

Cooperative systems

With research interests in wireless embedded systems, **Dr Dirk Pesch** applies self-organisation and fault detection to the management and control of wireless sensor networks in building automation applications

DR DIRK PESCH



Could you outline the background of your research into building management systems (BMSs)?

About 75 per cent of the roughly 26 million commercial buildings under 1,500 m² in Europe do not have a BMS. This means heating and lighting are likely to use more energy than needed, which affects energy sustainability and contributes to global warming. The European Commission funded 'Self-organising, Cooperative and robUst Building Automation' (SCUBA) project tries to address this by providing tools to simplify design, deployment, and retrofitting of BMSs using largely wireless devices to save installation costs, and to simplify and make the commissioning of these systems more cost-effective through techniques for self-organising and self-commissioning.

Why is it important that large-scale embedded monitoring and control (M&C) systems work in tandem?

Most building automation systems (BAS) are silos that do not talk to each other. For example, the heating system does not interact with the light control system or the access control system. Another example is fault management. When an occupancy sensor in the light control system fails and cannot detect occupancy, the light in an office space may stay on over a weekend. However, a ventilation system could share information from a CO₂ sensor to indicate that the space has very low CO₂ levels, thereby indicating no human occupancy and enabling the lights to be turned off.

In what ways do current BMSs struggle to cope with increasingly complex control systems?

Designing and commissioning modern building automation systems is challenging due to the increasing complexity of the systems and the buildings themselves. A building's systems are typically composed of proprietary applications, with devices often installed by different system integrators. This further compounds the problem of interoperability, and leaves little room for cooperation among the different building systems. This in turn limits the utility of the building management system. In addition, many older buildings do not have a BMS, or one which only has limited functionality. Designing complex new BMSs or retrofitting additional functionality requires a new engineering approach. SCUBA achieves this in the form of tools for requirements capture, the design of wireless BMSs, and the definition of self-organisation functions to simplify the commissioning of BMSs.

What do SCUBA's industry partners contribute to the project?

Our industry partners have offered test-beds and technology to the project, and are working on channelling research output into standardisation around building automation system specification and design. They are also actively pursuing avenues to exploit the research output commercially.

SCUBA works in research cycles. Could you elaborate on this technical aspect of the project?

We have adopted a prototyping cycle where we develop and install systems in phases. The first phase implements an initial version of the technology, while the second cycle has more advanced and extensive implementations, technology deployments and demonstrations.

Have there been any difficulties in coordinating the multidisciplinary collaboration?

Multidisciplinary collaboration is always a challenge but we have managed very well

in SCUBA, with regular workshops and extensive discussions held among project participants. This has helped us to learn about one another's technology space and technical language, in order to facilitate effective collaboration. This approach has worked very well in the project.

How do you intend to provide proof of concept of the SCUBA approach?

To demonstrate the value of the SCUBA framework from various stakeholder perspectives, the platform is being validated at multiple test sites that are considered representative of typical office building stock in order to 'stress' and verify SCUBA's technical functional capabilities. We have three test sites: two in France and one in Ireland. We are deploying the SCUBA approach at these sites and carrying out tests to demonstrate proof of concept. Although complementary, the test scenarios all have different requirements, which enables the SCUBA platform to demonstrate its systematic engineering, adaptation and self-organisation capabilities in diverse settings.



Smart buildings

Coordinated by the Cork Institute of Technology, the FP7 **SCUBA** project is researching a novel architecture to apply to the automated control systems of buildings to make them safer and more efficient

BUILDING MANAGEMENT SYSTEMS (BMSs)

encompass a broad range of computer-based monitoring and control (M&C) systems, including heating, ventilation and air conditioning (HVAC), lighting, safety, and security. Combined, these systems account for the vast majority of a building's energy use. In the EU, buildings consume 43 per cent of total energy and citizens spend the majority of their time indoors, which highlights the importance of developing cutting-edge building automation systems (BASs) that are safer and more efficient, especially in an era of rising energy prices.

Different operators and manufacturers usually install a diverse range of M&C devices in a building, and the technology used is often proprietary in nature. This leads to a situation in which contemporary BMSs have very little opportunity for their various components to interact with each other. The lack of integration makes the overall system inefficient and also more prone to failure.

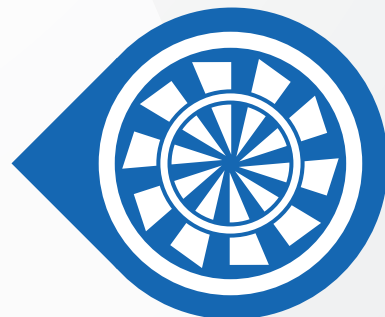
At present, major buildings such as airports and shopping centres tend to be constructed by big players in the building automation business, thus cooperative systems using HVAC, lighting and blinds are more common. Even in these cases, however, companies find they have to adapt 20 per cent of their products to be fully harmonised with the other systems.

INFORMATION EXCHANGE

At the Nimbus Centre for Embedded Systems Research at the Cork Institute of Technology, Ireland, Dr Dirk Pesch leads the 'Self-organising, Cooperative and robUst Building Automation' (SCUBA) project, which is addressing issues related to the inefficient and diverse BMSs currently employed across the EU.

M&C components cannot achieve their optimum efficiency unless they communicate with one another. "When the light control system detects nobody is in a room, or the room booking system indicates nobody will use a meeting room for the next hour, the heating control system is unable to take advantage of the situation and thus cannot reduce the heating by a degree or two to save energy, as occupancy information is not exchanged between the systems," explains Pesch.

