Opto 22 SNAP Ethernet FAQ

This document contains the most frequently asked questions related to Opto 22's SNAP Ethernet-based hardware, which includes SNAP Ultimate, SNAP Ethernet, and SNAP Simple brains, as well as the SNAP-LCE controller. All information is kept current and is assumed to be accurate. Please check back regularly for updates to this document. Additional questions and answers are welcome. Please send them to webmaster@opto22.com.

1.00 About Ethernet

1.10 What is Ethernet?

Ethernet is a local area network (LAN) protocol that was originally developed to link computers. Invented by Bob Metcalfe at Xerox Palo Alto Research Center (PARC) and later refined by Xerox, DEC, and Intel, the Ethernet technology specification was later adopted by the IEEE as standard 802.3. The original Ethernet specification called for a bus topology over several media types, including coaxial cable. Today's common Ethernet implementations use four twisted pairs of copper wires, commonly referred to as Category 5 (Cat-5) or Category 6 (Cat-6) cabling, and provide a raw data transfer rate of 10 or 100 megabits per second (Mbps). A newer Gigabit Ethernet standard, supporting data rates up to 1,000 Mbps, was approved in 1999.

1. 11 What is Ethernet in simple, non-technical terms?

Physically, Ethernet is just wires, connectors, and computer cards that allow computers and computer-based devices to talk to each other. Ethernet networking is similar in many ways to a telephone system. It uses common copper wire. The connections for the wire are just like telephone jacks, except bigger. Devices on each end of the wire, such as an adapter card in a computer or one of Opto 22's SNAP Ethernet-based brains, must work together. While a phone system works between two telephones and transfers voice, Ethernet works between two computer-based devices and transfers data.

1.20 How do the Ethernet, TCP/IP, and application layer protocols fit together?

The following table outlines how the pieces of an Ethernet and TCP/IP communications system work together:

Opto 22 Supported Protocols					Internet Model
Email, paging	Opto 22's IEEE 1394-based protocol	Modbus/TCP protocol	FTP	SNMP, streaming	Application
SMTP					
Transport Control Protocol (TCP)				UDP	Transport
Internet Protocol (IP)					Internet
Physical interface For example, an Ethernet card and cable or modem (coaxial, twisted pair, fiber optic, dial-up, wireless)					Physical

1.21 That seems very confusing. Is there an easier way of looking at it?

Actually, there is. You can break the technology down into three major parts, from top to bottom:

Application layer

This is where the application-level protocol resides. Examples of application level protocols include Modbus/TCP and Simple Mail Transport Protocol (SMTP). Several application protocols are supported with SNAP Ethernet-based brains, and all can be used simultaneously. (The protocols supported vary by brain model; see Opto 22 form #1486, the *SNAP Ethernet-Based Brain Comparison Chart*, for details.) For example, since both Modbus/TCP and SMTP are supported on the SNAP-B3000-ENET brain, you could retrieve data from this brain using a product like Wonderware's Intouch, while the brain simultaneously sends email to alert a technician about a problem. Opto 22's own IEEE 1394-based memory map protocol is also supported at the application layer.

Transport layer

The transport layer encompasses the TCP/IP protocol suite, and is the most important layer. All messages transferred between a host and SNAP Ethernet-based hardware are encapsulated in a TCP or User Datagram Protocol (UDP) packet. Therefore, any application-layer protocol that works with a socket interface (and therefore with TCP/IP) can be used with this transport layer, without regard to the physical layer. Likewise, any physical layer component that works with TCP/IP can be used, without regard to the top application layer.

Physical layer

The physical layer includes only the actual physical connection to a device, such as Ethernet, fiber-optic, or serial. SNAP Ethernet-based hardware currently supports Ethernet Cat 5 (or higher) twisted-pair cabling and has an RS-232 serial port for use with modems or other remote communication devices. Some models offer a wireless cellular or wireless LAN option. Fiber-optic support is available through an external fiber-to-copper transceiver.

