Photo courtesy Bsquare

 By Warren Webb, Technical Editor

Directing distant devices

GET A JUMP ON YOUR COMPETITION BY ADDING A MANAGEMENT SYSTEM TO YOUR EMBEDDED DESIGN TO REMOTELY UPDATE FEATURES, REPAIR BUGS, COLLECT DATA, AND ENABLE NEW SERVICES THROUGHOUT THE PRODUCT'S LIFE.

Network connectivity has become the norm in new embedded-product designs. Network connections enable remote operation, data storage, software updates, troubleshooting, and performance monitoring. You can even increase the apparent performance of your product by offloading computing tasks to remote machines. However, this connectivity also creates new headaches. With potentially thousands of devices in the field, how do you manage the data transfer and guarantee the software configuration of each unit? As with any design problem, there are alternative approaches to consider along with off-the-shelf remote-management-software products that you can integrate into your embedded design.

First, it is important to differentiate between device-management tasks and the primary mission of the embedded system. For example, the primary mission of a copier's embedded processor is to interact with the user's control panel and monitor sensors and control the sequencing of motors to produce copies. Management functions, which you can initiate remotely over a network, include monitoring the toner level or paper supply, retrieving usage statistics, and updating the processor firmware. The firmware changes can be to correct bugs or add new features that were unavailable in

the original product. Management data from all devices in the field provide valuable feedback to troubleshoot inherent problems or improve the next hardware iteration.

Embedded-device vendors use a variety of techniques to manage processor firmware. The simplest software-management strategy is not to update it at all. In fact, most embedded devices have no provisions for changing the firmware. Toys, watches, calculators, telephones, entertainment electronics, and household appliances are all examples of embedded devices that come with preloaded software that you cannot upgrade. Customers are stuck with the features available at the time of purchase and must replace the entire unit to take advantage of new innovations or services. Most consumers are currently accustomed to this type of product; however, user expectations will change as connectivity shows up in more embedded products.

STAMP OUT EPROMs

Another firmware-management technique is to manually remove and replace the programmable devices within the embedded system. This approach can have enormous support costs especially if the embedded systems are expensive and located at remote site. Avionics systems are good examples of embedded devices that you manually update. When an airline operator detects a critical avionics bug, the Federal Aviation Administration may ground all similar devices until it finds a fix. The avionics manufacturer determines a software modification, revalidates the code, and updates the software in a sample unit. The manufacturer ships replacement systems to aircraft sites only after a complete final test of the entire avionics unit. Because of the high cost of replacements, the manufacturer serially updates units as they are returned. Manufacturers that choose or are forced into this expensive firmware-management strategy use extensive simulation and testing to prove proper operation before deployment.

The transition to automatic software-configuration management began with the serial-debugging console. Users could bring up a serial terminal, connect it to the embedded system, and then troubleshoot or modify the software through a small resident-monitor program. The serial console provided a cheap, easy-to-implement, and reasonably secure local software-management system. With telnet client software in the embedded system, you could even access the device from a remote terminal. The serial-console interface is text-based and requires no software external to the embedded product.

As enterprise-level TCP/IP (Transmission Control Protocol/Internet Protocol) networks evolved, users developed the SNMP (Simple Network Management Protocol) to provide a method of managing servers, routers, hubs, and bridges from a central-management computer (see **sidebar** "Keep it simple"). The device manufacturer usually provides matching SNMP software for the managed device and the management computer. Users can configure network devices, monitor performance, find faults, detect inappropriate access, and audit network usage. SNMP is a popular approach for the IT (information-technology) departments of large organizations because they are managing a large number of expensive devices connected to the same network. Hewlett Packard's OpenView software is a widely used SNMP management-computer-software package that you can use with Windows NT or Windows 2000 networks.

MANAGE BY WEB SERVER

Although you can manage remote embedded devices with SNMP, you may find

AT A GLANCE

- Network access to embedded devices enables remote debugging, software upgrades, data collection, and configuration management.
- Designers can configure the software-management system to initiate updates from a management server or from the remote embedded device.
- Remote-management technology for embedded devices borrows standards and techniques from enterprise-network management.
- Manufacturers can more quickly ship embedded products with the ability to correct bugs and update firmware in the field.
- Remote updates enable subscription content and pay-per-use services to give device manufacturers new revenue sources.
- Off-the-shelf hardware, networking software, and remote update products offer an easy path to long-distance device management.

