Novel long range wireless sensor network monitors remote areas

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Imagine the challenge of real-time monitoring of the moisture content in soil across hundreds of acres of land, or the movement of clandestine materials in remote parts of the world. Now imagine the monitoring happening over many months or years and far away from the scientist, rancher, or soldier that needs this information.

Is there an affordable and effective solution? The answer may lie in a novel and innovative Los Alamos National Laboratory technology.

Wireless sensor networks of the past were developed for indoor applications and were not suitable for vast outdoor extreme environments. Additionally, they were expensive to deploy and maintain, required specialized programming skills, and often unreliable and difficult to manage.

The new Long Range Wireless Sensor Network (LRWSN) system developed at the Laboratory is robust, energy-efficient and covers large geographic areas using a self-healing, self-forming mesh network of long-range radios.

Solving a local problem

Part of the genesis for the network came from the Laboratory's own need to monitor storm-water runoff for environmental compliance over its approximately 40 square mile facility. Sensor systems needed to be deployed in remote locations with restricted access and often extreme environments with limited resources (e.g., no access to power). The systems required persistent monitoring (24/7) over periods of years with high data transmission reliability.

The network needed to be self-forming network, meaning the nodes discover their route back to the master node (sink node) and have no knowledge of their routes prior to deployment in the network. This important feature allows a field technician to place the nodes ad hoc for installation.

The network also needs to be self-healing, so if a node fails, its failure will not take down the rest of the system because the other nodes are able to discover alternate paths. These properties are critical to maintain uninterrupted service in extreme, remote environments.

When it became clear that commercial off-the-shelf parts did not meet their needs, the Lab's research team, led by Janette Frigo, began building their own hardware and developing software.

The system they developed is low cost, consumes low average power and is ruggedized for extreme temperatures and outdoor use in remote environments from the arctic to the desert.

It has a novel networking protocol that enables scaling to the order of hundreds of nodes, and its sensor nodes have two modes of operation, continuous or scheduled monitoring.

Between 2013-14 a team of Los Alamos scientists in the Arctic Circle were researching the effect of reduced snow fall on arctic plants and connected their sensors to a Long Range WSN system for 24/7 monitoring and transmission. That system operated continuously for over two years with temperatures as low as -25 C.

Closer to home, the team has also implemented a system on the storm-water runoff project in the Los Alamos watershed with node-to-node distances up to 19Km (12mi). The system has been operating for nearly 2 years, 24/7 in a network with 60 to 120 nodes.

One future application of the Long Range WSN is on a ranch near Las Vegas, NM to monitor such things as daily rainfall, soil moisture content and wind speeds to determine if the pasture is stressed due to climate impacts. The rancher's current system requires manual collection of data, but the LRWSN technology will use line-of-sight radio frequency mesh communication to collect data and transmit to the master node at the ranch house and thus, connect to the rancher's computer.

The mesh network can also be combined with satellite communication capability to provide 2-way communication with nodes anywhere on the earth and it is designed for monitoring over 5-10 years continuous service using photovoltaic power and/or rechargeable batteries. This makes it suitable for use by crop farmers or others in vast and/or remote areas that have little or no infrastructure, power, or cellular reception.

Future use for the Long Range WSN may include monitoring crop health and environmental conditions in rangeland, environmental intelligence and equipment performance, and monitoring of distributed power structures including solar farms. Future security applications could include monitoring for the movement of radiological materials, International Atomic Energy Agency (IAEA) facilities, and the security of perimeters, buildings, national borders and ports.

Learn more about the technology.