By Edward F. Steinfeld,
Embedded Computing Market Consultant,
Automata International Marketing.

Embedded Web Servers Invade SOHO

From a Web browser on a PC you can setup and manage print servers, DSL routers, wireless access points, and AC power controllers. From any PC running a Web browser the Small Office Home Office (SOHO) user has full access to devices that in the past were either manually accessed or through serial ports using a Telnet protocol. In fact, too many devices are still not using this easy to implement, low cost technology. Users should be demanding the technology. Manufacturers can inexpensively add the technology and do it at a very low cost. Some devices might even be less expensive to build using embedded Internet/Web technology. We need more ideas that are creative. This technology is so easy to develop and deploy. Yet, we see relatively few devices using it.

WHO IS DOING IT TODAY?

There are many electronic devices on the market today using embedded Internet or Web technology. Most of the devices are network enabled as part of their basic functionality. Adding Internet and Web technology was an easy and obvious next step. Although there are a few devices in which a network connection came as a surprise.

One device that was a very creative idea and one you might not expect to be networked is the APC MasterSwitch power control unit. It is like the power control unit you may have under your monitor that allows you to turn on or off the printer, monitor, computer, or any other electric device. The MasterSwitch does this not with switches on the front panel but via HTML pages and your browser. You can power on any device connected to the MasterSwitch from any place where you have a network connection (See Figure 1). The APC MasterSwitch has an embedded Web server from Allegro Software Development Corporation (See Figure 3). The embedded processor and Rom store HTML pages that are requested by the user logged into the MasterSwitch controller. These pages permit the user to turn on or off a device as well as set whether it should be powered on at startup, delay after startup, and links to other Web servers with information about the device. In the SOHO network application shown in Figure 3, the device is used to turn on printers, desk lamp, and a fan - all from anywhere in the house where there is a computer with a Web browser.

Some devices have had embedded Internet capability for a long time but just recently have begun to use embedded Web technology for management and control. The print server was designed to connect printers to local area networks. In the past, they were managed by connecting a terminal to a serial port to pass commands to set up the device. The Osicom NetPrint 1000 and Hewlett Packard JetDirect 500X print servers are examples that have embedded Web servers to allow the print servers to be managed and setup from a browser.

Not shown in Figure 3 is the Cisco Internet telephone model 7960. The Voice over IP telephone uses an embedded Web client to obtain telephone directories

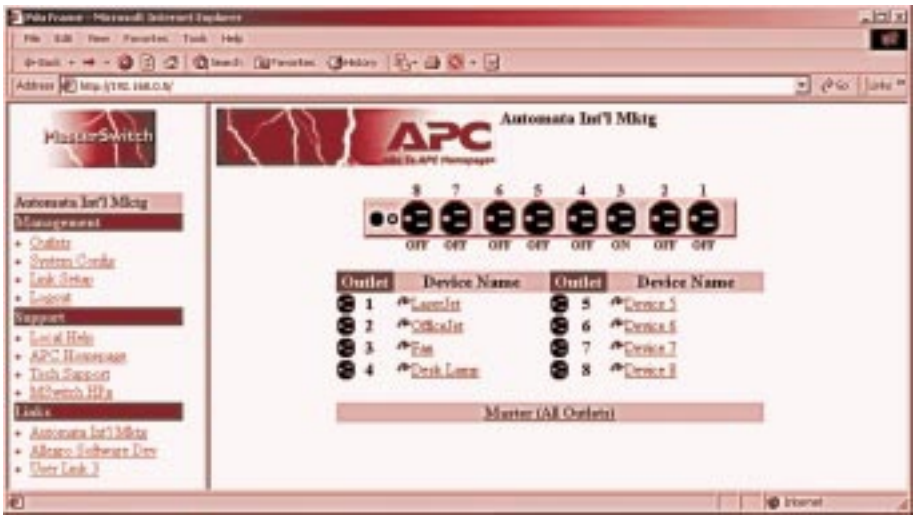

Figure 1. APC MasterSwitch controls the power to various devices using an Allegro RomPager Embedded Web Server talking to a standard Web browser.