1.30 What is CSMA/CD?

CSMA/CD is an acronym for Carrier Sense, Multiple Access/Collision Detect. This acronym describes a network's operation at the Ethernet physical layer. In its original form, Ethernet is a broadcast mode bus. A device that wants to transmit on the network listens for a carrier (a wire with a signal). Once a valid carrier is detected, the device transmits a packet. In most cases, all the other devices on the bus receive this packet and begin processing it. However, a second device on the network may begin transmitting a packet before it realizes that the first device is already transmitting. This occurs only if there is a signal propagation delay between the two devices. In this instance, a collision is said to have occurred. Each device realizes that its transmission has been jammed by another transmission, and each device will back off and retry its own transmission a random period of time later. This behavior results in a lack of determinism; a node on the network never knows when another node is going to attempt a transmission. It is important to note, however, that determinism is sacrificed only during a collision event.

1.40 Is Ethernet deterministic?

Ethernet, purely defined, is not deterministic. However, the implementation of Ethernet determines performance. There are two ways to achieve near-deterministic performance with Ethernet:

- In applications that require high speed, such as those used in control environments, you can choose to implement SNAP Ethernet-based hardware in a dedicated network architecture. Using traditional Ethernet hubs in this manner won't provide determinism, but traffic in a dedicated network segment would typically be low enough that collisions would be rare. SNAP Ethernet-based hardware works on both 10 and 100 Mbps networks, auto negotiating network speed as needed. This increased speed further improves performance, and reduces the likelihood of bandwidth saturation and, therefore, collisions.

- For even higher speed requirements, a near-deterministic Ethernet solution can be achieved with network switches. A switch is a network device that quickly routes signals between ports on the hub. It repeats a packet only to the port that connects to the destination for the packet. Refer to Section 4.40 What's the difference between a switch and a hub? on page 11 to learn more.

1.50 Do I need a separate network for industrial control?

Not necessarily. If you require high-speed control or have concerns about security, having a separate control network might be a good idea. SNAP Ethernet-based hardware can work either as a separate network or as part of an existing business network. SNAP Ethernet-based hardware works well as part of an existing network, especially if the application is data acquisition, and high-speed control is not required.

1.60 What is the IEEE?

The Institute of Electrical and Electronics Engineers (IEEE) is an organization of engineering and electronics professionals. IEEE developed the standards for the physical and data-link layers of local area networks. The IEEE 802.3 Ethernet standard defines rules for configuring an Ethernet network, for how Ethernet devices interact, and for how an Ethernet packet is framed.

Opto 22's IEEE 1394-based memory-mapped protocol is also based on an IEEE specification. The Opto 22 protocol is two things: a definition of how to build a communication packet the Ethernet-based brain can understand, and the organization and structure of the Ethernet-based brain's data memory map. This protocol is fully documented (see Opto 22 form #1465, the *SNAP Ethernet-Based I/O Units Protocols and Programming Guide)*.

1.61 What is IEEE 1394 and why is Opto 22 using it?

The IEEE 1394 specification describes a physical medium and transport mechanism based largely on technology developed by Apple Computer and marketed under the trademarked name "FireWire." FireWire was adopted by the Institute of Electrical and Electronic Engineers as IEEE 1394-1995 to be an industry-standard serial data bus. At about the same time, Sony introduced its own variant of the standard called "iLink". As the protocol was developed by industry leaders such as Apple, Sony, Compaq, and others, the IEEE 1394 Organization adopted a joint standardization. Currently, there's no practical difference between the brand names "Firewire" and "iLink" and the IEEE 1394 specification standard.

One of the really cool things about FireWire/IEEE 1394 is that it's a platform-independent technology. FireWire/IEEE 1394 works with both Macs and PCs, as well as Linux, and partly with Unix and Sun. One of the biggest benefits of FireWire/IEEE 1394 is that it can support very, very fast speeds—typical speeds are currently at 400 Mbps, and it's capable of speeds of up to 1,600 Mbps.

