Machine-to-Machine Technology Gears Up for Growth

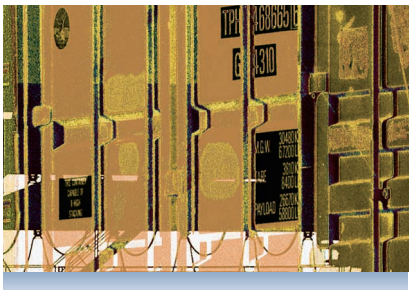
George Lawton

There are many more machines—defined as things with mechanical, electrical, or electronic properties—in the world than people. And a growing number of machines are networked. Harbor Research, a technology consultancy and analysis firm, estimates that by 2010, at least 1.5 billion devices will be Internet-connected worldwide.

The increasingly popular machine-to-machine technology plans to take advantage of these developments. M2M would leverage connectivity to enable machines—including manufacturing and telecommunications equipment, data centers, storage tanks, property-security products, industry-specific assets such as public-utility systems, and even vending machines—to communicate directly with one another.

For example, M2M could enable a set of devices that monitor traffic in a city to communicate data to the city's stoplights to regulate the flow of vehicles. Or it could let technician-monitored machines receive information about problems with manufacturing equipment. The technology could also help with data collection, remote control and monitoring activities, robotics, offsite equipment diagnostics, vehicle fleet management, and telemedicine.

M2M is based on the idea that a machine has more value when it is networked and that the network becomes more valuable as more machines are connected, noted Rob Conant, vice president of business development at Dust Networks, a sensor-networking vendor. With M2M, machines could not only collect data about other devices but also, in some cases, take action based on the information.



Sensors that gather the information that some M2M systems transmit are becoming more widely used and thus are driving demand for the technology, noted Mark Pacelle, vice president of marketing at Millennial Net, which makes hardware and software for low-power, wireless sensor networks.

The lower cost of sensors and initiatives for integrating them into larger systems are also increasing the approach's popularity. The biggest new trend is that vendors are expanding M2M into wireless technology, using radio chips or modules they can attach to almost any device or machine. Thus, M2M is gearing up for exponential growth. In fact, Conant said, this approach may be the next major Internet application.

Despite its considerable upside, M2M is still relatively new and faces significant obstacles to success such as cost-effectiveness and managing huge data streams from systems with multiple sensors.

BEFORE M2M

The key M2M components have been around for years. However, expensive communications equipment and the lack of technology standardization, which kept costs high and made implementation more difficult, prohibited M2M's use in all but high-end commercial or scientific applications.

Don Wallace, vendor M2M Data's vice president and chief operating officer, said that 30 years ago, companies began deploying manually controlled analog systems fed by proprietary hard-wired sensors to enable machines to communicate directly.

In the early 1990s, digital technology drove the development of supervisory control and data acquisition systems. SCADA is based on technology in which a centralized server reaches out and polls field equipment regularly. However, SCADA's field-based nodes can't push data to the server.

SCADA is also based on proprietary technologies, so its costs never dropped enough to make widespread deployment practical. Instead, the technology was best implemented as part of large projects. In addition, its implementation can be complex and time-consuming.

HOW M2M WORKS

Unlike SCADA, M2M works with standardized technologies—such as TCP/IP, IEEE 802.11 wireless LANs, cellular communications technologies, and wired networks such as Ethernet.

Using standards allows easier device interoperation in M2M systems and facilitates using mass-produced, standards-compliant equipment, which makes implementation less expensive,

simpler, and quicker, explained Wallace. M2M nodes can operate autonomously, push information to multiple systems and other nodes, and make some decisions on their own.

With SCADA, sensors and controllers are hardwired to the host, which limits the number of sensors the technology can serve and the distance over which data can be transported. M2M is thus a more flexible technology.

Prominent M2M-related vendors include Crossbow Technology, Dust Networks, M2M Data, Millennial Net, and SensorLogic.

System elements

As Figure 1 shows, M2M-system elements include field nodes for sensing real-world conditions and events and for controlling physical devices, communications equipment for relaying data to centralized management applications and other nodes, and software for analyzing the input and for making decisions based on the analysis.

Field nodes can be sensors of properties such as temperature, humidity, flow measurement, and soil moisture, as well as controllers and actuators for machines such as air conditioners, elevator pumps, and traffic lights.

The sensors collect and aggregate data and then translate the information into analog signals and eventually to digital signals for transmission across a network. Centralized management software, based on information from the sensors and a set of rules, then sends commands to controllers or actuators, which issue the electrical signals necessary to make machines take action.

Wireless M2M

Wireless approaches add mobility to M2M and save money by eliminating the cabling-related installation and equipment costs involved in wired implementations. Wireless M2M systems transmit data in several ways, including single-chip radios or radio modules.

