Communicating Machines Are Triggering an Embedded Revolution

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The introduction of the Internet has changed the way we communicate and run our businesses, with the count of people using it totaling over one billion strong. Yet a similar, but significantly larger, revolution is poised to take place in embedded computing with the advent of machine-to-machine (M2M) communications. This linkage of machines has enormous market potential and holds the promise of dramatically altering and expanding the landscape of embedded computing,

At its heart, M2M simply involves devices that can communicate over a network. These wired or wireless communications can be quite simple, offering only the ability to send data and to receive data and simple command-and-control parameters over the network. The specific network protocol or means of connecting to the network are not what's important. The key ingredient is the ability of a device to become part of something larger, resulting in enhanced information flow in numerous environments and markets. Market research estimates put the applications potential at well over a trillion devices by 2010 (Figure 1).

In some ways, M2M resembles traditional industrial control. Both involve communications among machines. But traditional industrial control networks, such as SCADA (supervisory control and data acquisition), have more restrictive requirements than M2M. Industrial control networks require reliable, real-time communications in order to fulfill their purposes. Individual SCADA devices depend on signals from the network in order to perform their functions properly, and they must receive information in a timely fashion. In many cases, these networks also require a human operator to process data, make control decisions, and issue commands.

M2M networks have no such restrictions. The primary purpose of M2M networks is not necessarily to control a process, but rather to simply gather and pass along data to a central server. As a result, M2M devices tend to be relatively autonomous, performing their functions with little or no input from outside sources. This allows the networks used to be tolerant of delays and even failures in communications. In turn, easing the network restrictions gives M2M networks wider range. Devices can be scattered across a large area - even worldwide - because they do not depend on time-critical information from the network. Although commands and parameter updates may come across the network, either from a human or a central server, the function of an M2M device does not depend on such communications.

> Embedded devices are getting the ability to autonomously exchange information via low-cost commercial links. Machine-to machine communication lets developers combine them in large, even, vast systems whose functionality is greater than the sum of its parts.

Low Cost Drive M2M

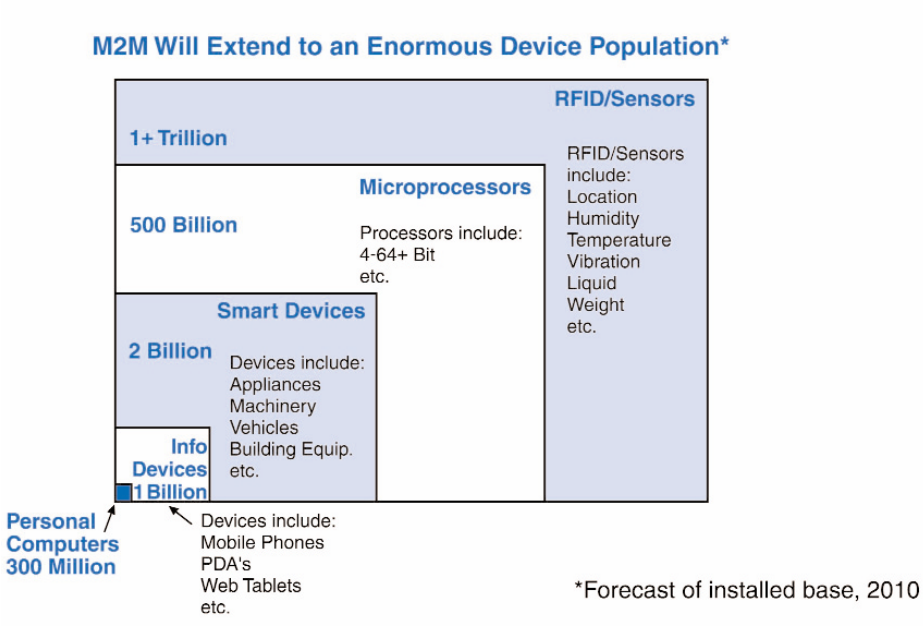
The rising interest in M2M systems has several drivers. One is the lowering cost and increasing performance of processors. Many devices that might have once used

hard-wired logic to provide a low-cost implementation can now be run as software on an embedded processor for the same cost, with the benefit of increased design flexibility.

