# The Internet of Things

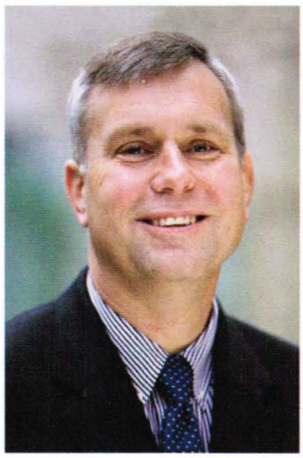
## From concept to reality: Plans for a network that connects everything and everyone everywhere are well under way.

By John Edwards

IMAGINE BEING ABLE TO POINT a smartphone, tablet or other device at an image of a place or item of interest and retrieve instant, detailed information about the object, with text laid over the image. Move the device around a landscape or room and the text changes along with the images. Augmented reality, an emerging field that will let users see their world in entirely new ways—literally—is perhaps the boldest application to be powered by the "Internet of Things" (IoT), a network that promises to connect everything and everyone everywhere to everything and everyone else.

Other potential IoT applications run the gamut from improving supply-chain visibility to helping people locate misplaced keys (see "Unlimited Potential" on page 38). But what all these applications have in common is the concept of ubiquitous connectivity.

The IoT's roots were sown in the early 1990s, when the Internet began allowing people to connect with each other. Then, RFID came along to enable the tracking and monitoring of various types of inventory and business assets. "We are entering an age where not just everyone will be connected, but everything will be connected—an Internet of Things—a merging of the physical and digital world as we have



*Simply put, the Internet of Things implies the ability of almost anything to communicate with any other thing via the Internet.*

—PAUL STEINBERG

never seen before," says Paul Steinberg, Motorola's chief technology officer.

The implications of such a network are far-reaching, perhaps even profound. The technology has the power to revolutionize the way people work, shop, travel, learn and entertain themselves, by enabling them to interact with the things they use all the time in an unimaginable number of ways. "Simply put, the Internet of Things implies the ability of almost anything to communicate with any other thing via the Internet," Steinberg says. "This implies evolving from person-to-person communication to machine-to-machine communication and, finally, object-to-object communication."

The basic IoT concept has been knocking around for more than a decade. In 1999, several RFID visionaries created the Auto-ID Center at the Massachusetts Institute of Technology, which was sponsored by several organizations and corporations, including Motorola. "This was important in the evolution of RFID technology, as it created a center that brought industry, academia and the standards communities together with an express goal of making RFID technology ubiquitous," Steinberg says.

Kevin Ashton, a cofounder of the Auto-ID Center, is generally acknowledged for coining the phrase the Internet of Things. "Kevin has been one of the key visionaries in our field, and was among the first to see the vast potential of RFID technology," Steinberg says. "He foresaw the myriad applications possible and their potential to benefit society."

Of course, connecting everyone and everything in the world isn't simple or easy. Transforming the IoT from an interesting concept into reality requires the development of a complex technological foundation based on standards covering a wide range of network and device operational and compatibility requirements. This work is already under way. Steinberg says: "In addition to the wired backbone of today's modern Internet, there are four wireless technologies that are enabling the Internet of Things: LAN [local area network], WAN [wide area network], short-range device-to-device [communication] and RFID."

*The IoT is an evolution of RFID rather than something entirely new... it is not, in itself, one particular application or one particular technology.*

—HENRI BARTHEL

Looking into the future, the IoT's sheer scale involves numbers usually reserved for discussions on the nature of the universe. "One analysis put forth the estimate that [the IoT will include] connectivity among 50 to 100 trillion different objects, with each human being surrounded by 1,000 to 5,000 distinct objects," Steinberg says. "RFID, which imposes a cost of only pennies per tag, enables the cost-effective connection of such a large number of objects."

## Building the Foundation

THE IOT IS AN EVOLUTION of RFID rather than something entirely new, says Henri Barthel, VP of system integrity and global partnerships for Brussels-based GS1, the organization dedicated to the development of global standards and solutions to improve supply-chain efficiency and visibility. "The IoT is not, in itself, one particular application or one particular technology," he says. "It's an assembly of different types of applications, different types of technologies."

The IoT will be like today's RFID systems, only more powerful and pervasive and, in

many cases, will draw from a more flexible technical foundation. While serialization will still play a major role in IoT systems, unique serial numbers won't be absolutely necessary for all tagged objects, marking a major change from traditional RFID systems. "I could create an Internet of Things application that wouldn't care which widget it was, just as long as it was a widget of a particular type," says Stephen Halliday, an RFID standards expert and president of High Tech Aid, an RFID consulting firm, in Gibsonia, Pa. A nonserialized object could be something as ubiquitous as an advertising poster that activates a video ad and discount coupon on a user's smartphone. "It could be any one of a thousand of those widgets, all the same, that would trigger an event," he says.