Driving wireless M2M. Wireless M2M has become more practical because of cost reductions in wireless communications technologies, as well as advances in their performance, functionality, and reliability. The technologies include cellular approaches; IEEE 802.11; Bluetooth, generally used for short-range device connectivity; IEEE 802.15.4 low-rate, short-range networks; the Zigbee protocols (www.zigbee.org), built on top of IEEE 802.15.4 for low-power monitoring, sensing, and control networks; radio frequency identification (RFID), which uses electromagnetic or electrostatic coupling to transmit status signals from tagged devices; and the IEEE 1451.5 wireless communication methods and data format for sensors, controllers, and actuators.

Mesh networks promise to drastically reduce M2M's power requirements and thus let remote sensors operate longer between battery changes. Mesh networks enable nodes to communicate with and pass data directly to other nodes, permitting the data to travel in short hops over long distances. Traditional networks send data from servers to individual nodes and back and thus are limited by their single-hop transmission range.

Lower costs and increased accuracy in sensors have made wide deployment easier and less expensive. "Now you can peel and stick them to any type of machine you need to monitor," said Millennial Net's Pacelle. Major cellular operators have developed services for M2M systems with rate plans that cost as little as $4.99 per month per node, noted John Andre, vice president of business development at Airdesk, an M2M systems integrator.

Andre said that for large M2M applications, integrating embedded cellular-radio modules—such as the Nokia 12 GSM or the Sony Ericsson GT48—into nodes can make sense. These modules translate and format data for transmission over wireless networks, thereby simplifying the connection to M2M systems, and are less expensive for many companies than developing their own equipment.

Using wireless M2M. Wireless M2M can be desirable for cost-sensitive deployments. In addition, wireless M2M networks let users track mobile assets like truck fleets or equipment in the field, the quantity and location of products in stock, and items in a vending machine.

Wireless M2M could also be embedded in projects where wires aren't practical, such as with sensors measuring the stress in walls or bridges.

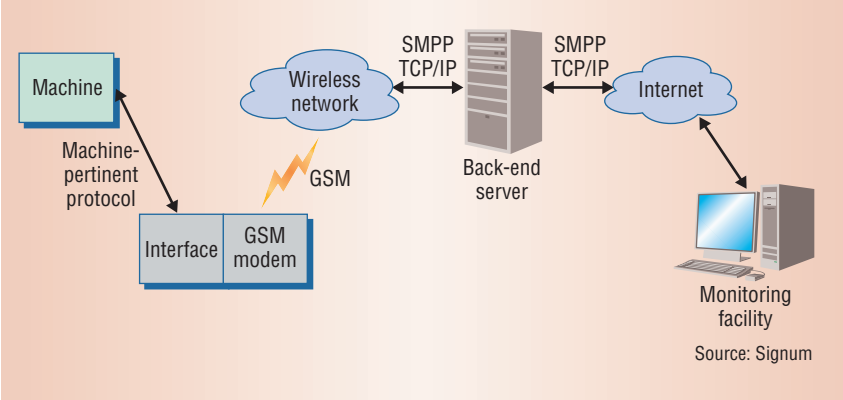


Figure 1. A typical wireless machine-to-machine implementation sends information on a machine's status to a wireless network via a modem, in this case one that works with Global System for Mobile Communication (GSM) cellular technology. Via protocols such as TCP/IP and the Short Message Peer-to-Peer Protocol, the system sends information to a back-end server, which processes the data and sends it via the Internet to the facility that monitors and controls the machine.

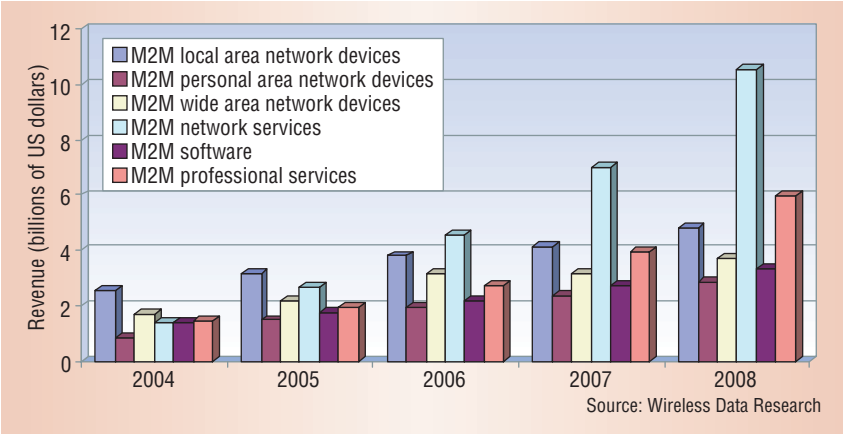


Figure 2. Industry observers predict steady growth in the entire machine-to-machine technology market, including devices, software, and services.

Wired M2M

While much of the excitement about M2M focuses on wireless deployment, wired systems are likely to be important in some situations. For example, in manufacturing plants, wired M2M systems could work despite steel or reinforced concrete in buildings and equipment, through which wireless systems' radio waves might not pass.

Wired M2M works basically like wireless M2M except for the wireless protocols and radio-based infrastructure.