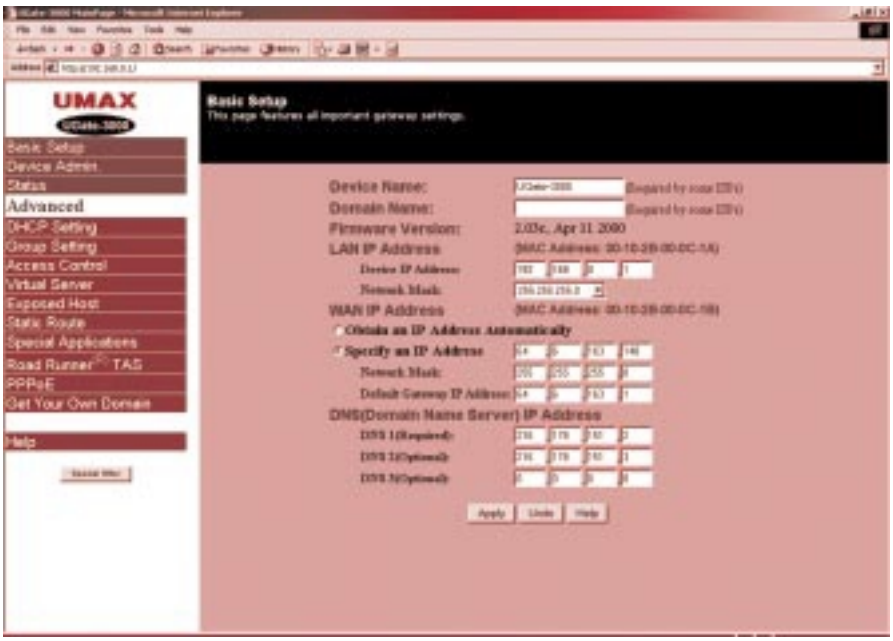

Figure 2. The UMAX UGate-3000 Cable/ADSL modem sharing gateway is used in the author's home office. This screen is displayed via a browser and is used to setup the device.

and send the voice over the network.

Netopia, D-Link, and UMAX make DSL routers and hubs that are managed from Web browsers. Setting up the DNS server, host IP address, DHCP address list, and other parameters is accomplished by filling in forms on an HTML page on any Web browser on a PC connected to the hub/router See Figure 2).

Some of the latest uses are with wireless systems. The wireless access point or connection of the wireless portion of the network to the hardwired portion is now done using Web technology. Both Proxim and RadioLAN use this technology in their wireless systems.

Many printers are network ready. Meaning, they allow users to submit print jobs via the network. It also means the printer is not dedicated to a single computer. Printers like this come from Xerox and QMS. Effectively they have a print server built right inside the printer.

In larger offices and buildings, one can use the Andover Controls Web managed heating, ventilation, and air conditioning (HVAC) system. This system has a Web server to allow individuals to control lighting, fans, and even detect whether an office is occupied. So far, there seems to be nothing for the SOHO.

With so many companies currently using embedded Internet/Web technology, why don't we see more doing it? It isn't rocket science. It isn't expensive. It isn't difficult or costly to implement. There are a few process control companies offering embedded Web technology for their low-end products. Schneider Electronics has just received a patent for the combination of a programmable logic controller (PLC), Ethernet controller, and embedded Web server for use in factories. But, we don't see medical equipment, fax servers, telephone equipment, test equipment, or home-based lighting and heating control systems using this technology. What we need are engineers like you to come up with new and creative ideas where Internet/Web technology can be used. Having a single interface to manage and control devices will make work easier and more fun.

WHAT ARE EMBEDDED WEB AND INTERNET TECHNOLOGIES?

The networking of devices has been used in manufacturing since the late 1970s. In order for the process to be an integrated system, the manufacturer or the user often had to develop their own network protocols, user interfaces, and development tools. Many times they would force fit the applications onto a single vendor architecture or be forced to rewrite the protocols and user interfaces for each architecture.

