Networks of the Future: Extending Our Senses into the Physical World

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(PhysOrg.com) -- The picture of a future with wireless sensor networks-webs of sensory devices that function without a central infrastructure--is quickly coming into sharper focus through the work of Los Alamos National Laboratory computer scientist Sami Ayyorgun.

Proponents of this new technology see a world with deployments to improve a wide range of operations. Engineers could wirelessly monitor miles of gas and oil pipelines stretching across arid land for ruptures, damage, and tampering. Rescue workers might detect signs of life under the rubble of a collapsed building after an earthquake, thanks to a network of sensors inside the structure. Armed forces could keep an eye on a combat zone or a vast international border via a sensor network that could promptly provide alerts of any intrusion or illicit trafficking.

"It's not easy to envision the impacts that sensor networks will make, both socially and economically," Ayyorgun said. "Like many other researchers, I think they are likely to rival the impact that the Internet has made on our lives."

Ayyrogun has developed a new communication scheme that brings the reality of these and other applications a step closer. He has shown for the first time that concurrent gains in many measures of performance are possible, including connectivity, energy, delay, throughput, system longevity, coverage, and security.

In recognition of the multifaceted improvements Ayyorgun's research

makes on state-of-the-art technology in this field, his recent paper, "Towards a Self-organizing Stochastic-Communications Paradigm for Wireless Ad-hoc/Sensor Networks," has been nominated for the Best-Paper Award from a pool of more than 250 manuscripts at the International Conference on Mobile Ad-hoc and Sensor Systems (MASS) of the Institute of Electrical and Electronics Engineers (IEEE).

Ayyorgun will present the paper at this prestigious meeting of the IEEE beginning September 29, in Atlanta, Georgia.

Like cell phones, wireless sensor networks depend on small, independently powered devices, often called motes, to communicate. But unlike cell phones, which always relay their signal through a base station such as a tower, multihop sensor motes use each other to relay signals, transmitting communiqués through a series of "hops" from one mote to the next. Without the need to build a mesh of base stations that must be wired or have a substantial supply of energy, creating information-bearing ad-hoc networks to suit each unique set of circumstances would significantly reduce costs.

"Wiring or 'beefing up' system resources is expensive and is often not feasible for many applications," Ayyorgun said, calling that a "major impetus" for wireless network research.

But with nearly all motes dependent on a portable source of power like a battery, it is important that the devices be as energy efficient as possible. "Energy efficiency is a first-class design criterion," he said.

And energy utilization isn't the only consideration. Other performance aspects of concern include the system's connectivity; the delay, or time it takes for data to be transported; the throughput, which measures the amount of data the system can handle at once; and network security, to name a few.

Many solutions aimed at advancing wireless sensor networks have managed to improve performance over at most a few metrics at the expense of others. Ayyorgun analogizes the conundrum to a Rubik's cube, the cube-shaped toy in which the aim is to match each of the six sides with one distinct color. Often, gains in one aspect of wireless sensor network performance such as energy efficiency have only been achieved with losses in another area, such as the end-to-end delay.

With Ayyorgun's scheme, however, "all of the colors have started to match," he said. The sensor network was more energy efficient with shorter delay times, and the other performance considerations mentioned earlier have all improved as well.

"The motes communicate randomly, but their random behavior-their genetic code, if you will-has collective intelligence by design," he said. That collective intelligence results in the concurrent performance gains over many aspects, he added.

"We have good colors on all sides, but it's not perfect yet," Ayyorgun said, emphasizing that wireless sensor networks are still in the development stage. Many issues remain to be addressed, just as we are beginning to realize the potential of these "networks of the future."

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