Placing Legacy Hardware on Ethernet LANs

By Gilbert Held

In many organizations, equipment upgrades and replacements represent an annual occurrence. Although the so called 'LAN WAR' of the late 1980s and early 1990s, during which Ethernet networks gained considerable market share over Token-Ring, is history, the recurring equipment upgrade and replacement process creates interesting problems for most organizations. Serial port printers, plotters, disk arrays, point of sale (POS) terminals and even building automation devices are commonly upgraded or replaced with newer models. Because most organizations standardized their LAN requirements through the use of Ethernet, both stand alone older equipment and many devices purchased as replacement products cannot be directly integrated into an Ethernet network. As a result of the inability of many types of hardware to be integrated into an Ethernet network, organizations cannot take advantage of the use of the Simple Network Management Protocol (SNMP) and other management tools commonly used to manage a wide range of enterprise hardware. This means managers and administrators could be required to use multiple platforms to manage different systems within a building or industrial complex or even forgo the use of management tools for hardware whose operational status was not directly supported by a management tool.

Recognizing the previously mentioned problem, several vendors introduced Ethernet conversion products that enable both stand-alone legacy and new products to be interfaced to an Ethernet LAN. Through the use of such products, managers and administrators obtain the ability to commonly manage a variety of hardware products through the use of Ethernet management tools. In addition, by obtaining the ability to integrate stand-alone hardware products into an Ethernet network wiring may be simplified, resulting in additional economic benefits. A third advantage associated with the use of an Ethernet conversion device is the ability for multiple users to access equipment interfaced to the conversion device. Instead of stand-alone equipment that can only by accessed by an individual computer, equipment can now be accessed by a computer connected to the network. In fact, devices can even be accessed from remote computers that can access the network to which the stand-alone equipment is connected. This allows managers and network administrators to even use the Internet to access formerly stand-alone devices that are now connected to Ethernet networks.

In the first portion of this article we will briefly obtain an overview of Ethernet and its many 'flavors' that were developed since its birth during the 1970s. Once this is accomplished, we will turn our attention to the use of a special type of conversion device that enables any serial device to become a participant on an Ethernet network. As we examine the use of this conversion device, we will also note how different types of serial devices can be managed from a central location.

Ethernet Overview

Ethernet represents a network cabling and signaling system that operates at the lower two layers of the Open System Interconnection (OSI) Reference Model. Those layers are the Physical layer (layer 1) and the Data Link layer (layer 2).

Ethernet was originally developed at the Xerox Palo Alto Research Center (PARC) during the later 1970s. In 1980, Digital Equipment Corporation (DEC) (which was taken over by Compaq Computer and then merged into Hewlett Packard), Intel Corporation, and Xerox joined together to promote the use of Ethernet operating at 10Mbps over thick coaxial cable. The three vendors published a set of specifications for Ethernet, referred to as the Blue Book Standard due to the color of the cover. The standard defined the operation of the Carrier Sense Multiple Access with Collision Detection (CSMA/CD) protocol used as the access control mechanism to the media as well as the format of an Ethernet frame.

Under CSMA/CD a LAN station first listens to the wire to determine if another device is currently transmitting. If another device is transmitting the station defers its transmission. If no activity is noted, the station will commence its transmission while listening to the wire to hear if another device began its transmission at the same time. When two or more devices transmit at the same time a collision will occur, resulting in a high level of voltage that each station on the network can detect. The stations currently transmitting stop and initiate a random exponential backoff algorithm, under which each station ceases transmission for a random period of time, listens again to the wire, and if no activity is heard, retransmits the frame.

To promote the use of Ethernet, Digital Equipment Corporation, Intel and Xerox turned over its development to the Institute of Electrical and Electronics Engineers (IEEE). The IEEE was tasked by the American National Standards Institute (ANSI) with the responsibility to develop LAN standards. Over the years the IEEE 802 Committee developed a comprehensive series of LAN standards. CSMA/CD standards fall under the efforts of the IEEE 802.3 subgroup of the 802 committee. Exhibit 1 provides a summary of major IEEE 802.3 Ethernet network standards.

Exhibit 1: IEEE 802.3 Ethernet Standards

Nomenclature	Cable Type	Operating Rate
10BASE-5	Thick coaxial cable	10Mbps
10BASE-2	Thin coaxial cable	10Mbps
10BROAD-36	Broadband coaxial cable	10Mbps
10BASE-T	Twisted-pair	10Mbps
100BASE-T	Twisted-pair	100Mbps
1000BASE-T	Twisted-pair	1000Mbps(1Gbps)
1000BASE-LX	Fiber Optic (long wave)	1000Mbps(1Gbps)
1000BASE-SX	Fiber Optic (short wave)	1000Mbps(1Gbps)

Baseband versus Broadband

In examining the entries in Exhibit 1, you will note that the IEEE uses a nomenclature of the form R-[BASE/BROAD]-[D/CT] where:

R indicates the data rate
BASE indicates Baseband transmission
BROAD indicates Broadband transmission
D/CT indicates total network cable distance (D) in hundreds of feet or
(CT) Cable type.

