

## Wireless sensor networks: Driving the New Industrial Revolution

By Rob Conant

*Modern industry is increasingly dependent on the seamless transfer of information between plant systems and business systems. In this article, wireless sensor networking expert Rob Conant describes the vision for wireless sensor networks comprised of motes connecting wireless sensor elements, and highlights several industries applying the technology today to deliver financial results.*

Globalization, rising energy prices, and a strict regulatory environment are driving companies in a wide variety of industries to cut costs while increasing efficiency and productivity. Companies are changing organizational infrastructure and processes in their facilities to stay competitive. Meanwhile, trying to meet production and profitability goals remains a significant organizational hurdle. Given these market dynamics, industry leaders are feeling pressure to adopt new technologies that will help them gain competitive advantages wherever they can find them.

These forces are contributing to a wave of innovation in how things are done in industrial sectors that has not been seen for many years. The same pressures that led to eighteenth century developments by inventors such as Eli Whitney, James Watt, and Charles Babbage are reasserting themselves in the collision of the two worlds of industrial and Information Technology (IT). Just as the seed press and the steam engine catalyzed industries, so, too, are today's manufacturing innovations – particularly those that can provide more access to more knowledge to plant managers and process engineers. This convergence of industry and information is leading to the New Industrial Revolution.

Imagine, for example, if environmental information and other data from the

physical world could be measured, managed, and refined with the same reliability as wired networks, but at a lower cost. Data from the physical world, including temperature, lighting, humidity, energy consumption, and movement could then be married to the world of industrial systems and IT. Wireless sensor networks and industrial systems are now converging and giving rise to greater efficiencies not experienced since the first Industrial Revolution. As industrial plant managers discover they can do more with less, they are turning to wireless mesh networks that seamlessly integrate with legacy plant systems to develop comprehensive monitoring and control strategies.

Wireless sensor networks allow information to be collected with more monitoring points, providing awareness into the environmental conditions that affect overall uptime, safety, or compliance in industrial environments and enabling agile and flexible monitoring and control systems. These networks connect critical processes or assets with the systems or experts that can interpret the data or take immediate action. At the end of the day, operational teams with more visibility into their processes can prevent shutdowns and increase efficiencies while reducing the total cost of data acquisition. All of this can add up to a distinct competitive advantage and a head start in the New Industrial Revolution.

### Why wireless, why now?

Recent advances in wireless networking technologies leverage the capabilities of the existing monitoring and control infrastructure in areas not possible before the New Industrial Revolution, more than doubling the available monitoring points at a lower cost per point than current wired solutions. Wireless sensor networks are comprised of battery-operated motes that have the ability to quickly form a

network and communicate with each other. They are deployed in a full mesh networking topology where each mote is a router – ensuring extremely low power and achieving over 99.9 percent reliability. Through techniques such as redundant routing and frequency hopping, wireless mesh networks approach the reliability of wired networks, significantly knocking down the barriers to collecting information from the physical world by field intelligent devices.

While the potential to marry physical monitoring with wireless has always existed, the adoption of wireless technology has been slow in making its way into industrial-grade monitoring and control systems. Many organizations have discovered that traditional point-to-point wireless networks are prone to failure when faced with the challenging and dynamic Radio-Frequency (RF) landscape presented by commercial and industrial environments. Likewise, wireless sensor networks designed for consumer-grade applications such as home automation, PC peripherals, and remote controls are simply inadequate for industrial applications. However, with recent technological advances in wireless mesh networking technology, seamlessly integrating wireless sensors into existing plant infrastructures can enable a whole host of monitoring and control applications, such as oil and gas, cold chain, and machine health monitoring. The flexibility and adaptability of wireless lowers the physical and cost limitations posed by wired systems, thereby lowering the total cost of ownership of an adaptive control strategy.

### Reliability for harsh environments

The measure of success for an industrial-grade wireless sensor network is not how any individual network device performs, but how the system as a whole ensures a

reliable flow of critical data. Reliability is an absolute requirement for any monitoring technology, because if the data is not reliable, the economic benefits of its low installation costs are rendered irrelevant.

