WINSOC Project Advances The Promise Of Wireless Sensor Networks

Written by Maria Angeles Grado Caffaro
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Wireless sensor networks are poised to expand as they become more popular. WINSOC (Wireless Sensor Networks with Self-Organization Capabilities for Critical and Emergency Applications), is a project funded by the FP6 Information Society Technologies programme of the European Union. The project goal is to improve the performance of sensor networks by using a biologically inspired design –inscribed in the frame of the so called bioinspired science that basically consists of looking at nature to solve problems, that is, using living organisms as a model to study and conceptualize problems in a variety of fields as engineering and design, materials or sociology for example.

Wireless sensor networks

Wireless Sensor Networks (WSNs) is a hot topic within the network communications community as it appears as the driver of a fully pervasive scenario. These wireless sensor networks are made up of many miniature, low power, inexpensive devices, deployed throughout a physical space, that are able to sense, compute and communicate. In fact, these devices

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communicate and collaborate each other to gather and share/disseminate information about the instrumented environment—monitoring parameters distributed in it. These parameters are related to a variety of applications such as infrastructure security, chemical and biological hazard detection, natural hazards and the broad area of environment including disaster relief, emergency, patient and habitat monitoring, traffic control, and any other application/field still unexplored that could be part of a pervasive scenario.

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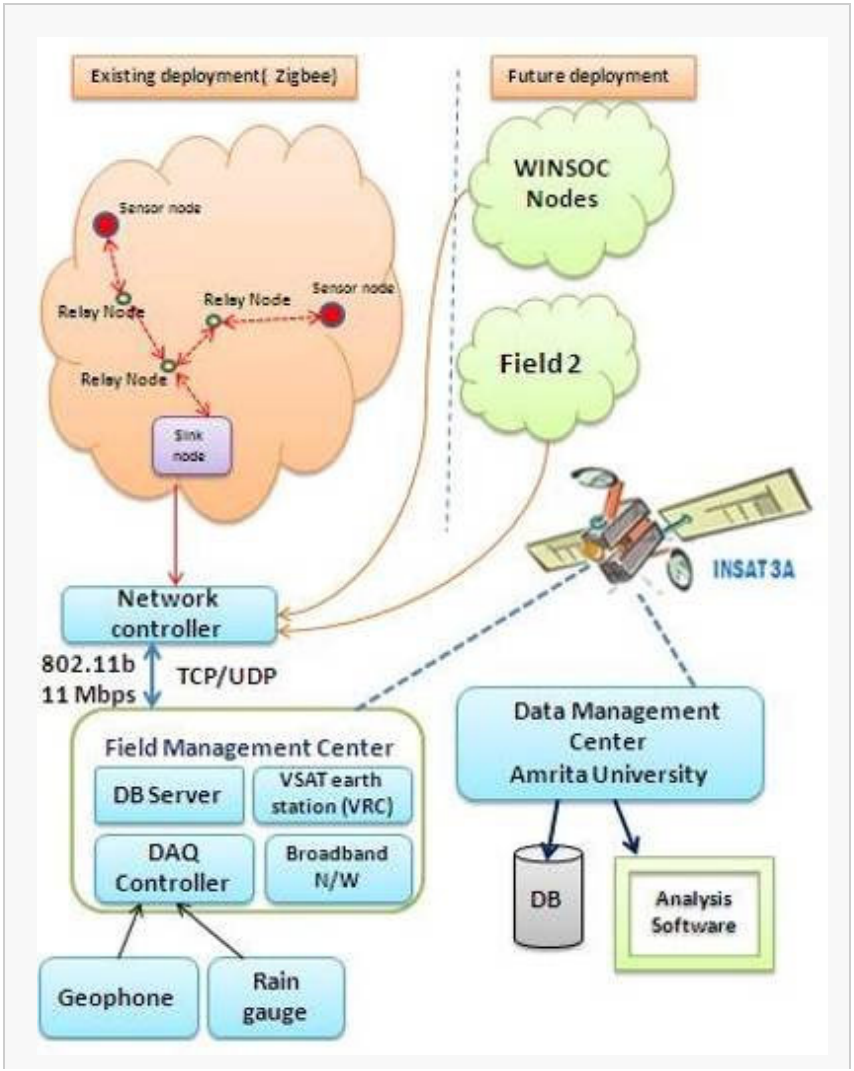
The emergence of sensor networks has been possible due to the advances in the design and fabrication of low power VLSI circuitry that has enabled the production of small, low power, and cheap sensors with which the network is made up. Advances in nanotechnology make the sensor network arena even more promising and challenging —the sensors would become part of the manufacturing process for materials and objects, would take the energy from their environment, and the vision would continuously evolve, requiring also new information technology architectures and design paradigms. As a matter of fact, WSNs as being the driver of the confluence of embedded and real time systems, promise to revolutionize our ability to sense and control a variety of physical environments, and helps to create a nascent infrastructure for a technical, economic, and social revolution.