Another factor driving M2M interest is the success of standards for robust and versatile communications channels. Networks such as Ethernet and protocols such as TCP/IP have permeated the industry, leading to high-volume production and thus lowering the implementation cost of hardware and software. The success has also ensured widespread design expertise, easing system development.

The growth in wireless systems has also spurred the development of M2M applications. While an M2M system does not have to involve wireless communications, freedom from wires provides design flexibility that greatly increase the scope of potential applications. As with the networks and protocols, the success of wireless systems has lowered the cost of hardware implementation through high volume production. Wireless transceiver modules are available for numerous standards, including Bluetooth, WiFi, cell phone, and satellite communications. (See Figure 2)

The common thread in all of these drivers is lowered cost. Many potential M2M applications provide value in proportion to the number of devices on the network. Automated wireless gas meter reading, for example, benefits the gas company by increasing the efficiency of meter readers and thereby reducing operating costs. The more meters the gas company automates, the greater the savings. A low per-unit implementation cost helps quickly amortize the investment needed to first establish the network.



By 2010, machine-to-machine communications could extend to a device population well over a trillion, according to estimates from The Focal Point Group (www.fpgroup.com).

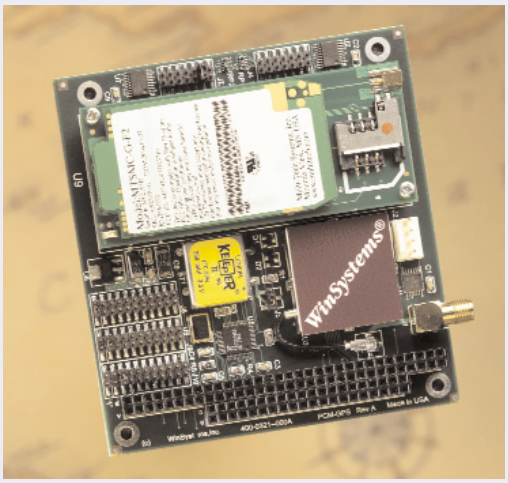
Figure 1

Other M2M applications provide benefits that do not directly reduce operating costs but instead increase the utility or flexibility of a device. A consumer appliance with communications capability, for instance, can receive upgrades or alert service personnel of imminent failures. Both activities increase customer satisfaction, potentially increasing revenue but without providing a direct line-item benefit. Such features will not command a substantial price premium from consumers, however, so they must be inexpensive to implement on a unit basis.

Fortunately, the cost of adding communications capability to an embedded system, especially wireless communications, is low and dropping. This is fueling an increase in M2M applications that is sure to accelerate. Any application that can benefit from the easy exchange of information is a candidate for an M2M system. So are applications that can extend their geographic range or their scope by using wireless connections. Similarly, applications that are impractical because of the difficulty in making a wired connection can become feasible when wireless connections are used.

Adding Communications Boosts Value

An example can help illustrate the growth potential of M2M systems. Consider a roadside traffic sign, the kind that flashes a message about road conditions or public service messages (see Figure 3). These sign systems use embedded processors to handle the message display and manage battery power. The on-board processor may have a selection of pre-defined messages in memory that are user selectable or may even have a means of accepting custom messages from a human operator. The sign system might



A representative M2M module for mobile, industrial applications, such as WinSystems' PCM-GPS, includes either a CDMA or GSM cell modem for communications and a GPS receiver for determining location.

Figure 2

also be tied in with traffic sensors to make an automated traffic control system. The sensors would monitor the passage of cars and determine if they are slowing down, indicating a jam in the making. The signs could then automatically begin announcing the traffic conditions ahead without human intervention.