Currently, Opto 22 implements IEEE 1394 at a software protocol level. In the absence of an "industry-standard" application level protocol, Opto 22 is using the IEEE 1394-based memory map as a method of organizing the I/O data for transfer to a host computer via the TCP/IP protocol. If the application you are using does not support Opto 22's IEEE 1394 memory-mapped protocol, other communication options are available, such as Modbus/TCP.

1.62 Do I need to understand the IEEE 1394-based protocol to communicate with SNAP Ethernet-based hardware?

No. See for more information.

1.70 Where can I find more information on Ethernet?

There are many Web sites and technical books that can help you further. We've found the following Web sites to be especially informative:

http://www.cisco.com
Cisco Web site

http://www.3com.com/technology_resources/
3Com Technical Resources Web site

http://webopedia.internet.com/TERM/E/Ethernet.html
(Basic Ethernet information starting point provided by internet.com.)

http://publib-b.boulder.ibm.com/Redbooks.nsf/RedbookAbstracts/gg243376.html?OpenDocument
(TCP/IP tutorial and technical overview provided by IBM.)

http://www.lantronix.com/learning/tutorials/index.html
(Overview provided by Lantronix.)

2.00 About Opto 22 SNAP Ethernet Systems

2.10 What is an Opto 22 SNAP Ethernet system?

Fundamentally, Opto 22's SNAP Ethernet system is the combination of a SNAP Ethernet-based brain, a mounting rack, assorted I/O or serial modules, and a power supply. With a SNAP Ethernet system and an Ethernet connection, you can monitor and control analog and digital inputs and outputs, or interface to serial devices, anywhere in your facility—or anywhere else in the world.

2.11 How do Opto 22 SNAP Ethernet systems work?

It's quick and easy to assemble your own SNAP Ethernet system. All you have to do is attach your field devices (meters, valves, switches, etc.) to your SNAP I/O modules, mount the modules onto a SNAP mounting rack, attach a SNAP Ethernet-based brain, and then connect the brain to your Ethernet network. Now you're ready to communicate to the brain from any host on the network that supports the TCP/IP protocol.

For additional control capability, use a SNAP Ultimate brain or add a SNAP-LCE controller to your network, and run a control program you build using the ioProject software suite. The control program can control a number of SNAP Ethernet-based brains on the network.

2.20 What can I do with an Opto 22 SNAP Ethernet system?

The possible applications are endless. Some examples include remote monitoring, remote control, data acquisition, alarm and event notification, wire elimination, multiplexing serial devices, and much, much more. You can use a computer to acquire data, control points, monitor inputs, and so on from the SNAP Ethernet system. You can develop your own software using our ioProject software suite or OptoMMP Communications Toolkit, or use an off-the-shelf software package that has an OPC interface or a Modbus/TCP driver.

2.30 What is a SNAP Ethernet-based "brain"?

A SNAP Ethernet-based brain is a compact, high-performance communications and I/O processor. The SNAP Ethernet-based brain family includes several models; see Opto 22 form #1486, the *SNAP Ethernet-Based Brain Comparison Chart*, for details. SNAP Ethernet-based brains support both 10BASE-T and 100BASE-TX cabling. The brains also have a serial port for programming, diagnostics, and serial networking using Point-to-Point Protocol (PPP). The Ultimate brain's serial ports also allow a direct connection to serial devices.

2.31 How intelligent are the SNAP Ethernet-based brains?

Intelligence varies by model, from very little to fully programmable. For a complete list of currently supported SNAP Ethernet-based brain features, see Opto 22 form #1460, the *SNAP Ethernet-Based I/O Units User's Guide*.