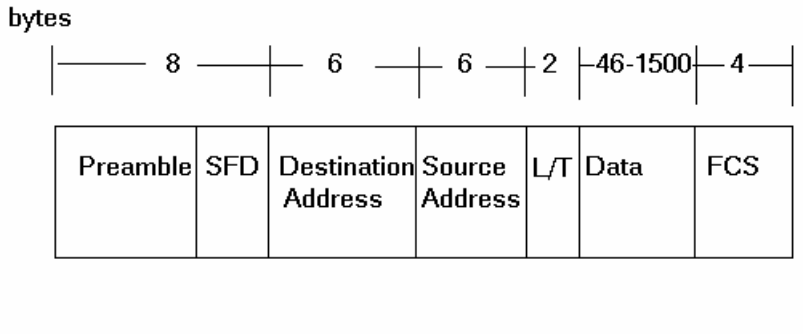
As a refresher, a baseband network only carries a single channel for communications. All Ethernet networks other than the 10BROAD-36 network are baseband networks. The 10BROAD-36 network is the only Ethernet broadband network to be standardized. As a broadband network, 10BROAD-36 uses one channel on a coaxial cable that is subdivided by frequency into multiple channels, permitting, for example, closed circuit TV to flow over the same cable along with Ethernet data. Although 10BROAD-36 never lived up to its expectations and represents an obsolete Ethernet network, it used the same basic frame structure associated with all Ethernet networks. Because of one of the key advantages associated with placing non-Ethernet compliant devices onto an Ethernet network is their addressability and device addressability results from the uniform frame format supported by each version of Ethernet let's turn our attention to the structure of Ethernet frames.

Ethernet Frame Structure

Perhaps the key reason for the success of Ethernet is its common frame format, which enables data to flow across different operating rate networks without alteration. Exhibit 2 illustrates the basic Ethernet frame, which consists of seven fields. The Preamble field consists of 62 bits of alternating binary 1s and 0s normally generated by the network adapter to provide a synchronization signal to the receiver. The second field, Start of Frame Delimiter, consists of two bits, both set to a binary 1. This field enables the receiver to align itself to the byte position and is also generated by the network adapter.

The third field, Destination Address carries the destination address of the frame while the fourth field, Source Address, transports the address of the device that originated the frame. Both Destination Address and Source Address fields are 6 bytes or 48 bits in length and represent Media Access Control (MAC) or layer 2 addresses.

Exhibit 2: The Basic Ethernet Frame



Legend:
SFD Start of Frame Delimiter
L/T Length or Type
FCS Frame Check Sequence

In actuality, both Destination Address and Source Address fields represent addresses burnt into the network adapter or Ethernet chip set installed in a computer. Manufacturers of network adapter cards or Ethernet chipsets request an address, referred to as a vendor code from the IEEE. The vendor address is encoded in the first three byte positions of the address position on the adapter or chip set. The last three byte positions represent a unique vendor assigned address, which in conjunction with the vendor code forms a unique six byte address. If the vendor is successful and runs out of unique addresses they would then request another three byte vendor code from the IEEE.

Address Resolution

It is important to note that frames are transported on an Ethernet network to their destination based upon the MAC address in the Destination Address field. When a layer 3 TCP/IP packet arrives at a router from the Internet or another location the router cannot directly use the IP address in the packet. This is because the router must deliver the packet inside an Ethernet frame, which requires the use of a MAC address. To learn the MAC address of the destination the router will transmit an Address Resolution Protocol (ARP) broadcast message to all stations on the Ethernet network. The ARP message will contain the destination layer 3 IP address taken from the packet received from the Internet. The Ethernet station configured with the matching IP address will respond, transmitting its MAC address to the router. The router will use that address to form an Ethernet layer 2 MAC frame that will transport the TCP/IP packet to its destination. To reduce data flow and processing time the router will also enter the MAC address associated with the IP address into cache memory, enabling additional packets flowing to the same IP address to be near instantly processed.

Length/Type Field

Returning to the basic format of an Ethernet frame shown in Exhibit 2, the length or Type field is 2 bytes. When used as a length field the value indicates the length in bytes of the following Data field. In the original Ethernet specification a Type field was used whose

value indicated the protocol transported. Because the maximum length of an Ethernet Data field is 1500 bytes all Type Codes are greater than 1500, allowing the use of both frames using Type fields and frames using a Length field to coexist on a network. For example, the Type field value would be set to hex 800 when IP is transported within an Ethernet frame.