Today there is one network protocol used by more than 90% of the networks - TCP/IP. The user interface used by the majority of networked computers is the ubiquitous Web browser. The development tools for these technologies are available from hundreds of vendors. The best part is these protocols have become available so widely that they are now operating system and hardware architecture independent.

The components of embedded Internet and Web technology are the same components that AOL and users that surf the Web utilize. They include the hardware network interface - usually Ethernet, the network software protocol stack - nearly always it is TCP/IP, a Web server that delivers files and objects, Web client to request and sent objects, and an expanded form of the Web client the Web browser as the human graphical interface, and sometimes email, XML, and other network services. The difference between what is used by AOL and their clients and the equipment in a supermarket is the size of the code, features, and number of

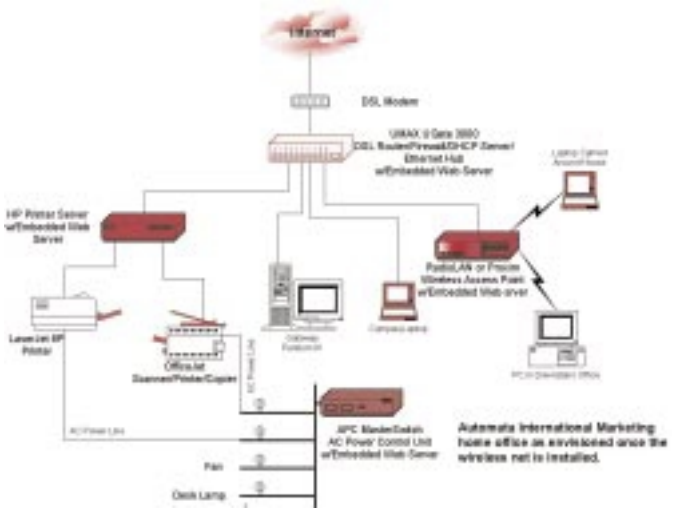

Figure 3. Automata International Marketing's home office network. The devices in color use embedded Internet/Web technology.

simultaneous users.

Today a device used to control a process may have an embedded Web server delivering text and dynamic graphics to a browser and receiving control inputs for the device. The Web server protocol, HTTP, is so widely used that development tools are inexpensive and the run-time licenses are free.

The display of text and graphical information use the HTML page formatting protocol to format the display. Using a simple text editor to write HTML tags one can create a colorful and dynamic display.

Web Server

Embedded Web servers can have a footprint as small as 7KB and for a full featured Web server it might grow to 30KB. These commercially available embedded Web servers are usually operating system and hardware independent. They interface to the TCP/IP stack and to the application inside the device.

When the user, via a Web browser, requests a page, the embedded Web server will retrieve the page from RAM, ROM, Flash, or is a few cases from a disk. The page includes the dynamic (realtime) data needed. The Web server then sends the page to the browser via the network. Using the embedded Web server and Web browser combination can eliminate the need for a front panel of knobs, switches, and displays on the device. The user's graphical Web browser becomes the front panel for the device, whether it is sitting next to the device or across the country.

Web Client

The majority of smart devices have little or no need for human input or they already have a dedicated front panel. These devices may still need input to set up, calibrate, or operate the device. A Web server has the primary function to deliver HTML pages to a browser. If the device is delivering data and receiving control inputs to and from another computer, the Web client may be the answer. A Web client can request objects from and send objects to a Web server. That server may be a large mainframe or another smart device with an embedded Web server.

A Web client is a very small footprint software function that can easily turn a smart device into a Web-enabled device. It can request control information on power-up and send data as needed to other computers.

Web Browser

A much larger Web client is the Web browser. Its main function is to render HTML pages and graphics received from a Web server to be viewed by a human. It can also accept input and send that information back to a Web server. Today we hear a lot about Internet appliances and their ability to browse the World Wide Web. However, few devices have the need to browse the Web. They may need to display limited information and collect inputs. Just slapping a browser on a device does not make that device more useful.