Wired systems, which generally use Ethernet for data transmission, could be more secure than wireless systems in many cases because the signals are not broadcast through the air, according to Ian Barkin, an analyst with the FocalPoint Group, an M2M consultancy.

USES

M2M applications are used for monitoring activities or environments and for controlling devices or systems. For example, M2M could be used to monitor and control building temperatures, lighting levels, and security. Agricultural operations could use M2M to monitor soil moisture to set irrigation schedules to use water efficiently. In addition, M2M monitoring applications can be used for tracking merchandise and equipment that have sensors, such as RFID tags.

M2M-based control applications require systems to make decisions based on input from multiple sensors. For example, a network of distributed temperature sensors could control a heating system or motion sensors could detect when people are moving toward a building lobby and call an elevator.

Today, Wallace noted, most M2M deployments are in areas where high-value assets make it clear the technology will make or save money and thereby justify its cost, such as in the oil and gas industries, which use large amounts of expensive equipment.

Intel director of research Hans Mulder said his company's large M2M deployment at a chip-fabrication plant monitors equipment and has eliminated the need to frequently check machinery manually.

According to the FocalPoint Group's Barkin, the transportation industry is using M2M applications for purposes such as vehicle diagnostics and truck and cargo tracking. He added that medical facilities are deploying M2M applications for real-time cardiac monitoring and to track patients with memory impairments.

CHALLENGES

Despite M2M's promise, the technology faces several significant challenges. For example, Barkin explained, M2M will change some business processes by putting a greater amount of data in the hands of more people, requiring companies to better train employees.

Integrating M2M elements with one another and integrating M2M operations with larger systems will require better system-integration skills. And creating reliable networks, particularly complex mesh networks, for M2M systems could be complex and expensive.

Security is another important issue, as users don't want hackers to break into M2M applications designed to control, for example, building security or environmental-control systems. Currently, M2M applications generally use just the security provided by their networks.

Immature technology

According to Airdesk's Andre, the immaturity of M2M technology and development tools, as well as users' unfamiliarity with the challenges of implementing the systems, cause about 70 percent of M2M projects to fail.

However, Andre predicted that as the technology becomes more mature and users become more familiar with implementation issues during the next few years, project failures could fall to 40 or 50 percent.

Cost-effectiveness

One challenge facing widespread M2M use is the cost of nodes and radio equipment. Nodes cost $25 to $150 each, depending on the qualities measured, the degree of precision required, and the quantity of devices purchased at one time, said Mike Horton, CEO of Crossbow Technology, a sensor-system vendor.

Hardware, software, and networking costs will have to drop considerably for M2M to be practical for small, everyday uses such as vending machines, noted the FocalPoint Group's Barkin.

Over time, though, higher production volumes and more efficient integration within M2M systems will drive

down the cost of deploying nodes and communications equipment. In fact, Horton predicted, deployment costs will drop by about one-half every 18 months.

Big M2M applications

Because of the opportunities the technology creates, users want to scale up their M2M networks. For example, Mulder said, Intel currently has M2M deployments of 60 to 200 nodes but eventually will want to increase its implementations, with each fabrication plant having 4,000 and the entire company having 40,000 to 50,000.

However, even with today's M2M deployments, organizations face a major challenge in converting the large amount of incoming data into a standard format and then aggregating and analyzing it. This makes it difficult to continue scaling up sensor networks.

A solution, according to Mulder, is the development of standards for the way M2M systems aggregate, manage, interact with, and use the data collected by the various kinds of sensors. Current systems for handling such tasks are proprietary and expensive, so not many organizations can afford to use them. Standards would reduce the costs of these systems and let them work with various types of data.

Industry observers predict increasing popularity for M2M, as Figure 2 shows. For example, the FocalPoint Group has projected that manufacturers will produce nearly 880 million new M2M-enabled devices annually by 2010, compared to 15 million in 2003 and a projected 45 million this year.

In the process, the technology will grow. For example, considerably more intelligence will be embedded into remote nodes, which will increase M2M's usefulness. Crossbow's Horton said there is even talk of using M2M to make wearable firefighting gear that could monitor factors such as temperature and smoke exposure.

According to Harbor Research analyst Glen Allmendinger, the next few years will see increased M2M deployments, including large systems, and thus will be critical for the technology's future. However, he said, that future is not certain because of the complexities and other challenges in deploying the systems. ■

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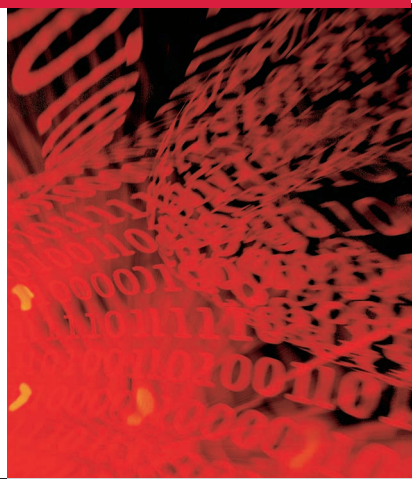

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