2.40 What methods can I use to communicate with a SNAP Ethernet system?

You can use any of the following methods—or all of them simultaneously—to interface with one or more Opto 22 SNAP Ethernet systems. Because of the nature of TCP/IP as a transport protocol, SNAP Ethernet-based hardware can communicate in several ways at the same time. That means, for example, that a control program could be running at the same time that an OPC client is obtaining data and a technician is being paged to respond to an alarm.

ioProject software suite—provides flowchart-based control programming, a full-featured HMI, a fast and efficient OPC 2.0-compliant server, and a configuration utility for SNAP Ethernet-based hardware. The control programs you build run independently on either SNAP-LCE controllers or SNAP Ultimate brain/controllers, which control other SNAP Ethernet-based I/O units. The HMI you develop can be used on an authorized Windows-based PC on the Ethernet network to monitor and control the SNAP Ethernet system.

Modbus/TCP driver—used for interfacing with any third-party software or hardware that uses the standard Modbus/TCP protocol. Any Modbus/TCP-enabled third-party software—for example, any human-machine interface (HMI) that talks Modbus/TCP—can interface directly with a SNAP Ethernet-based brain. Additionally, any hardware system that communicates via Modbus/TCP can communicate with the SNAP Ethernet system.

OptoOPCServer—provides access for OPC clients. Use the OLE for Process Control (OPC) 2.0 standard to communicate with SNAP Ethernet systems. OptoOPCServer, an efficient, fast OPC server, is available separately or as part of the ioProject software suite.

OptoMMP Communications Toolkit—an easy way to program applications for Ethernet-based brains. The included ActiveX components and C++ classes hide the details of Ethernet communications and the memory map protocol for faster programming. Use the ActiveX components to communicate with SNAP Ethernet-based brains from any Windows programming environment that supports ActiveX components, such as Visual Basic, Visual Basic for Applications, VBScript, and Visual C++. The C++ class can be used in programs written for Windows XP, Windows NT, Windows 9x, Windows CE, or Linux. All source code and many examples are included.

Opto 22's IEEE 1394-based memory map protocol—for writing your own application when you cannot use the driver toolkit. This protocol is open and documented, and sample utilities with source code are included to get you started. Full documentation is in Opto 22 form #1465, the *SNAP Ethernet-Based I/O Units Protocols and Programming Guide*.

Linux support—a demo utility with source code. Use the Linux operating system to communicate with SNAP Ethernet-based brains. This utility demonstrates how to formulate the IEEE 1394 packet and send it over Ethernet using Linux and a socket interface. For detailed memory map implementation, also see Opto 22 form #1465, the *SNAP Ethernet-Based I/O Units Protocols and Programming Guide*.

FactoryFloor—You can also use the Opto 22 FactoryFloor software suite and a powerful Opto 22 industrial controller with a 100 Mbps Ethernet card (M4SENET-100) to communicate with some SNAP Ethernet-based brain models. FactoryFloor includes four integrated components for programming and debugging a control system, developing a networked HMI, serving OPC and DDE clients, and connecting to standard Microsoft databases.

2.50 What does "multiple, simultaneous protocol support" mean?

Multiple, simultaneous protocol support means that a SNAP Ethernet-based brain is capable of communicating via several different application-level protocols simultaneously. The significant benefit of multiple, simultaneous protocols is that many hosts can communicate to the same Ethernet brain via different methods at one time. For example, a Modbus/TCP master—such as an HMI product like Wonderware InTouch or Intellution Fix Dynamics—can communicate with the SNAP Ethernet system at the same time as an application using the IEEE 1394-based memory-map protocol.

2.60 Do SNAP Ethernet systems support OLE for Process Control (OPC)?

Opto 22's OptoOPCServer lets any OPC-compliant client talk directly to a SNAP Ethernet-based brain or controller. This means you can now easily exchange SNAP Ethernet system data with any OPC client, such as third-party HMI suppliers like Iconics, Intellution, Citech, and Wonderware.

Please note that OptoOPCServer, part of the ioProject software suite, should not be confused with OptoServer, the OPC server component of Opto 22's FactoryFloor software. OptoOPCServer works with SNAP Ethernet hardware, including Ethernet-based brains and the SNAP-LCE controller; OptoServer works primarily with Opto 22 controllers running on serial or ARCNET networks (or a SNAP-LCM4 with an M4SENET-100 Ethernet card).

