Plotting the road ahead for wireless sensor networks

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Wireless sensor networks consisting of multiple objects, each capable of simple sensing, actuation, communication and processing have tremendous potential. To better realise their full capabilities researchers are developing a broad vision of innovative future applications.

Wireless sensor networks are a typical example of a network of ‘cooperating objects’, tiny embedded computers that cooperate together to produce an intended result. Such embedded systems, be they tiny processors in ‘intelligent clothing’ or the increasing numbers of computers in automobiles, are characterised by their need to interact with their immediate surroundings. However, it is only by cooperation with other objects that the full capabilities of such networks can be reached.

The problem faced by system designers is that, with so many cooperation possibilities with other networks, intelligent objects or even users themselves, how are they to know the best research direction to take? Which possibilities are likely to be taken up by society and industry globally, and which will turn out to be a blind alley?

These are the questions that the IST project Embedded WiseNts aims to answer. The project has brought together twelve partners from ten different European countries, the top research institutions in wireless communication, distributed computing and cooperating objects, to come up with some answers.

The project partners are focusing on the development of Wireless Sensor Networks (WSN) and their applications, especially in the form of Cooperating Objects (CO), to help develop a roadmap for innovative future applications. Their objective is to gain a broad vision of embedded wireless networks in the future (+/- 10 years), what their requirements would be and what technical progress is needed to this end.

Specifically, project researchers are looking at the current state-of-the-art in four key areas:

-- Typical application scenarios.
-- Algorithms used for routing, service-discovery, etc.
-- The vertical system functions that impact on several software layers, such as security, context and location management, exception handling, etc.
-- System architecture and programming models, how to develop middleware that could be used for cooperating objects in applications, hardware interfaces, industry applications, etc.

“By looking at these four areas, we identify the gaps in our knowledge, what is missing right now,” says Embedded WiseNts’ Pedro Marrón of

the University of Stuttgart. “With this starting point, we can begin to work out what people will be looking at in the next ten years.”

Need for middleware

What specific areas of weakness have the team found? “One of the first things we noticed is that most applications out there at the moment are very application specific,” says Marrón. “Which means that one key area we must address is that of adaptation. There is a distinct need for a middleware layer to cope with the diversity of software layers.”

“We have a big issue in energy-aware software, for example,” he continues. “When you have lots of small cooperating objects everywhere, you cannot keep stopping to change the batteries. So we need better energy efficiency both in hardware and software, and that can be either better batteries or algorithms that are more power-aware, that can turn off the radio module in the software, say, when it is not in use. As this will affect many software layers, we need to have cross-layer information.”

While systems designers are working on areas like energy-efficient hardware and software algorithms right now, Marrón believes that these issues and others even more important, such as security and authentication, will remain important issues for the next ten years.

Competition for innovative applications

As part of the project, the participants organised a competition, the ‘Sentient Future Competition’, that invited research groups to suggest innovative future applications for CO (Cooperating Objects) technology. Seventy-nine entries were received, and three applications in particular were awarded prizes at the EWSN 2006 annual workshop in Zurich,

Switzerland, on 13-15 February 2006.

First prize was awarded to the Catholic University of Rio de Janeiro in Brazil, for its application 'Large-scale body sensing for infectious disease control'. The Brazilian researchers foresaw an animal health monitoring system which would enable cattle ranchers to monitor the health of cattle herds and their susceptibility to infection. The system could measure the glucose, toxin and temperatures of individual animals on a daily basis, and if unusual symptoms were detected that animal could be isolated from the rest of the herd.

The second prize was won by students at the University of Zurich and ETH Zurich for a proposed intelligent waste management system, BIN-IT, which saw typical consumer goods such as fast-food packaging, tetra packs, bottles, jam jars, tins and batteries fitted with standardised RFID tags in the factory when they are produced. Waste bins and recycling collection points would be equipped with RFID tag readers and writers. The readers could monitor the volume of certain types of waste being deposited and feed this information to municipal waste organisations, while the writers could award credits to larger-scale waste producers such as restaurants that are members of a recycling scheme.

Third prize went to a PhD student in the UK's Lancaster University, for his vision of a congestion-free road traffic system in which vehicles are able to cooperate with each other to negotiate a clear space along their intended route. The system would function on the basis of 'virtual vehicle slots', which would guarantee a space and minimum safety distance for each vehicle along its traffic lane. Other vehicles not yet assigned virtual slots would have to avoid a particular slot by changing lanes or increasing speed.

Embedded WiseNts ends in December 2006. The project's findings are already feeding into other research areas associated with cooperating

objects. One example is the IST project AWARE, a new project which is examining the possibilities for using cooperating objects in combination with robotics.

“The promise of cooperating objects in robotics is very big,” says Marrón. “AWARE will be looking at how to develop a sensor system for the robots being introduced in fire fighting, as well as for the support of tiny autonomous flying objects known as unmanned aerial vehicles or UAVs.”

Source: IST Results