*I could create an Internet of Things application that wouldn't care which widget it was, just as long as it was a widget of a particular type.*

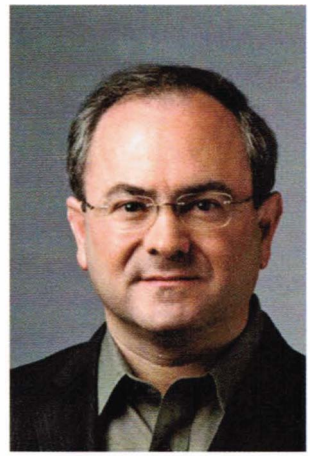
—STEPHEN HALLIDAY

Local and wide area networks will form the IoT's backbone by providing a continuous blanket of connectivity. "But it is RFID—particularly passive RFID—that makes it economically feasible to bring literally any and every item into the network," Steinberg says. He notes that the widely used ISO/IEC 18000 series of RFID standards will continue to be important in the upcoming IoT world. "The ISO/IEC 18000-6 [Part C] standard for passive UHF, which is based on the work of EPCglobal GS1 and ties directly back to the Auto-ID Center, is perhaps the key standard to realize the vision of the true Internet of Things," he says.

Near-Field Communication (NFC) technology, supported by the ISO/IEC 14443 standard, promises to extend the IoT's reach to millions of people by bringing a growing number of NFC-compatible smartphones into the loop, says Victor Vega, director of RFID solutions for NXP Semiconductors, in San Jose, Calif. "NFC is quickly becoming a social enabler and a popular technology for the public, helping end users gather additional information about objects and helping to link them to [other] objects and locations," he says.

While many basic IoT supporting standards are already in place, "The poor economy in Europe and elsewhere is slowing standards development," Halliday says. "Companies, as a whole, have much tighter budgets, and they're not as interested in being involved in standards as they used to be," he explains. "So we see far fewer people participating [in standards projects] and far fewer companies willing to pay the money to participate—I think standards are a problem right now."

With both standards setters and adopters facing serious economic and business challenges, it will likely take at least several more years for IoT specifications to coalesce into a mature, ready-to-use tool set. Even then, the development landscape will probably be far from settled. "I think there will be competing standards that will exist side by side," Halliday says. "It may be very useful, for example, to be able to use your NFC card to open a door or buy a ticket as part of a greater Internet of Things. But NFC may not be particularly useful at cataloging items in your refrigerator."



*NFC is quickly becoming a social enabler and a popular technology for the public, helping end users gather additional information about objects and helping to link them to [other] objects and locations.*

—VICTOR VEGA

## On the Road to Everything Everywhere

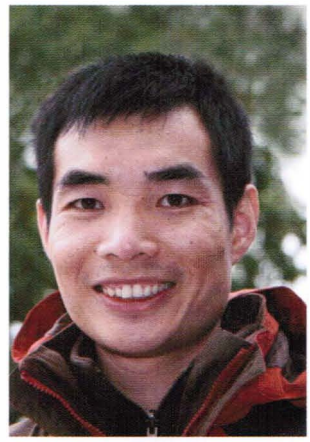
ALTHOUGH IOT STANDARDS are far from complete, some organizations—particularly in Asia—are leveraging existing RFID protocols to develop IoT-like solutions. The U.S. govern-

ment has not introduced any funding initiatives specifically earmarked for IoT projects, Halliday says. In Europe, after an initial spurt of enthusiasm and several trial projects, IoT development is now lagging. "We have to keep in mind that at the moment, people are tightening their belts and thinking about how much they spend," says Mark Harrison, director of the Auto-ID Lab at Cambridge University, in England. "They may not be willing to spend large amounts of money to embrace this Internet of Things. If it's available at very low cost, as a promotional feature or as an extra benefit to an existing product, then [businesses] will start to embrace it."

But enthusiasm for the IoT is building rapidly in China, according to Jeremy Liu, technical director of the U.S. division of Invengo Technology, an RFID systems developer in Shenzhen, China. "The Internet of Things is a very hot topic in China, where people know that RFID can enable it," Liu says. "People are focusing on how to use RFID and what RFID can do—RFID and now the Internet of Things. I think it's much more popular in China than it is in the West."

Halliday agrees, noting that at the end of last year, China announced that the Internet of Things was written directly into its five-year plan. Barthel, meanwhile, says he's seen an upswing in the number of IoT conferences being held in China. "Basically, they copied programs you could see in other countries, mostly Europe," he says.

Other Asian governments also are focusing on the IoT, Halliday observes. "I know the Korean government is financing things," he says. And he points to Japan's Tokyo Ubiquitous Technology project, which includes a neighborhood and attraction automated sightseeing



*The Internet of Things is a very hot topic in China.*

—JEREMY LIU

*We have to keep in mind that at the moment, people are tightening their belts and thinking about how much they spend.*

—MARK HARRISON

system. A person walking through the feasibility experiment area with a smartphone will have his or her current location identified automatically. This allows the user to obtain information on nearby shops and restaurants, tourist attractions, events and transportation. The participant also can access a "virtual tour guide" and other functions that provide brief descriptions of key sights.