2.70 What is Modbus/TCP and how do I use it?

Modbus is a de facto industry standard protocol for industrial control originally developed by Modicon. Widespread use of the Modbus RTU protocol made its move to Ethernet sensible. The Modbus/TCP protocol is basically the command/response Modbus RTU protocol wrapped up in a TCP packet, meaning limitations of the protocol in advanced applications still exist. The Modbus/TCP protocol is an application-layer protocol, and as such, resides on top of the TCP/IP and Ethernet layers.

Opto 22's SNAP Ethernet-based brains fully support Modbus/TCP for use in new or existing applications that may have standardized on Modbus. If your software application or hardware platform supports Modbus/TCP, no other drivers or software are necessary for you to get up and running. For complete details on Modbus coil and register layout, see Opto 22 form #1460, the *SNAP Ethernet-Based I/O Units User's Guide*.

2.80 What is FTP used for?

FTP (File Transfer Protocol) is supported on SNAP Ultimate brains and SNAP-LCE controllers (called *control engines*) with R5.0a or newer firmware. It lets you reliably transfer files between a computer and a control engine, or between control engines. Control engines can act as both FTP clients and servers. (An FTP client is the application or unit that is requesting data, and the FTP server is the one that is providing the information.) Starting with ioControl R5.0a, file management is supported in control strategies running on control engines.

FTP is a powerful way of accessing files because:

•   A strategy running on a SNAP Ultimate brain or a SNAP-LCE controller can store files in its RAM or Flash memory.

•   FTP clients can read files from and write files to the FTP server on the control engine.

- The ioControl strategy can read files loaded to the control engine from other sources.
- The ioControl strategy can retrieve files from other FTP servers (for example, another control engine).
- The ioControl strategy can send data in file or string format to another FTP server.

For more information about how to use FTP with SNAP Ultimate brains and SNAP-LCE controllers, see Opto 22 form #1450, the *FTP and File Management: Snap Ultimate I/O Training Center Supplement*, and Opto 22 form #1300, the *ioControl User's Guide*.

3.00 Working with Opto 22 SNAP Ethernet-Based Hardware

3.10 How do I assign an IP address to SNAP Ethernet hardware?

ioManager, a configuration tool included with your purchase of any SNAP Ethernet-based brain or controller, includes a BootP utility to assign IP addresses to SNAP Ethernet devices. Each SNAP Ethernet-based brain or controller ships from the factory with a unique hardware Media Access Control (MAC) address, and with a default IP address of 0.0.0.0, which is invalid. Each Ethernet brain or controller must have a valid IP address and subnet mask to communicate on the network.

If you are adding an I/O segment to an existing Ethernet network, your network administrator must provide IP addresses and subnet masks. If you are creating an independent, dedicated Ethernet network just for I/O, you can choose your own addresses.

In either case, the IP addresses assigned to SNAP Ethernet brains and controllers must be unique, fixed addresses. They cannot be assigned dynamically. If the existing network has a Dynamic Host Configuration Protocol (DHCP) server, assign a fixed IP address before connecting the SNAP Ethernet device to the network.

When a SNAP Ethernet device is first powered up, it determines if it has a valid IP address. If not, it begins sending out a BootP broadcast to request an IP address. ioManager "listens" for these BootP requests and displays all the SNAP Ethernet devices without valid IP addresses. At this point, you use ioManager to assign a fixed IP address to each SNAP Ethernet brain or controller.

3.20 How do I choose an IP address and a subnet mask?

Normally, your network administrator will provide the IP address and sub-network address, especially if the SNAP Ethernet brains or controllers will reside on a plant-wide network. This is necessary to ensure that all nodes on the network have unique addresses. However, if you are building a dedicated control network, you are free to select your own addresses.

If you intend to use a dedicated network to link your PC to a SNAP Ethernet device (through any hubs that may be necessary), you must make sure that the IP address for each device is unique. The subnet (sub-network) mask, however, should be the same.