KEEP IT SIMPLE

In 1988, the Internet Engineering Task Force developed the SNMP (Simple Network Management Protocol), which has since become the standard for managing enterprise-networked devices. SNMP is an approved Internet standard defined in RFC (Request for Comments) 1157 (**Reference A**). In a typical setup, software in a central NMS (network-management station), the client, communicates with SNMP agents, the servers, in each device. A treelike hierarchy known as an MIB (management-information base) (RFC 1213) specifies network-management variables or objects, which define the properties of the device. The networked device can asynchronously report unusual events to the NMS by sending messages or traps containing the affected variables. The NMS can also remotely query or modify the device's MIB data with GET or SET commands. Device manufacturers supply the SNMP agent and a corresponding manager for the NMS.

REFERENCE

A. Internet Request For Comments (or RFC), Ohio State University, Computer and Information Science, www.cis.ohio-state.edu/hypertext/information/rfc.html.

Figure 1 The $50 SitePlayer Web server from NetMedia packs a 10BaseT Ethernet controller, a flash Web-page memory, a processor, a serial interface, and networking software into a 1-in.² module.

several problems that make this approach difficult to integrate into a workable system. A dedicated management computer is a significant expense unless there are a large number of embedded devices to spread the cost. SNMP software also expects a constant connection between the network-management station and the managed device. In addition, SNMP uses UDP (User Datagram Protocol) to send packets, a transmission scheme that does not guarantee error-free delivery. And last, SNMP was not designed to efficiently update the entire embedded-device firmware.

The latest device-management approach is to use a Web-based HTTP (HyperText Transfer Protocol) server as a network-management agent. This protocol is the same one that serves Web pages in response to a URL address. The user can interface the remote device with any Web browser, thereby eliminating the need for a dedicated network-management station, software, and specialized training. The HTTP server sends packets by TCP, a robust protocol that ensures Internet delivery of control information and data. A management system based on HTTP can take advantage of Web-security routines to minimize unauthorized access. The downside of HTTP for management applications is that Web servers provide only data on demand. The user must request specific information from a server URL address. Periodic checks may show that the copier has been out of service for hours. When you combine HTTP with a way to send alerts, such as e-mail, the protocol is a viable remote embedded-device-management system.

Combining HTTP management with JavaScript and XML (eXtensible Markup Language) removes some of the limitations inherent in a one-way Web-server approach. XML allows Web-page designers to create their own customized tags for exchanging data between applications and organizations. Likewise, JavaScript is an open design language that enables interactive Web sites. Both technologies are platform-independent, which is ideal for embedded-device networks that may comprise a variety of processor types.

Off-the-shelf Web servers let you easily and simultaneously incorporate Internet connectivity and remote-device management (**Reference 1**). Many of these small Web servers are drop-in

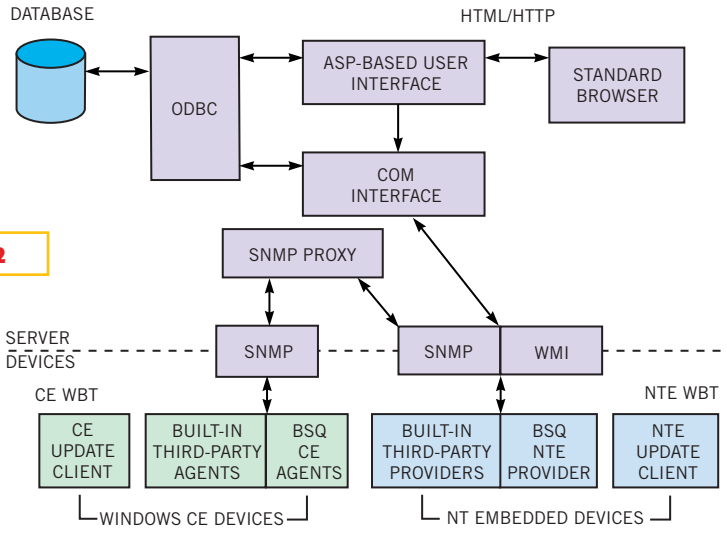

Figure 2 Bsquare's Remote Device Administrator allows users to access the server from any workstation or device with a standard browser and network authorization.