Specifically, for a wireless technology to be reliable in industrial applications, it must:

- Function in harsh industrial environments with unpredictable Electromagnetic Interference (EMI), RF fading, and multipath interference
- Coexist in the field with other wireless devices or noise emitters such as machine equipment, communications devices, walkie-talkies, instant connect phones, pagers, cell phones, remote controls, and other wireless frequency emitters common in the industrial environment

Typical industrial environments have time, frequency, and location varying RF interference, as shown in Figure 1.

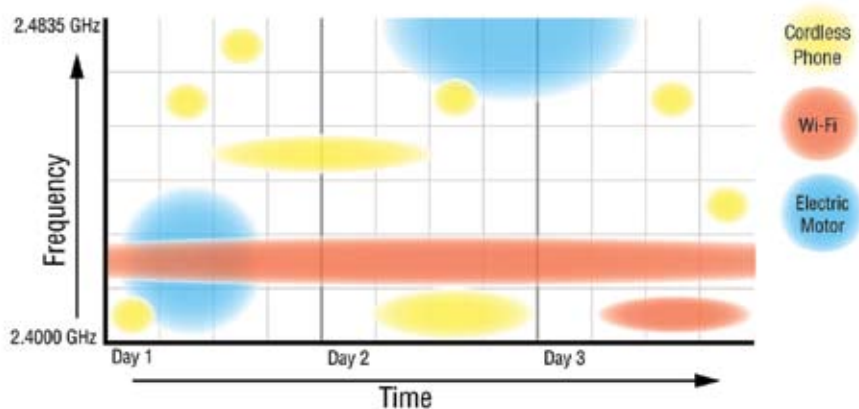


Figure 1

New wireless mesh networking topologies are one factor that drives new levels of reliability. In a mesh network topology, each mote has at least two parent motes with which it can communicate. Even if an individual link becomes inoperable, a mote still has a communication path available. This redundant routing ensures resiliency in case of offline motes or broken links.

Wireless sensor networks also use a combination of Frequency Hopping Spread Spectrum (FHSS) transmission and time synchronization, varying communications in both frequency and in

time to sidestep RF interference problems. This technique ensures that alternate paths are available if any signal is blocked due to RF interference. FHSS technology is particularly useful in industrial environments where intermittent RF interference is common.

Agile frequency hopping sidesteps interference by utilizing several discrete frequency slices, as depicted in Figure 2.

Wireless sensor networks provide adaptive monitoring systems in industrial environments with the flexibility and adaptability needed in a plant's monitoring and control strategy. Wireless motes are placed where needed without the need of specialized RF skills or site surveys, while the network handles the rest such as wireless connectivity, routing redundancy, and frequency agility. Additionally, these networks are adaptable to changes in both the configuration of equipment on the plant floor and in the layout of the network itself. If managers add or remove monitoring devices, the network simply

reconfigures itself automatically.

As wireless networking technology advances, it is also becoming more cost effective. Current wireless sensor networks are designed to ease development and integration with other systems. No customization, integration, or development is required, and there are no wiring or installation costs. Battery-powered motes don't require AC power, which can make wireless networks suitable for locations where power distribution is not designed for additional monitoring equipment. Because motes self-organize into a functioning mesh network, no site survey or wireless expertise is required, and the installer does not have to program or configure the devices.

Wireless mesh sensor networks are also designed to deliver long lives with a minimum of ongoing maintenance. Motes can have a lifetime of five to seven years on a single pair of AA batteries, and they report on their power status, so operators or managers can tell when battery replacements are due.

## Monitoring and control applications

The value of wireless networks is becoming apparent to organizations that have found they need real-time access to knowledge about their plant's environment, processes, and equipment in order to prevent disruption. Spurred by the recent technological advances, the New Industrial Revolution is beginning to impact three very distinct monitoring and control applications: oil and gas, cold chain, and machine health monitoring.

