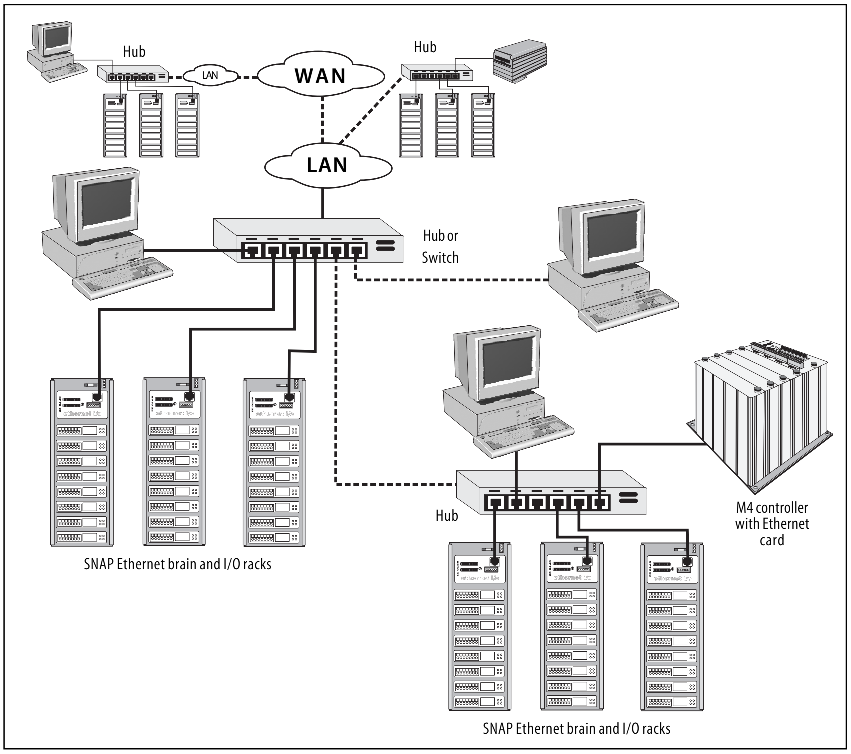
Understanding and Evaluating Ethernet and TCP/IP Technologies for Industrial Automation

Introduction

Networking is a major component in successfully implementing open systems, and a network's architecture should help to solve industrial automation problems as well as to achieve business objectives. When planning a network infrastructure, a business typically has several objectives. Open connectivity to a wide range of plant floor devices is one objective, while data sharing and gathering is another. Another objective is to have the flexibility to incorporate future advances in technology; without flexibility, businesses may be caught with dying technology that makes them unable to compete in tomorrow's opportunities.



Network Infrastructure

A structured approach is helpful when considering networking infrastructure. In a structured approach, you evaluate three main network components: the physical media, the transport mechanism, and application-level protocols.

Physical Media

The first component is the *physical media* used for moving data and connecting devices. One widely known and widely available medium is Ethernet cabling. This collection of twisted pairs of wire can be found in virtually any business today. The number of Ethernet connectivity devices dwarfs any other physical networking technology today. Furthermore, the Ethernet knowledge base within most organizations far surpasses that for any proprietary industrial network. Not surprisingly, the companies and vendor organizations who would hurt most from a wide-scale adoption of Ethernet at the plant-floor level are the most outspoken about its perceived shortcomings. At the same time, these same companies and organizations see the direction the industry is going and have begun to address Ethernet as a future networking option.