Some experts see the IoT taking off as standards fall into place and businesses become more comfortable with the idea of sharing supply-chain data for their mutual benefit. "I believe that business intelligence applications will lay the groundwork on the Internet of Things... and become its most important application," says Antonio Rizzi, professor of industrial logistics and supply-chain management at Italy's University of Parma. "Business intelligence gathers data from different data warehouses and puts all this information together, making it possible to determine what's going on in the supply chain in real time." The IoT promises to help shippers

## Unlimited Potential

**Many emerging technologies** promise unlimited uses. But the Internet of Things (IoT) may actually deliver on that promise. Speakers at a 2010 IoT conference in Tokyo, for example, discussed health-monitoring systems to support an aging society, distributed awareness to predict natural disasters and facilitate preparation and recovery, track-and-trace systems to reduce traffic congestion, product lifetime information to improve recyclability, and transparency of transportation to reduce carbon footprints. Here's a sampling of other potential IoT applications.

In logistics, the rich data supplied by IoT systems is expected to pave the way for faster, safer shipment of nearly all types of products. "For example, a smart tag might offer temperature and historical information about a fragile object that requires careful climate control," says Paul Steinberg, Motorola's chief technology officer. "This would allow an enterprise to validate the integrity of a product throughout a shipping cycle."

The technology also has the potential to reshape the way companies build products, guarantee quality, run production lines and maintain equipment. Examples include "verifying the proper attachment to a tool, enabling process optimization or establishing brand protection, like ensuring that only authentic consumables are used with their appliances," says Victor Vega, director of RFID solutions for NXP Semiconductors. "This protects revenue and limits liability, as well as reducing the number of warranty issues related to counterfeit products."

There are benefits for consumers, too, such as IoT-enabled product authentication. "With the prevalence of Internet purchases, consumers often inadvertently acquire counterfeits that do not meet manufacturers' or consumers' quality or longevity expectations," Vega says. "In many instances, not only will [IoT] technology help identify or curb counterfeits for the brand

follow a load beyond the warehouse or distribution center. "Information about whether goods are in stores, or properly placed on shelves, or waiting in the back room instead of in the shopping area—this is important information that companies are striving for," Rizzi says.

Despite the current challenges, Steinberg believes it's only a matter of time before there's a surge in IoT deployments. "RFID tagging will become ubiquitous and buildings... will incorporate RFID into their infrastructure, as they are doing with Wi-Fi today," he predicts. Ubiquitous RFID will enable an entire building, campus or community to be "instantaneously illuminated," to detect, read and sort all the RFID tags located within, to conduct an immediate site inventory. "This may take more than a few years to reach a similar point of where we are today with wireless," Steinberg says. "But the benefits to individuals and enterprises that the Internet of Things concept offers suggests that it will happen sooner rather than later." ◘

*I believe that business intelligence applications will lay the groundwork on the Internet of Things.*

—ANTONIO RIZZI

owner, but it helps protect the consumer as well."

IoT applications could be a boon for the chronically disorganized. "Imagine that every asset in your home has an embedded RFID tag," Steinberg says. "All of a sudden, you now have 'smart objects' that can tell you what they are, where they are and their present condition or health. Have you ever misplaced your keys or wallet? [IoT] applications that help you identify and locate all of your personal assets would be great for that."

Experts see augmented reality (AR) technology being used in a variety of ways. Text superimposed over images of office buildings, storefronts, people, vehicles, rooms, artworks, doors, theaters, store products and just about anything else in the real world will give viewers fast facts on what they're looking at, what's about to happen or where they need to go. Links embedded in the text will lead users to Web pages providing enhanced insight, such as a building's history, the professional background of someone sitting at a conference table, a car's repair history or the story behind a museum painting.

AR also has many potential business applications. In manufacturing, plant floor supervisors could obtain at-a-glance statistics on a production line's status simply by snapping a photo of the equipment. A storage facility owner or manager might use the technology to see who is leasing a particular locker, as well as the leaseholder's payment history, just by looking at the unit through a viewfinder. Stock clerks, meanwhile, could enter a storeroom and view inventory levels at a glance.

AR isn't limited to handheld devices. "One might be able to look through an augmented display—goggles, eyeglasses or some form of heads-up display—and have specific objects, points of interest or locations highlighted and augmented in the display in some manner," Steinberg says. "For example, if one is trying to locate a specific tag that represents an item or a location, a display might indicate where the item is located or provide visual directions to the item." Additional information about an object might be presented in the form of text highlights or graphics. "A heat map might be used to indicate temperature or radioactivity level of a particular item," he says.

Google is rumored to be working on a glasses-based AR system. The system may relate to a patent the company holds on eyeglasses containing RFID tags.

Rapid advancements in visual recognition technology are helping to make AR both usable and reliable. Says Justin B. Patton, managing director of the RFID Research Center at the University of Arkansas: "We're getting close to the world of being able to recognize items by their appearance, and having a computer do that automatically." —*J.E.*