Although the heterogeneity of M&C components makes their integration quite complex, the SCUBA project sets out to develop BASs that will allow a much greater degree of systems integration and



communication. Pesch intends to achieve this by using wireless deployment planning, developing system design tools and investigating machine learning and fault tolerance.

COOPERATIVE SYSTEMS

With funding of €2.6 million from the European Commission over a three-year duration from November 2011, the SCUBA project has five main objectives, the first of which is to develop a novel architecture for building system interoperability and cooperation. SCUBA has already developed a prototype of this architecture at a test bed in Grenoble, owned by industry partner Schneider Electric (France). This test bed was used to develop innovative building management concepts in the earlier French HOMES project, which ran from 2008-12. SCUBA also uses another former HOMES test bed, located at a commercial building – LAMA – in Chambéry, France.

TOOL CHAIN

The second aim of the SCUBA researchers is to develop a systematic engineering approach for interoperable and self-organising building control systems. To this end the team has developed a prototype engineering approach based on a tool chain: this includes a tool for specifying BAS requirements developed by TU Dresden; a tool for the design and implementation of the wireless monitoring system; a coordination scheme editor developed by CEA in France that allows for the self-organisation of the BAS; and a strategy manager module which aligns the system's operation and design thereby allowing for the evaluation of – and adaptation to – any changes in the system's operation.

The project's third aim is to develop a middleware platform to allow for the self-organisation and interoperability of heterogeneous technologies at the device layer of the BAS. The project achieves this by using a resource-based middleware called LINC, developed by CEA. "A prototype implementation of the Link Interface Controller (LINC) middleware in conjunction with the coordination scheme editor is implemented on the test bed in Grenoble," reveals Pesch. In addition to the LINC middleware, CEA, one of the SCUBA partners, has implemented a framework called PUTUTU, which has been designed to provide the features most frequently required to integrate new technologies into the BAS.

EVACUATION TIMES

The fourth aim of the SCUBA project is to develop a service-based system able to provide semantic descriptions for information exchange and self-organisation at the system layer of the BAS. "The service-orientated approach, together with the semantic models, will provide the basis for cooperation among heterogeneous, multi-vendor, multi-domain building monitoring and control systems," elucidates Pesch. An early version of this service-based system is already being implemented by the SCUBA partners and will be demonstrated at the Chambéry and Cork test bed sites.

The global building management market is expected to be worth more than US \$36 billion by 2015

The final objective of the SCUBA group is to develop techniques and algorithms for fault detection, cooperation and energy efficiency services. This work is split into two areas: first, the development of adaptive and cooperative M&C services to improve building efficiency (developed by Ennovatis and Philips Research), and safety (developed by UTRC); and second, the development of scenario recognition and diagnosis services (TNO-ESI) to allow M&C to recognise faults and emergency situations. The latter is of vital importance, as any lack of information exchange between M&C can affect evacuation times in the event of a fire, etc.

The design of these algorithms and protocols brings together the otherwise disparate wireless networks used in BASs. This in turn moves the SCUBA team closer to their overarching goal of producing a novel architecture that will lead to simpler engineering and commissioning of M&C systems, more flexible maintenance and better inter-system cooperation.

SHARING THE REWARDS

The cutting-edge cooperative BASs being developed under the SCUBA project promise to form the foundation of the next generation of BMS. These new systems will bring numerous benefits.

The energy efficiency and safety of buildings will improve once air-flow, access control, fire fighting systems, etc. are able to cooperate in an automated system. The products of the project's partners will become more competitive thanks to SCUBA's research, which will bolster Europe's building automation industry in general. And it's not just a European phenomenon: the global building management market is expected to be worth more than US \$36 billion by 2015.

For older buildings that do not yet have a BMS, SCUBA's work will provide a cost-effective approach to retrofitting efficient BASs, which will benefit both EU industry and citizens. Ultimately, the SCUBA researchers aim to develop BASs that will improve the energy efficiency of buildings by 5-10 per cent, leading to significant cost savings for building operators.

SCUBA's findings will be disseminated through workshops and conferences to various academic partners, which will aid future teaching and research programmes in BMS engineering. In addition, the SCUBA team intends to share their research findings with the broader community. "We are currently developing computer-aided building automation design and deployment tools and plan to make the software platforms for this available as free software to the scientific and industrial communities," concludes Pesch.

INTELLIGENCE

PROJECT SCUBA: SELF-ORGANISING, CO-OPERATIVE AND ROBUST BUILDING AUTOMATION

OBJECTIVES

Project SCUBA aims to facilitate the development of:

- Architecture for building system interoperability and cooperation
- Systematic engineering approaches for interoperable, self-organising and robust building automation
- A service-based system concept with service discovery and semantic descriptions for information exchange and self-organisation
- Techniques and algorithms for adaptive and cooperative monitoring, control services, scenario recognition and diagnosis of building automation systems

KEY COLLABORATORS

The SCUBA consortium is led by **Cork Institute of Technology**, Ireland, and includes the partners: **Schneider Electric**, France • **Philips Research Laboratories**, The Netherlands • **United Technologies Research Centre**, Ireland • **Ennovatis GmbH**, Germany • **TNO-ESI**, The Netherlands • **CEA LETI**, France • **Technische Universität Dresden**, Germany

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