both of novel hardware platforms, like the Crossbow eKo node, and software solutions, like the Open-ZB stack from CONET's IPP-HURRAY.

So, if you could not make it to Cork, please consider visiting the event web site at <http://sites.google.com/site/ettx2009> where you can find the:

- Videos from the keynote by David Culler and the tutorial by Phil Levis
- Slides from all the talks in the Working Group Reports and Community Contribution Sessions

We hope to see you all again at the next TinyOS Technology Exchange! ■

## Announcements

**International CONET Summer School** CONET is organizing its First Summer School with the presence of leading researchers in the area of Cooperating Objects.

SENIOT: From Sensor Networks to Networked Intelligent Objects. July 26 - August 1, 2009, BiCi, Bertinoro, Italy

<http://www.cooperating-objects.eu/school>

APPLICATION DEADLINE: May 15, 2009

**Tutorial at IPSN** CONET partner SICS will give a Contiki hands-on tutorial on IP-based sensor networks at IPSN on April 16.

<http://ipns.acm.org/2009/tutorials.htm>

**CONET Roadmap** Prof. Pedro Jose Marron presented an overview of the CONET Roadmap at the Workshop on Wireless Sensor Networks and Cooperating Objects (WASP) held in Darmstadt, Germany. The first CONET roadmap will be published this year.

**SPOTS Award** Luca Mottola from SICS, co-authored a paper that received the best paper award of the SPOTS track at the prestigious IPSN 2009 conference.

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