When one looks for an embedded browser the person should ask, what are the functions I need to collect and display? Is JAVA necessary? Will this device just display text and tables? Is JPEG and JIF support required? Once these and other questions are answered, the developer can select the browser that fills the need. By restricting the browser to just the necessary functions, one might reduce the memory footprint from the multi-megabyte browser to as little as 200KB.

Email

Sometimes there are questions about why email is included with embedded Internet technology discussions. Email can be used to alert supervisors of an alarm condition and to download software into the smart device. When a process trends toward an out-of-limits condition the device can send an alert to the remote operator where the operator using their browser can enter new instructions to the device. It is also an

easy way to send to the device a binary attachment containing a new menu, diagnostics, or updated software.

XML

The latest way to define data content, for use among a number of different applications, file systems, and devices is the eXtensible Markup Language, XML Similar to HTML in syntax, XML is used to define content rather than format it. Embedded XML parser-framers presently have limited availability. The Allegro Software Development RomXML parser/framer is available and is being used in test equipment, Internet telephones, and time and attendance stations. As XML gains popularity with data servers it will also gain popularity in devices used to collect or distribute data.

Time

Remember the flashing 12:00 on the VCR? Now Internet devices have a way to set or synchronize their time with a network server. Using an embedded Network Time Protocol (NTP) client, a device can determine the time of day from the network rather than requiring a user to enter the time of day for the device. Because most Cisco and other routers provide NTP server support and maintain synchronization with the national network clocks, devices on your desk can easily maintain accurate time.

DNS

An embedded Domain Name Services (DNS) tool will allow embedded devices to look up Internet addresses from any Domain Name Server. This permits configuration of a device to be made simpler by using addresses in text name rather than IP numerical addresses. DNS tools can be used with embedded Web servers, Web clients, Web browsers, email, and NTP clients

SSL/TLS

The Secure Socket Layer (SSL) and it's replacement Transport Layer Security (TLS) protocols were designed to enable encrypted, authenticated communications across the Internet. URL's that begin with "https" indicate that an SSL/TLS connection will be used. SSL and TLS provides three important things: Privacy, Authentication, and Message Integrity.

In an SSL/TLS connection, each side of the connection must have a security certificate, which each side's software sends to the other. Each side then encrypts what it sends using information from both its own and the other side's certificate, ensuring that only the intended recipient can de-crypt it, and that the other side can be sure the data came from the place it claims to have come from. Although most browsers are SSL capable, few non-PC devices are. The only SSL/TLS tools I know available for embedded devices come from Allegro Software Development. Allegro provides a SSL/TLS product for both their RomPager embedded Web server and RomWebClient embedded Web client.

The SSL protocol uses a Security Certificate to establish a secure connection. Security Certificates contain information about to whom it belongs, who issued it, a unique serial number or other unique identification, valid dates, and an encrypted "fingerprint" that can be used to verify the contents of the certificate. In order for

Product Name	Description
RomPager Basic	Embedded Web Server, small footprint, communicates with all Web browsers. Many devices have limited functionality; this embedded Web server may be all that is needed.
RomPager Advanced	Embedded Web Server, full featured, communicates with all Web browsers. Includes Web Application toolkit with compile-time HTML parsing and compression
RomPager Secure	RomPager Advanced with SSL/TLS protocol capabilities. Allegro provides digital certificate services so each vendor device built with RomPager Secure has a unique digital certificate.
RomWebClient	Embedded HTTP client, sends and receives to all Web servers, used when a full browser is not required
RomWebClient Secure	For Internet enabled devices that do not require a full browser but still need to request and send objects to and from secure servers, includes SSL/TLS protocol and certificate capabilities
RomMailer Basic	SMTP Client, sends Internet email
RomMailer Advanced	SMTP Client, adds attachments and MDN/DSN support
RomPOP Basic	POP3 Client, receives Internet email
RomPOP Advanced	POP3 Client, adds attachments and MDN/DSN support
RomXML	Embedded XML parser/framer. Converts internal data to and from XML documents.
RomUPnP	Implements Universal Plug and Play Discovery and Description services
RomTelnet	Telnet server for communications with Telnet terminal clients
RomCLI	Command Line Interface toolkit for implementing text line interfaces for embedded devices.
RomTime	Sets time from a central server, no more flashing 12:00
RomDNS	Domain Name Services client
RomPager Graphlets	Java applets for dynamic data presentation. Send data to the browser for continuous display as line charts, bar charts, graphs, etc