When selecting an IP address, use the subnet mask to make sure that the PC and the SNAP Ethernet device have the same network number and different node numbers. The subnet mask indicates what part of the IP address is the network number (that's the part that's "masked" off), and what part is the node number. The node number must be different from the node number of any other device on the same network. Note that a node number of all binary zeroes or all binary ones is invalid.

To determine the network number, bitwise AND the IP address with the subnet mask. To determine the node number, bitwise AND the IP address with the bitwise COMPLEMENT of the subnet mask. As an example, take the dedicated network address of 10.0.0.1 with a subnet mask of 255.0.0.0. The resulting network number would be 10, and the node number would be 1.

Example:

IP address: 10.0.0.1
Subnet mask: 255.0.0.0
Resulting Network Number: 10
Resulting Node Number: 0.0.1

A good starting point for a dedicated network address scheme is 10.x.x.x with a subnet mask of 255.0.0.0. This provides the widest range of node numbers in a single network number.

3.30 What if my SNAP Ethernet system has the same IP address as a PC on my network?

If a SNAP Ethernet brain or controller has the same IP address as a PC on the network, the PC will automatically take itself off the network. The SNAP Ethernet device will remain on the network. The PC will display the MAC address (for example: 00-a0-3d-xx-xx-xx) of the conflicting Opto 22 SNAP Ethernet device.

3.40 What do I do if I can't ping the SNAP Ethernet brain or controller?

The most common reason for not being able to ping the Ethernet brain or controller is incorrect addressing. For example, the SNAP device and the PC may be on different subnets. To fix this, try the following: either change the subnet mask on the device to be on the same subnet as your host, or "widen" the subnet mask so that both IP addresses are on the same subnet. Use IPCONFIG on Windows XP/NT or WinIpCfg on Windows 9x to determine the PC's IP address. If a SNAP Ethernet-based brain's ERD (Ethernet Receive Data) LED blinks while pinging, then the PC is able to transmit and the brain sees that transmission. (Note that this light will also blink if any traffic exists on the network. Look for a pattern of blinking as the ping command is executed.) For a SNAP-LCE, if the LNK led is lit, the controller is connected to the network. If the Ethernet brain or controller does not respond, then either it's at a different address, or it thinks the PC is not on the same subnet.

If the steps above don't work, verify that TCP/IP is installed on your machine. Type PING at the command prompt (DOS window) followed by the loopback address 127.0.0.1. This will ping your own machine (without actually going out on the network) to confirm that the TCP/IP protocol suite is installed. This procedure will not verify correct addressing on your network.

For additional troubleshooting help, see the Troubleshooting chapter in Opto 22 form #1460, the *SNAP Ethernet-Based I/O Units User's Guide,* or the Troubleshooting section in form #1475, the *SNAP-LCE User's Guide.*

4.00 Setting Up Your Ethernet Hardware

4.10 Where can I find Ethernet hardware?

Ethernet hardware products are widely available from many sources. Office supply stores, computer stores, resellers, and the Internet are a few places to look. You can also try any local Internet service provider that has consulting services. For industrial-grade Ethernet hardware connectivity solutions, check out Black Box online at http://www.blackbox.com or Hirschmann at http://www.hirschmann.com.

4.20 What are Ethernet's cabling requirements?

Ethernet packets can exist on several types of media. Opto 22 Ethernet products support only twisted-pair cabling, commonly referred to as 10BASE-T or 100BASE-TX. (SNAP Ethernet-based brains and controllers also support packet transmission through the serial port via Point-to-Point Protocol (PPP), but that method is not truly "Ethernet.") The cabling designation is an IEEE shorthand identifier. A "10" in the media type designation refers to a transmission speed of 10 Mbps. The "BASE" refers to baseband signaling, which means that only Ethernet signals are carried on the medium in a single frequency range. The "T" represents twisted pair.