Data Field
The Data field ranges in length from a minimum of 46 bytes to a maximum of 1500 bytes. When the actual contents are less than 46 bytes pad characters are used to increase the field to its minimum value, which is required to enable a sufficient time for collisions to be detected.

FCS Field
The final field in the frame is the Frame Check Sequence (FCS) field. This 4-byte field transports a 32-byte Cyclic Redundancy Check (CRC) character, which is normally generated by the network adapter or Ethernet chip as a mechanism for the receiving device to check the integrity of a received frame. That is, the receiving device uses the same algorithm to generate a local CRC, which is compared to the CRC contained in the received FCS field. If the two match the frame is considered to be received error free while a mismatch indicates one or more bits in the frame were received in error. Now that we have an appreciation for the 'flavors' of Ethernet and its common frame format, let us turn our attention to the use of products that enable serial devices to be connected to Ethernet networks.

Serial Device Servers

Recognizing the need of organizations to interface such devices as modems, point-of-sale terminals, building automation and even parking lot gates into existing Ethernet networks, several vendors now market serial device servers. Such products essentially are conversion device, converting a serial data stream into Ethernet frames and vice versa.

The serial device server is a 'two-sided' device, with one side containing a LAN interface while the other side contains one or more serial device connectors. Because it's relatively easy to connect to a twisted-pair network, serial device servers currently do not support coaxial cable nor fiber optic connections. Thus, their use is limited to attaching to 10BASE-T and 100BASE-T networks, which represent the vast majority of existing Ethernet networks.

The actual selection of an appropriate serial device server requires consideration of six general product features. Those features are listed in Exhibit 3 and will be described in detail to obtain an appreciation of each feature.

Exhibit 3: Serial Device Server Product Features

Feature	Description
Port support	Permits multiple devices to be supported by a single server
Connectors	Defines the physical interfaces used for connection
Serial interface	Defines the type of serial device the device server supports
Network interface	Defines the type of Ethernet LAN the device server supports
Network Protocol	Defines the protocol used to access the device server
Security	Permits controlled access and/or encryption of data

Port Support

Most serial device servers have either 1, 2, or 4 serial ports, with the number of ports controlling the number of serial devices that can be connected to an Ethernet network via a single conversion device. The most popular type of serial device server is a single-port device, because of cabling limitations and the location of serial devices with respect to the wiring of an Ethernet network. For example, RS-232 interfaced devices, which represent the most common type of serial interface used with communications products, typically have a cabling limitation of 50 feet. Thus, if two RS-232 serial devices required connection to an Ethernet network but were located more than 50 feet from one another, you would either have to move the devices closer to one another to obtain the ability to use a multi-port serial device server or use two single-port serial device servers.

Connectors

The type of connectors governs the type of Ethernet LAN and type of serial device a serial device server can support. On the network side, serial device servers include an RJ-45 connector, permitting the device to be connected to either a 10BASE-T or 100BASE-T Ethernet network. The serial side of the device server commonly uses a DB-9 connector, which represents the port connector commonly used on laptop and notebook computers due to their smaller space requirement than a 25-pin DB-25 connector used in many desktop PCs for a serial interface.

Serial Interface

The serial interface defines the type of serial device that can be supported by the serial device server. The most common interface supported is the RS-232 interface, which is built into stand-alone modems, printers, point-of-sale terminals and building automation systems. Other types of serial interfaces supported by serial device servers include RS-422 and RS-485.

Network Interface
The network interface defines the type of Ethernet LAN a serial device server can be connected to. Most serial device servers include an auto-negotiation capability that enables them to be connected to a 10BASE-T network operating at 10 Mbps or a 100BASE-T network operating at 100 Mbps, while a few devices can only be connected to a 10BASE-T LAN.

Network Protocol
The network protocol defines the manner by which serial devices are accessed over an Ethernet LAN. Most serial device servers support the TCP/IP protocol stack to include the UDP protocol. Because SNMP is transmitted via the UDP protocol, this allows the serial device server to be managed from a common management console along with other network devices.

Security
While some serial device servers do not include any security capability they are typically the exception. Most serial device servers include a password access capability. Other serial device servers incorporate an ID/password capability. This capability allows multiple access from different employees, with each employee being able to be assigned his or her own password. Adding to security, some manufacturers of serial device servers include an encryption capability, which enables data to be protected from any monitoring on the network.

