Sensors and Sensor Networks Mix Old and New Technologies

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This month's Technology Report is primarily an introduction to the article that follows on p. 32, which provides descriptions of a wide range of sensors that use microwave technology. These sensors—along with more conventional electrical, mechanical, thermal and environmental sensors—are receiving much attention as elements in a wireless sensor network. Transmission technologies such as ZigBee, IEEE 802.15, ultra wideband (UWB) and others are driving a new family of wireless applications.

The ZigBee Alliance (www.zigbee.org), an industry group for developers and users of the ZigBee standard, identifies the following as key early applications for their members' wireless networking efforts:

Home Automation

Control—Flexible management of lighting, heating and cooling systems from anywhere in the home.

Conservation—Capture highly detailed electric, water and gas utility usage data. Embed intelligence to optimize consumption of natural resources.

Convenience—Install, upgrade and network home control systems without wires. Configure and run multiple systems from a single remote control.

Safety—Easily install wireless sensors to monitor a wide variety of conditions. Receive automatic notification upon detection of unusual events.

Building Automation

Control—Integrate and centralize management of lighting, heating, cooling and security. Automate control of multiple systems to improve conservation, flexibility and security.

Conservation—Reduce energy expenses through optimized HVAC management. Allocate utility costs equitably based on actual consumption.

Flexibility—Reconfigure lighting systems quickly to create adaptable workspaces. Extend and upgrade building infrastructure with minimal effort.

Safety—Network and integrate data from multiple access control points. Deploy wireless monitoring networks to enhance perimeter protection.

Industrial Automation

Control—Extend existing manufacturing and process control systems reliably. Improve asset management by continuously monitoring critical equipment.

Conservation—Reduce energy costs through optimized manufacturing processes. Identify inefficient operation or poorly performing equipment.

Efficiency—Automate data acquisition from remote sensors to reduce user intervention. Provide detailed data to improve preventive maintenance programs.

Safety—Deploy monitoring networks to enhance employee and public safety. Streamline data collection for improved compliance reporting.

All of these networks involve the gathering of pertinent data from a variety of sensors, then either reporting that data or applying controls based on changing inputs.

Advanced Applications

Some of the important wireless sensor networks that have been implemented or planned are:

- Weather and environmental monitoring
- Automated wildlife tracking
- Data acquisition in long-range or wide-area test platforms
- Monitoring areas with hazardous conditions that can hamper installation or damage wired networks
- Allow a large number of sensors to be placed where the bulk of wiring would affect performance, such as airframes and other structures

One of the most valuable application areas is academic and industrial research. With a network of low-power wireless sensors, experiments can rapidly be set up or changed. Many development efforts are aimed at low cost, which would allow sensors to be deployed in areas where they may not be recoverable. A large array of sensors for precise characterizations can be deployed into environments where they will eventually be destroyed by temperature, pressure or other hazards. Many new studies are envisioned where sensors are airborne or deployed via aircraft into areas where recovery is unlikely.

A wide range of sensor technologies and wireless transmission methods are required to address all the potential needs regarding precision, data rate and communication range. Ultra low power is needed for long-life sensors that cannot be reached for maintenance or replacement. Higher power or UWB-type bandwidth is required for interference-prone environments. Low data rate or infrequent reporting intervals are important techniques for power management.

Currently, the interplay of hardware/firmware development by manufacturers' and users' planning for new applications enabled by these sensor networks is in full swing and will determine the course of this technology as it continues to develop.