The actual Ethernet cable is four twisted-pair wires (eight total), commonly referred to as Category 5 cable. Cat 5 cable is a copper medium tested and certified for use in 100 Mbps environments. Cat 5E and Cat 6 cables are tested and certified for transmission speeds of up to 1 gigabit per second and are compatible with Opto 22 SNAP Ethernet hardware. The connectors at both ends of Cat 5 and Cat 6 cables are referred to as RJ-45 connectors.

The physical length of any 10BASE-T or 100BASE-TX Ethernet segment cannot exceed 100 meters. An Ethernet segment is defined as the link between two Ethernet nodes (for example, a computer with a network interface card and a SNAP Ethernet-based brain) and a port on a hub. However, distances between two Ethernet nodes over several segments can exceed 100 meters by use of repeaters, switches, or mixed media segments such as fiber-optic cable.

4.30 How do I connect to Ethernet devices that are more than 100 meters apart?

The use of repeater hubs, bridges, routers, or switches will extend the distance between nodes. A *node* is defined as a connection point on the network. The 100-meter limitation is between two nodes on a 10BASE-T or 100BASE-TX network. (If you use fiber-optics, referred to as 10BASE-FL or 10BASE-FX, the distance between nodes is 2,000 meters. Use of fiber-optic cable is not directly supported by SNAP Ethernet hardware; a fiber-to-copper transceiver is necessary.) For example, the distance between a SNAP Ethernet device and a repeater hub cannot exceed 100 meters. But then the distance from the repeater hub to your computer could be an additional 100 meters. However, you cannot indefinitely continue to daisy chain hubs to extend the distance of your network. Ethernet must follow the "5-4-3" rule of repeater use: the network can only have five segments connected; it can only use four repeaters; and of the five segments, only three can have users attached to them; the other two must be inter-repeater links. To extend beyond the "5-4-3" rule, the use of bridges, routers, or switches is necessary.

4.40 What's the difference between a switch and a hub?

When connecting Ethernet segments together to build your network, hubs (or repeater hubs) are typically used. In a star topology, a hub is necessary to connect several point-to-point segments in a hub-and-spoke fashion. However, attaching several devices to a hub simply "shares" the network. All devices attached transmit and receive over the same "shared" network, and therefore contend for the same medium and bandwidth. As more devices communicate on the network, performance may diminish as more collisions occur. In a repeater hub network, all attached devices are said to be in a single *collision domain*.

A network switch, on the other hand, provides for independent collision domains on each port. This means that within the switch, processor technology is used to accept an incoming Ethernet packet on one of its ports, determine the destination port, and forward the message to that port only. This is in contrast to a hub that simply rebroadcasts any incoming message out on all ports.

As an example, in a small network with two computers, six Ethernet-based brains, and an eight-port switch, each device and its corresponding switch port represent a single collision domain. There-fore, each device has access to the full bandwidth on the segment (no sharing of bandwidth), with-out contending with other devices (no collisions). This results in dramatically higher performance and near-deterministic response times. Furthermore, most switches allow for full-duplex operation, resulting in an effective doubling of throughput (that is, 10 Mbps becomes 20 Mbps, and 100 Mbps becomes 200 Mbps) because transmits and receives occur at the same time over separate twisted-pair wires. When a SNAP Ethernet device is connected to such a switch, full-duplex, 200 Mbps over-all throughput is fully supported and attainable.

4.41 Would you recommend using a switch or a hub with a SNAP Ethernet system?

It depends. For high-speed, near-deterministic response times, we recommend using a network switch. Any available commercial, off-the-shelf switch or hub will do; however, Opto 22 has success-fully tested Cisco and 3Com switches internally. Using a switch instead of a repeater hub will elimi-nate network collisions by isolating each network segment into individual collision domains. In lower throughput or slower systems, traditional 100 Mbps or even 10 Mbps hubs may be used. For systems that use traditional repeater hubs, care must be taken to physically segment the network to avoid network congestion and collisions. For network configuration information, talk to your network administrator.