The nature of the network

However, much work remains before WSNs reach all their potential gains: these networks have unique attributes as limited power and memory and computational resources, and also a dynamically varying network configuration. These limitations make difficult to address WSNs in the same way than conventional networks even introducing adaptation and scaling— "current paradigms in WSNs state of the art greatly reflect, although scaled and adapted, well known and consolidated methodological approaches borrowed from telecom networks, which however have been developed to cope with totally different requirements with respect to a sensor network" WINSOC team explains. WINSOC major aim is to introduce a new paradigm to actually solve the important problem about the specific conflicting requirements appearing in a sensor network – low complexity in sensor devices, high reliability of the decision/estimation/measurement of the network as a whole, long term lifetime, high scalability, and resilience to congestion.

To this end, the network design is conceived as a biologically inspired system which means that is able to self-assemble into organized structures, in which the sensor nodes behave as biological entities—are able to make decisions based on their local environment and their own individual state; these nodes are "small" calculating machines in the network that need only to carry out very simple rules, thus eliminating the need of the inefficient complex protocol interactions used for end to end communications. This approach permits to build distributed detection and estimation capabilities which are key to gain understanding of a WSN scenario.

Innovative design

"WINSOC develops a totally innovative design methodology where the high accuracy and reliability of the whole network is achieved by introducing a suitable coupling among adjacent, low cost, sensors, enabling a global distributed detection or estimation more accurate than that achievable by each single sensor", says Paolo Capodieci from Selex Communications who coordinates the project, "in this way we eliminate the need for sending all the data to a fusion centre". With this new idea of taking inspiration from processes found in biology to devise sensor networks, WINSOC is intended to significantly improve performance and competitiveness in both generic network sensor design —paving the way for the likely dramatic evolution of the technology— and in the broad area of environment and emergency applications. Three system level simulators have been developed and tested for prediction and detection of landslides and also for monitoring temperature fields, the latter within the application to forest detection and fire risk estimation.

Both wildfires and landslides are the applications targeted. Landslides and avalanches in Europe and all over the world cause important economic and societal losses and, further, the number of casualties as direct or indirect consequence is increasing. The growing number of land-use and critical infrastructures, as well as the global climatic change, are major risk factors associated with landslides and avalanches.

Connecting to the web

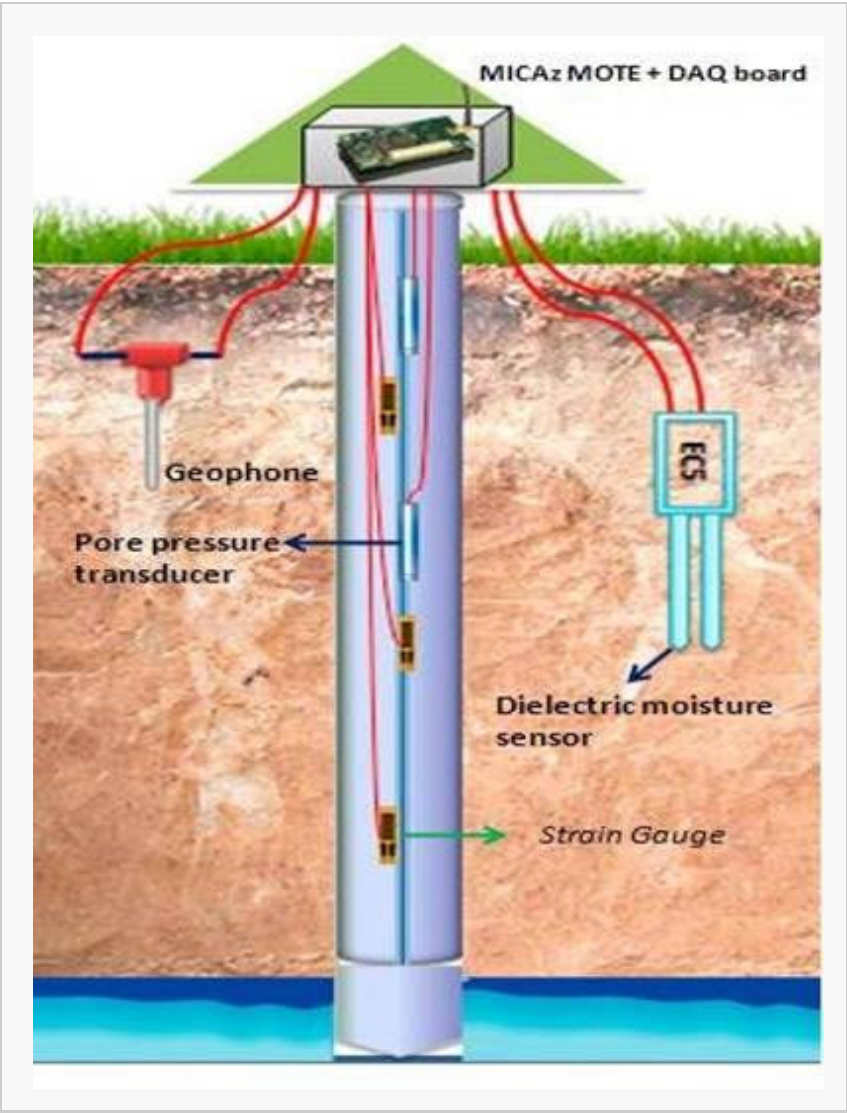
The key issue in the project that makes the difference is that of using distributed algorithms; as a matter of fact, the uniqueness of the research is decentralising the decision making to the node level: "we have obtained a distributed consensus mechanism that allows a set of nodes to reach globally optimal estimation or detection tests, without requiring a fusion centre, in the case where the whole network is observing a common event" Paolo Capodieci remarks.