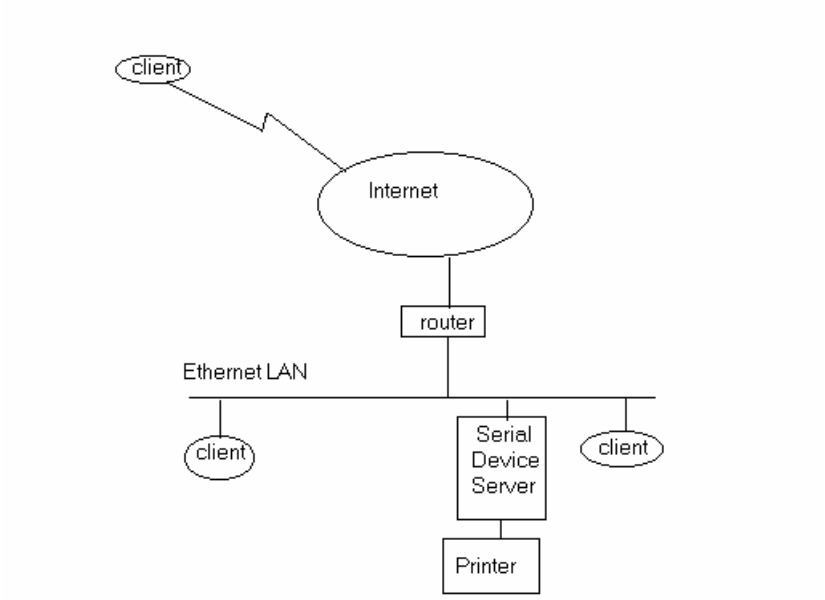
Using Serial Device Servers

Now that we have an appreciation for the major features of serial device servers, we can use that information as a foundation for discussing their use. In doing so we will reference a few application diagrams that will illustrate two examples of the numerous methods by which serial device servers can be used to interface serial based devices to an Ethernet network and the advantages of doing so.

Supporting Serial Printers
Most printers manufactured prior to 2000 contain both serial and parallel ports, with the latter used to support the popular Centronics interface connection. Although printers manufactured after 2000 commonly include parallel and USB connectors, there are millions of older printers that include a serial interface and could be used as a network printer.

Exhibit 4 illustrates the use of a single-port RS-232 interface serial device server to connect a printer to an Ethernet network. Because the serial device server supports the TCP/IP protocol, that device can be configured with an IP address in addition to its fixed or burnt-in Ethernet MAC address. Thus, print jobs could be directed to the printer from client stations on the local Ethernet or even from remote clients via the Internet.

Exhibit 4: Interfacing a Serial Printer



Creating a Modem Pool

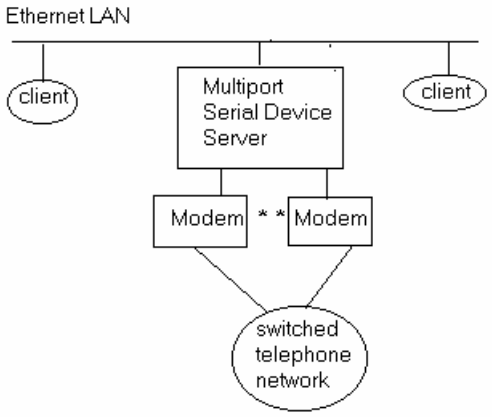
A second application that deserves mention is the creation of a modem pool. Instead of providing each computer user with his own modem and business line, considerable savings occur when modems are placed in a group that all users can contend for access. In doing so, it's common to use a multi-port serial device server that can provide a common connection to a group of modems.

Exhibit 5 illustrates the use of a multi-port serial device server to create a four device modem pool. Note that instead of each client station having its own modem and business line, modems and business lines are consolidated in one area. Because business lines can cost over $30 per month, telephone line costs can be significantly reduced through the use of a modem pool.

Software Considerations

No discussion of a serial device server would be complete without a discussion of software. Most vendors manufacturing serial device servers include software that can be used to manage their product. For example, B&B Electronics Manufacturing Company provides purchases of its products with Windows compatible software that enables the serial device server to be controlled. When a B&B Electronics Manufacturing serial device server is connected to an Ethernet LAN, the vendor's management software automatically determines the presence of the device via recognition of its MAC address. This enables the operator of the management software to assign an IP address to the device so that it can be accessed via TCP/IP applications. Other vendors manufacturing serial device servers provide management software with similar capabilities.

Exhibit 5: Using a Multi-Port Serial Device Server to Establish a Modem Pool



Recommended Course of Action

Organizations with serial operating devices ranging from printers and modems to teller terminals and parking entry gates now have a mechanism to integrate such devices into their Ethernet network. Doing so can not only facilitate the management of multiple devices from a single management console but in addition extend the life of legacy products while simplifying cabling. Thus, if your organization operates an Ethernet network and also uses stand alone serial interfaced devices you should consider integrating such devices into your LAN via the use of a serial device server.

About the Author

Gilbert Held is an award winning author and lecturer. Gil is the author of over 50 books and 500 technical articles. Some of his recent publications include the fourth edition of *Enhancing LAN Performance* and *Practical Network Design Techniques*, both published by Auerbach Publications. Gil can be reached via email at gil_held@yahoo.com.