FOR MORE INFORMATION...

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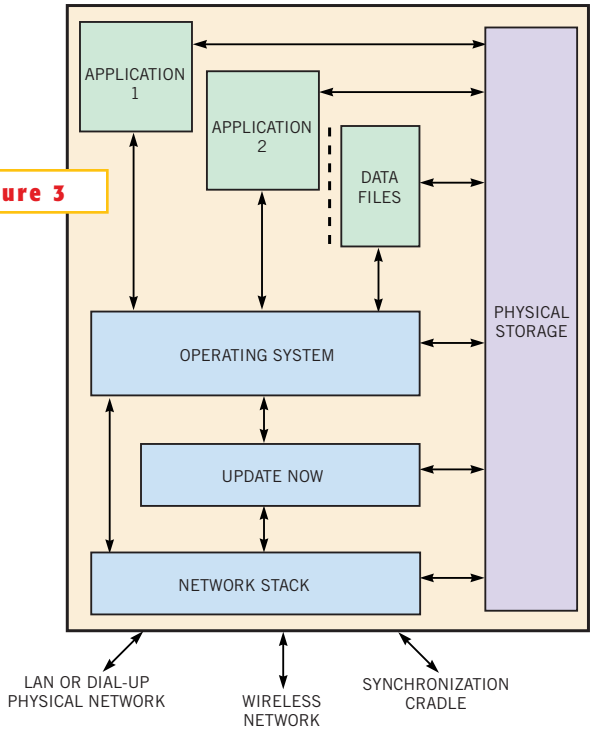
boards that provide a serial interface to your embedded product on one end and a 10BaseT or 100BaseT Ethernet interface on the other end. The Web server now includes all networking software, leaving designers free to concentrate on the embedded application. For example, the $27.95 (1000), 1-in.^{2} SitePlayer from NetMedia is an inexpensive plug-in Web server (**Figure 1**). If your processor can support the extra load, you can integrate the Internet tasks into your application with Web-server and networking software from operating-system vendors.

An effective remote-device-management scheme may even change the way you design embedded systems. Several vendors have adopted the strategy of shipping a product without extensive software testing to beat the competition to market. The idea is that companies can later fix bugs, because they can easily update the firmware in the field. Another strategy is to offer an inexpensive device with limited functions and then try to sell the user on extra features or services that you enable remotely. Both approaches require solid, general-purpose hardware platforms that you can adapt to unplanned software applications.

Another consideration as you build a remote-device-management system is who will be responsible for making the updates. If employees of large companies use your embedded device, then the companies' IT departments will want to maintain configuration control on each unit along with periodic backups. Your task will be to update the IT department with firmware changes, and IT will update individual embedded units. Third-party vendors also couple update services with subscription content.

Figure 3



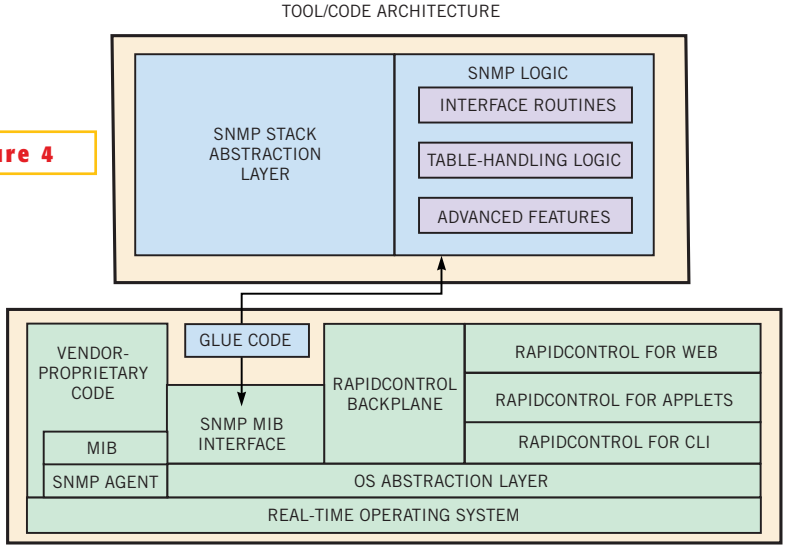
The UpdateNow technology from Marimba enables designers to add self-updating features to embedded devices with a set of libraries and application-programming interfaces.