## Oil and gas

Oil and gas manufacturing is one industry looking toward wireless sensor networks

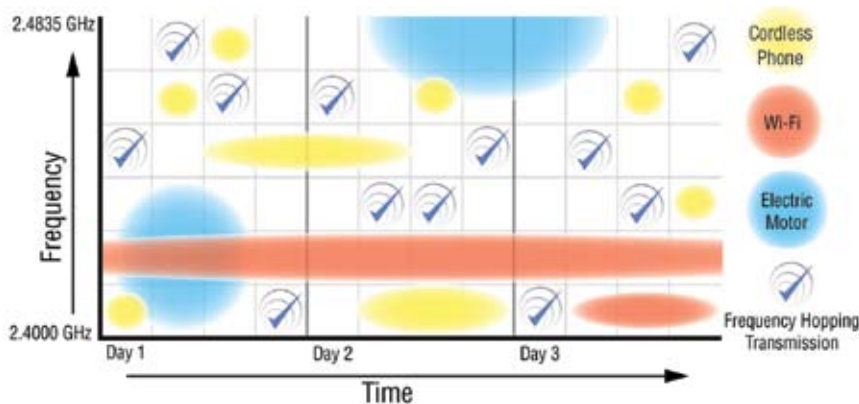


Figure 2

# Executive Speakout: Adaptive Automation in Action

to solve critical information gaps. Large industrial sites, such as oil refineries, already have complex process control systems in place, but many additional points could provide additional data to optimize processes. Because of the complexity and cost of integrating these non-mission-critical points into the existing control architectures, many of these points are not automatically measured today. Monitoring is usually done manually as inspectors check the status of key motors, valves, pumps, and supporting process variables. Not only is this time consuming, but when multiplied across an enterprise's global infrastructure it also becomes very expensive. Dedicated staff inspecting the refinery may be able to detect a problem, but most likely only after the problem has occurred.

Wireless sensor networks reduce the oil and gas industry's reliance on inspection

personnel by supplying information about utilization rates, energy usage, equipment conditions, and environmental conditions. Information derived from wireless networks can help quickly identify and address issues that could jeopardize overall uptime, safety, compliance, and profits. The network drastically reduces the cost of accessing information per point, and the ability to gather information around the clock provides unprecedented monitoring capabilities.

## Cold chain

Companies in the food, chemical, and pharmaceutical industries have unique business problems and monitoring requirements as well. The shrinkage of perishable product inventory can range from between 5 and 10 percent. In real dollar terms, that could translate into hundreds of millions of dollars in losses at a large grocer, for example.

Companies in these industries depend on the cold chain – the monitoring of environmental conditions such as temperature and humidity throughout the supply chain – in order to prevent such losses. These conditions have a major effect on freshness, and poor cold chain management results in spoilage and other conditions that make products unsuitable for stocking.

Financial considerations notwithstanding, the cold chain is also crucial to the food, chemical, and pharmaceutical industries' compliance efforts. For example, federal penalties can be thousands of dollars per violation when regulators find that perishables have not been stored within federally mandated levels to ensure food safety. The risk of drugs stored in inappropriate environments can be orders of magnitude higher. Wireless sensor networks can provide actionable

## Set it and forget it

Industrial environments pose a big question for any wireless network: Can needed reliability and power efficiency be delivered to truly *set and forget* the network over years? Dust Networks has developed wireless sensor networking that tackles this challenge, helping large industrial sites extend monitoring and control capabilities including points not previously measured due to the complexity and cost of reaching them.

Dust Networks' SmartMesh products are built to be highly reliable, ultra-low-power, and scalable. They are designed with industry-standard IEEE 802.15.4 radio chipsets and utilize frequency hopping and continual network self-healing to maintain more than 99.9 percent network reliability for the life of the network. They utilize a time-synchronized communication protocol to enable deep duty-cycling; tightly limiting radio activity results in power efficiency allowing batteries to last 5-10 years.

A SmartMesh wireless system includes:

- Battery-powered nodes as shown in Figure 1
- A network manager
- An Application Programming Interface (API)
- Mesh networking software

These elements help make it easy for an OEM to integrate wireless sensor networking capabilities into new or existing monitoring and control systems.