Adding communications capability can greatly increase the sign's utility. As part of an M2M network it can communicate its status to a central office and receive commands. Thus, the sign can inform a central office of its need for maintenance or battery replacement. It could also accept message downloads from the network, eliminating the need for an operator to update or change messages. Traffic-detecting signage could also inform a central office of local traffic conditions, allowing the central office to update the signs with messages suggesting alternative routes based on the traffic levels that those other routes show.

If the sign were transportable and had GPS (global positioning system) capability, it could inform the central office of its installed location automatically, eliminating the need for manual location tracking. This would allow operators to simply position signs without having to register them. The office can customize messages to each sign based on its location and coordinate the messages displayed by a series of signs, without any operator involvement beyond placement. The position information could also allow the system to alert police when an unauthorized move takes place (i.e., the unit is being stolen).

The addition of communications capability to the sign's hardware thus opens the door for several new functions and applications, expanding on and automating the original system's function. The addition of GPS expands the system's potential even further with a minimal unit cost increase. Linking these devices in as part of a larger system creates whole new applications for the signs beyond their original use. This, then, is the essence of the M2M revolution: a relatively minor addition of communications capability unlocks the potential for a wide range of application possibilities.

Focus on Technical Strengths

Developers seeking to capitalize on the rising wave of M2M possibilities will need to carefully evaluate their technical strengths against the myriad communications options open to them. These options include wired Ethernet, WiFi, WiMAX, ZigBee, Bluetooth, cellular wireless, satellite communications, POTS (plain old telephone system) and TCP/IP-based channels. Because these options are standards-based, however, many developers will want to consider purchasing the appropriate hardware and software expertise and concentrate on building the application software.

The communications option selected for an application will depend strongly on the application

Adding M2M communications to something as simple as a traffic sign allows remote management and message updating, greatly increasing the sign's utility while reducing its operating costs.

Figure 3

requirements. Wired connections are among the easiest to implement at the system level, but may not be practical for the actual field installation. As a result, many M2M systems implement a wireless connection, prompting the common belief that M2M refers only to wireless implementations. Many M2M systems can be implemented with wired communications links, however, if device locations already possess or can readily accept wiring. It all depends on the application.

When choosing a wireless communications channel, the geographic range of the installed device base, the cost of the communications channel on a per-bit basis, and regulatory requirements should all be carefully evaluated in the early stages of system development. Devices that cluster close together, as in a single building, are candidate for channels such as WiFi. When an application needs city- or country-wide coverage, however, cellular technology may be the appropriate choice.

Developers should also be prepared to spend considerable effort at compliance testing when choosing a wireless communications link. Governments will demand testing to show compliance with spectrum usage regulations. Protocol review boards, such as the CTIA (Cellular Telecommunications and Internet Association) will also require compliance testing to ensure a device's compatibility with the network. Finally, the carrier service providers, such as cellular companies, will want testing to ensure a system will not affect service to other customers. As with the communications hardware and software, developers may often choose to purchase the radio system elements and expertise and concentrate on applications development.

The ability to purchase system components, which stems from the standards-based nature of M2M, is a key component of M2M's potential. Smaller system development companies can buy rather than build the elements of their systems and then focus their efforts on leveraging their application expertise. Hardware and software development companies, such as WinSystems and nPhase, can focus on providing the system elements, meeting the needs of a wide customer base. The potential market is large enough for companies of all types to carve out a niche, including consulting, testing, and system integration vendors.

Ultimately, M2M will fundamentally change the nature of embedded systems. With communications capability readily and inexpensively integrated, there will be little benefit in having an embedded design that cannot communicate. Those that can communicate will gain an ability to become part of something larger than themselves, enhancing their inherent functions with the all the power that comes from the free exchange of information. And as the last decade's experience with the Internet shows, the power of information can be transformational.

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