PAY PER PROGRAM

Remote-management-software vendors also offer management functions integrated with a service-delivery package. Espial's DeviceTop and DeviceServer software packages give device manufacturers the tools to specify personalized information for delivery to individual users and to record usage and billing data. DeviceServer also modifies the delivered information depending on the specifications of the embedded device. For example, if a mobile phone requests a Web page, the server software strips out graphical information and reformats the text for the small display. If the remote device is a PDA (personal digital assistant), the software fits a limited graphical page into the display size.

Some remote-device-management-software vendors specialize in specific operating systems. Bsquare Corp provides the Remote Device Administrator for Windows NT 4.0 or Windows 2000 servers and corresponding update clients for Windows CE and NT embedded devices (**Figure 2**). Bsquare software enables you to initiate remote updates from either the server (push) or the embedded device (pull). Push technology allows you to actively manage the device from a central location using the Remote Device Administrator server software. With pull technology, most of the intelligence lies in the embedded device. The device can pull down updates from any file server that supports an IP-based FTP (file-transfer protocol). The RDA server costs

Figure 4



With MIBway for RapidControl from WindRiver Systems, designers can add Web-based management to SNMP devices without re-creating MIBs (management-information bases).

$995 for as many as 25 remote devices. A $595 payment unlocks server access for an additional 100 users.

Another system designed to work with Windows CE devices is the DeviceRMS remote-management system from Intrinsyc Software. DeviceRMS extends the functions of the vendor's Web server to provide remote administrative capabilities on an embedded Windows device. DeviceRMS includes managers for device-file updates, application installations, process control, and registry editing. A remote manager is useful for Windows CE developers working with headless devices. The deviceWeb manager and companion Web server occupy approximately 200 kbytes of memory depending on the processor.

Extended Systems offers a remote-management system that targets mobile devices, such as handheld computers and mobile phones. Company officials realize that it is practically impossible for organizations to force employees to use a standard mobile device. Personal preferences and changing technology mean that corporations must support multiple devices, operating systems, and a wide selection of applications. XtndConnect server from Extended Systems enables users to synchronize mobile devices directly with company servers. This strategy bypasses the standard practice of connecting by serial link or modem to a PC that the company server, in turn, updates. XtndConnect Server costs $225 per user for fewer than 10 devices and drops to $95 for more than 1000 users.

YOU CAN EXPECT REMOTE UPDATING TO SOON BECOME THE STANDARD METHOD OF DEPLOYING AND MAINTAINING EMBEDDED DEVICES.

Marimba's UpdateNow technology provides embedded designers with a set of tools to implement a remote-management system. **Figure 3** shows how UpdateNow driver software interfaces to an embedded device's operating system and network stack. UpdateNow provides a set of libraries and APIs (application-programming interfaces) so designers can include update capabilities directly in the application code. For example, you can configure a device to check for updates every time it connects or when you run a specific application. You can also tailor updates for devices, delivering custom services or applications only to designated users.

REAL-TIME MANAGER

WindRiver, supplier of the popular VxWorks real-time operating system, offers more than one approach to remote-device management. Its MIBway for RapidControl package gives developers direct access to SNMP MIB (management-information-base) variables (**Figure 4**). Because virtually all of the network equipment now shipping requires SNMP manageability, MIBway allows you to reuse GET and SET routines without new code. WindRiver also includes provisions for remote management in its Tornado for Internet Appliances development environment. A content manager permits developers to remotely modify the code base for a target system by adding, deleting, or updating application modules.

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Although you can remotely update few devices today, you can expect remote updating to soon become the standard method of deploying and maintaining embedded devices. Most new designs already have some type of built-in network connection so the necessary hardware will be available. The only added cost to the embedded design will be for additional memory to house the management client. Remote updates promise to give users the ability to pick and choose device applications, features, and services. Manufactures will also benefit from drastically reduced product-support cost.□

REFERENCE

1. Webb, Warren, "Designing Web appliances on a shoestring," *EDN*, April 13, 2000, pg 89.