For instance, an oil refinery needs thousands of sensors providing critical readings on pressure, flow, and temperature. Forgoing wires and linking these sensors via a reliable, low-power wireless sensor network helps process engineers add more monitoring points at a lower cost. These points can include new locations that were previously inaccessible to the operations team—and they can be left unattended for years. The data from the sensors can then be linked to an alert system that can trigger alarms to key personnel. The benefits from expanded monitoring capabilities are reduced costs, prevented disruptions, greater uptime, and ultimately improved production goals.

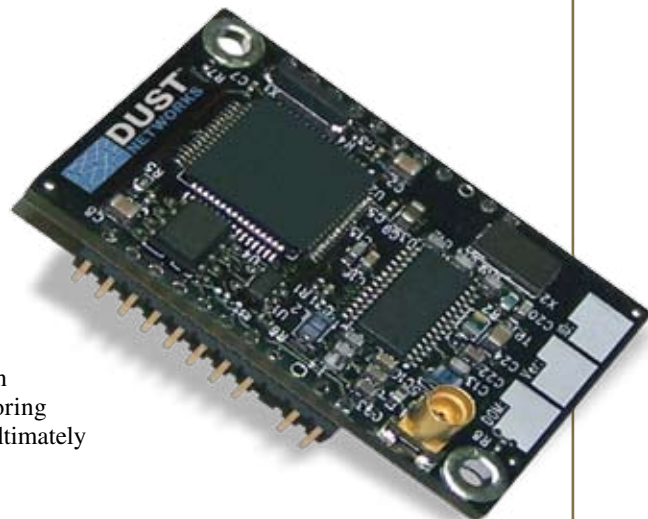


Figure 1

“The New Industrial Revolution is the long awaited convergence between industrial systems and reliable, flexible sensor networks.”

*driving embedded wireless networking technologies to the forefront of ubiquitous sensing. He invented the micromirror technology for MEMS-based fiber optic switches, and led various teams in engineering and business development to deliver leading market technologies. Rob holds a PhD and MS in Electrical Engineering and a BS in Mechanical Engineering from UC Berkeley.*

To learn more, contact Rob at:

#### **Dust Networks**

30695 Huntwood Avenue

Hayward, CA 94544

Tel: 510-400-2900

E-mail: [rconant@dustnetworks.com](mailto:rconant@dustnetworks.com)

Website: [www.dustnetworks.com](http://www.dustnetworks.com)

information about environmental conditions in physically challenging environments such as a cold storage container, a large distribution facility, or in a hospital. Information on temperature, humidity, and carbon dioxide levels alerts managers that preventative action must be taken. It can also provide evidence of compliance to regulatory bodies, thus avoiding fines, and alert managers to equipment that may be outdated or operating at less than optimal levels. The resulting savings are critical, and the low-cost nature of wireless mesh sensor networking eases adoption barriers.

#### **Machine health monitoring**

In many industries, especially manufacturing, equipment performance is of critical importance. In many plants, the maintenance of machine condition or operation has traditionally been performed manually. Bearing problems are one of the most common faults in industrial machines, causing unplanned downtime on essential production equipment. Typically, monitoring vibration to detect bearing problems involves manual recordings, or requires expensive systems or services. Another aspect of machine health monitoring, temperature monitoring, detects abnormal or suboptimal machine behavior in order to prevent equipment from further deterioration.

Wireless sensor networks continuously collect information about the condition and behavior of machines within plants.

Those responsible for equipment benefit from access to expanded monitoring information at greatly reduced costs, allowing them to prevent disruptions, achieve greater uptime results, and meet production goals.

#### **The New Industrial Revolution is here**

Spurred by global competition, rising energy prices, and a strict regulatory environment, the New Industrial Revolution is the long awaited convergence between industrial systems and reliable, flexible sensor networks. Today's plant managers and engineers can now expand the capabilities of existing monitoring and control solutions to new applications and be free from the physical and cost limitations of wiring to achieve effective adaptive control strategies. The ramifications for the industry as a whole are clear – greater insight into machine behavior, less unplanned down time, improved data analysis, and a safer and more productive working environment, which all translates into dramatic improvements in plant operations, reduced costs, and increased competitive advantage. **IES**



**Rob Conant** is vice president of marketing and business development and cofounder of Dust Networks. With a history of bringing technology to market in industries ranging from telecom to aerospace, Rob is focused on