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Smart sensors that harvest power from sun, heat or vibrations

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European researchers have developed advanced energy harvesting technology that allows wireless sensor networks to power themselves from the sun, heat or vibrations. The innovation is a key enabler for smart cities, environmental and pollution monitoring, and effective disaster management, among many other applications.

From monitoring weather and pollution to empowering ‘smart cities’ of the future, wireless sensor networks promise to make our lives more comfortable, safer and more productive. But while many of the challenges to deploying networks of tiny sensor devices have been addressed, one key issue remains: how to power them.

Like any electronic device, sensors need energy to operate. Until now this has largely been solved by hooking them up to the grid or using batteries, but both approaches have considerable drawbacks.

Grid-connected sensors need cables, limiting where they can be used, and contribute to electricity consumption and CO2 emissions, while battery-powered ones only last as long as their battery life. But what if sensors could harness energy directly from their environment – from the sun, from ambient heat, from radio waves or vibrations?

The result would be sensors and sensor networks that can be set up anywhere with ease and in theory would operate perpetually with little or no maintenance or environmental impact. And that is precisely what a team of EU-funded researchers are achieving in the SWAP ('Symbiotic Wireless Autonomous Powered system') project.

Supported by almost EUR 1 million in research funding from the European Commission, four companies and research institutes from Italy and Spain have combined their skills and expertise to develop the next generation of innovative, autonomously powered wireless sensors.

“In recent years, wireless sensor networks have enjoyed a tremendous upsurge and the field has reached a level of maturity,” says Professor Michele Rossi from Consorzio Ferrara Ricerche and the University of Padova, Italy. *“There were many technical limitations in terms of communication capabilities that have been solved and the communication aspect of the network no longer represents the main challenge. The main challenges now revolve around the self-sufficiency of networks. What is needed are networks of devices that can survive by scavenging the energy they need from the environment."*

Harvesting the sun, vibrations and radio waves

The SWAP team are studying, testing and deploying novel technologies that enable sensors to use solar and thermal energy as

well as radio waves and vibrations to power themselves. They are focusing on making energy harvesters more efficient and are integrating multiple energy harvesting and sensing circuitry into individual devices.

The researchers are also developing intelligent algorithms (small programs) to efficiently manage the energy obtained from the environment. The algorithms are then used with advanced signal processing techniques to reduce the amount of data that has to be sent for a given monitoring application. This approach, in turn, reduces energy consumption.

Apostolos Georgiadis, a senior research associate and the SWAP coordinator at CTTC in Spain, says the design of energetically self-sufficient networks differs sharply from that of standard battery-powered ones.

"The goal is no longer to minimise energy draw so as to maximise the lifetime of the battery reserve, but rather to use energy when it is available and save it when we know it will be scarce, so that the system will remain operational – ideally – forever," he says.

Combining the expertise of the academic and industrial partners, the SWAP team has developed an advanced sensor platform to validate the approach, and the industrial partners are incorporating the algorithms and hardware innovations into commercial products.

In the longer term, Nicola Bui, the former CEO of Patavina Technologies, a project partner based in Italy, sees such efficient energy harvesting systems playing a crucial role in the Internet of Things, the concept that in the future myriad different devices, or 'things', will form interconnected networks for a wide range of potentially revolutionary applications.

For example, autonomous sensor networks that can be deployed quickly and easily anywhere will greatly improve disaster and emergency management, enabling first responders to have a much better understanding of the impact and scale of any event.

Sensor networks already play a crucial role in environmental, weather and climate monitoring. Making them better will serve to improve the efficiency of such applications.

The introduction of these technologies will allow for a new class of applications involving large-scale monitoring of real-time situations, such as forest fires, or in agriculture and water management, suggests Ignasi Vilajosana, CEO of Worldsensing, a project partner based in Spain.

"In the context of smart cities, for example, sensing technologies will allow the introduction of new services for citizens that will benefit quality of life, such as traffic and pollution monitoring, smart water metering and even smart parking guidance systems that help drivers to quickly find parking spaces," he predicts.

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See also: CORDIS [3]

Newsroom Item Type:

- Project stories [4]

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