This approach provides full scalability, low vulnerability, robustness to duty-cycle, low congestion, and makes the system particularly attractive to detection and estimation applications.

"We also are developing a Sensor Web that will allow that both applications and services can access sensors of all types over the Web; this aspect will be particularly important to the wireless sensor network community" he adds. Sensor Web is a technology that is increasingly attracting attention as it opens up new strands for distributed sensing and control: it can be described as a distributed sensing system in which information is globally shared and used by all networked platforms, and was conceived in 1997 at the NASA/Jet Propulsion Laboratory (JPL). The objective of a Sensor Web is to extract knowledge from the data it gathers and use this information to intelligently react and adapt to its surroundings.

Applications to the landscape

Apart from the efforts in pure sensor network technology, the project pays special attention to the applications since it is well known that WSN design is generally application driven: the specific application's requirements determine how the network behaves. Both wildfires and landslides are the applications targeted. Landslides and avalanches in Europe and all over the world cause important economic and societal losses and, further, the number of casualties as direct or indirect consequence is increasing.



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change, are major risk factors associated with landslides and avalanches. In WINSOC the landslide application is being developed in India as this country is particularly affected by the problem of landslides; the annual loss due to landslides are around 400 million dollars —this makes it a good scenario to develop the application study; Amrita University conducts this work. According to Maneesha Ramesh, from Amrita, the work under development will be particularly useful to actually bridge the gap between a highly occurring natural hazard as are landslides and a strong innovating technology as are the bioinspired wireless sensor networks that WINSOC teams are developing.

In March 2008 the design of a prototype node was already completed and the work teams leaded by Selex Communications started its development “we are driven by a commitment of translating our research results into a product that can sell, that is why we are going to articulate the node implementation in terms of ability to adapt to different operational scenarios, flexibility meaning no intrinsic constraints, reconfiguration capability, and in terms of suitability for multi-application overlay that means parallel running procedures; and also suitability for potential networking enabling clustering. In this way, we will be able to actually introduce the knowledge produced by WINSOC into the marketplace” Paolo Capodieci explains.

Project partners and summary
WINSOC is coordinated by Selex Communications (Italy); other partners include the University of Rome “La Sapienza” (Italy), the Ecole Polytechnique Fédérale de Lausanne (Switzerland), Intracom (Greece), the Commissariat per l’Energie Atomique-LETI (France), the Czech Centre for Science and Society (Czech Republic), Dune (Italy), Technical University of Catalonia - UPC (Spain), Indian Space Organisation (India), Amrita University (India), and the Sci-Tech consultancy firm Sapienza (Spain).

WINSOC started in September 2006 and will run till the end of February 2009. WINSOC first results have been obtained and reported in journals as IEEE Signal Proc. Magazine and IEEE Transactions on Signal Processing among others as well as in conferences— the papers, deliverables and other informative material can be downloaded from the project website at www.winsoc.org.

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