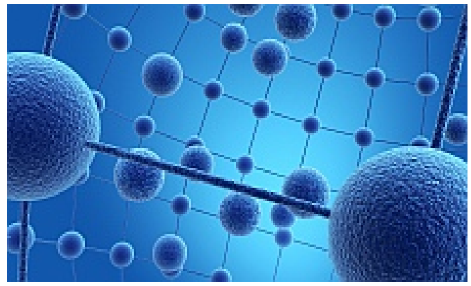
Wireless sensors learn from life

European and Indian researchers are applying principles learned from living organisms to design self-organising networks of wireless sensors suitable for a wide range of environmental monitoring purposes.



Monsoon rains in the Indian state of Kerala often bring increased risk of landslides. What can be done to warn nearby communities that a landslide is imminent?

One answer is to use a wireless sensor network to monitor geological conditions. Wireless sensors are becoming popular because the sensor nodes are small, simple and cheap and require no cabling to connect them together and to the control centre. They can be used for numerous purposes and are well suited to environmental monitoring.

There are downsides, though. Sensors and communication links can fail, and the nodes rely on battery power. Large networks can become congested with many sensors reporting at the same time to the same control centre.

However, what matters is not so much the reliability of the individual sensors but the reliability of the network as a whole. Does this system reliably monitor air pollution in the city centre? Does that system reliability measure weather conditions on the motorway bridge?

Biological analogy

These are the kinds of problems being tackled by WINSOC, an EU-funded project to find new ways of organising wireless sensor networks to make them robust against node failures and capable of being implemented on large scales.

What makes **WINSOC** different from earlier projects is that it has taken its cue from biological systems. Where sensor networks are made up of many individual sensors, living organisms are made up from many individual cells.

“Living systems are intrinsically robust against cells dying or being damaged,” says Sergio Barbarossa of the University of Rome 'La Sapienza', who is the scientific coordinator of **WINSOC**. “The behaviour of most organs is an emerging feature, resulting from the interaction of many cells, where no cell is particularly robust or even aware of the whole behaviour.”

A striking example is the rhythm of the heart, which is controlled by the interaction of several pacemaker cells, each of which can be seen as a pulse oscillator. Even though individual oscillators are not particularly stable or reliable, the heart as a whole is extremely stable and can readily adapt to changing conditions.

Self-organisation

“The starting point in **WINSOC** was to provide mathematical models of biological systems and translate them into algorithms to determine how the sensor nodes should interact with each other,” says Barbarossa.

A prototype sensor node is being developed, but the challenge is to make the network able to continue to function even when several sensors fail.

The answer is self-organisation. In the **WINSOC** approach, sensor nodes communicate with their neighbours to arrive at a consensus on what has been sensed. The network then finds the best path through the available nodes to relay this information to the control centre.

This biological principle is being tested in the landslide detection system. A prototype network of geological sensors has been installed in the Idduki rainforest of Kerala, India, a region vulnerable to landslides in the monsoon season.

“Our Indian partners have buried sensors in the terrain, with the capability of monitoring the humidity and porosity of the terrain and the acceleration forces,” Barbarossa says. “The sensors are then linked to a satellite which gathers the data and conveys them to the control centre.” The network includes 12 geological sensors connected to 15 wireless sensor nodes spread over three hectares.

Forest fires

In a second demonstration, the team has implemented a computer simulator that emulates the spread of a fire through a forest. The simulator also mimics a sensor network designed to monitor and alert of forest fires. Sensors have been placed in a forest in the Czech Republic to detect and locate sources of heat and smoke.

The consortium is also developing a ‘Sensor Web’ to allow applications and services to access sensors of all types over the internet. This is a distributed sensing system in which information is globally shared and used by all networked platforms.

In the long term, the group expects two kinds of benefits to emerge from the project. “The first is related to the monitoring of the Earth with a system capable of autonomous decisions,” says Barbarossa. “This is particularly important in remote areas where it is difficult to recharge batteries or replace defective nodes.”

A second major goal is progress in the design of self-organising systems. “We believe that cross-fertilisation of ideas from biology to engineering and vice versa can provide substantial benefits to both areas.”

WINSOC is funded by the **EU**'s Sixth Framework Programme for research and is due to finish in February 2009.