Table 1. List of Embedded Internet/Web tools from Allegro Software Development Corp.

an SSL connection to be created, both sides must have a valid Security Certificate. Allegro provides the tools to create the certificates and the embedded software to validate and decrypt the data.

UPnP

Universal Plug and Play (UPnP) is an open standard technology for transparently connecting appliances, PCs, and services by extending Plug and Play to support networks and peer-to-peer discovery and configuration. UPnP may become the ideal method to connect devices in your office.

Open Internet-based standards are the best solution to this problem, because IP standards:

- Provide the greatest flexibility and security.
- Are more cost effective for developers.
- Leverage the same technologies and standards.

UPnP is a pragmatic approach to the complex problem of connecting multiple device and service types across multiple kinds of media. Universal Plug and Play enables the industry to develop new products for new uses in the SOHO and home. Some of these might be:

- Sharing PC peripherals; such as storage, printers, and cameras
- Enabling new form factors such as embedded and wearable computing devices
- Providing network services such as remote printing, bulletin boards, airport schedules

TCP/IP

The most important part of any Internet enabled device is the TCP/IP network protocol stack. These software stacks are available from many vendors but one should look for a stack that supports their target microprocessor. Most of the embedded Internet tools described above will require the TCP/IP stack be sockets based. Then most are. The TCP/IP stack may be the largest portion of code in the system (unless you are using a full featured browser). Versions use in embedded applications can be simpler than what is used in a workstation or file server.

LOW COST AND EASY IMPLEMENTATION

Locating embedded Internet and Web tools should not be difficult. Many vendors offer some portion of the set described above. But, no vendor offers everything, yet. A list of the majority of these tools is in Table 1 along with a brief description and the size of the code footprint. These tools can be used in any combination or as standalone. Embedded Internet tools are usually provided in C source and will run on any target microprocessor capable of supporting TCP/IP. They may be used with or without an operating system.

RESOURCES

- Allegro Software Development
  - http://www.alegrosoft.com
- Andover Controls
  - http://www.andovercontrols.com/webserverdemo/default.htm
- APC (American Power Conversion)
  - http://www.apcc.com/
- Cisco
  - http://www.cisco.com/warp/public/cc/cisco/mkt/iptel/ipphone/prodlit/7960_ds.htm
- D-Link Systems
  - http://www.dlink.com/
- Hewlett Packard
  - http://www.hp.com/net_printing/ppss/500x_info.html
- Netopia
  - http://www.netopia.com/equipment/index.html
- Osicom
  - http://www.osicom.com/products/access.asp
- Proxim
  - http://www.proxim.com/symphony/index.shtml
- QMS
  - http://www.qms.com/
- RadioLAN
  - http://www.radiolan.com/products.html
- UMAX
  - http://maxgate.net/product_3k.htm
- Universal Plug and Play
  - http://www.upnp.org/
- Xerox
  - http://www.xerox.com/ ■

Edward F. Steinfeld is Embedded Computing Market Consultant for Automata International Marketing.
Ed has more than 25 years experience in realtime and embedded computing. He began as a programmer writing code and designing hardware to test hybrid circuit boards for Picker X-ray. He has marketed embedded and realtime products to OEMs and resellers for Digital Equipment Corporation, VenturCom, Inc., and Phar Lap Software. His international experience includes a stint in Hong Kong as a Far East Channels Manager and responsibility for international OEM sales in Europe and the Pacific Rim. Ed provides market research, planning, and services to the embedded computing industry.