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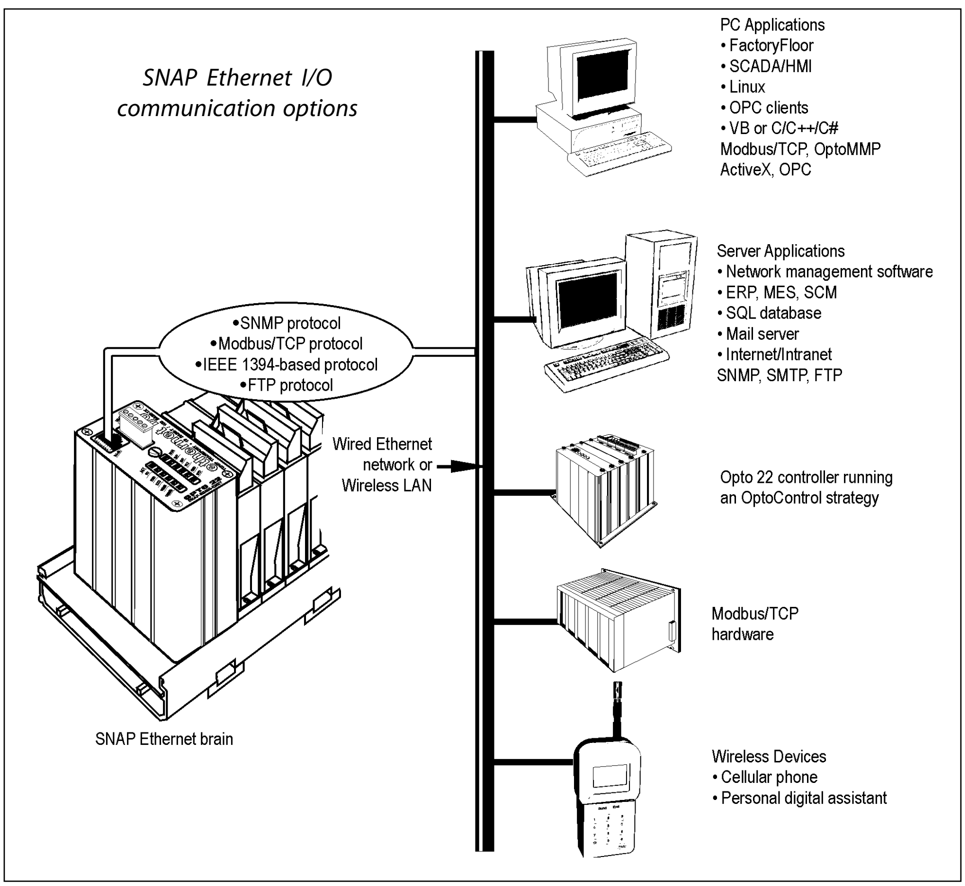
Other physical media that can work throughout an organization are fiber-optic cabling and wireless communications. Fiber provides a noise-immune method of transferring data within harsh environments. Fiber also allows for very high-speed data transfer over long distances. Wireless is just coming onto the scene. While it promises to break us free from the necessity of running cable throughout, pervasive wireless networking is still a future technology. The selection of an open network, however, must take into account future developments such as wireless to preserve and extend current investments. This consideration takes us to the second component, which is arguably the most important.

Transport Mechanism
The second component, the *transport mechanism*, is how data is transported over the physical medium, for example how data is sent on the wire (Ethernet), through the glass (fiber optics), or over the air (wireless). The transport mechanism has little to do with the data itself, but more with how the data moves from one device to another over a selected physical medium.

Clearly the undisputed global leader in transport is Transmission Control Protocol over Internet Protocol (TCP/IP). The beauty of TCP/IP is its ability to bind to many types of physical media, from wire to wireless or LAN to WAN, and on the other end, to encapsulate virtually any type of data. TCP/IP then becomes the true key to networking flexibility. Because it can adapt to both the physical layer and the application layer in virtually any way, its use is limitless.



Application-Level Protocols

The final component, *application-level protocols,* is perhaps the most contentious within the industrial automation community. Most of the opponents of Ethernet technology claim that the lack of a "standard" protocol at the application level is the Achilles heel that prevents Ethernet from becoming a truly interoperable networking technology. (But remember, Ethernet is only the first part of the networking infrastructure—the physical part—and is not an all-inclusive technology.) However, that didn't stop the rest of the world from adopting it.

For the sake of interoperability, a common method of sharing data from one device to another *is* important. But that doesn't mean that all plant-floor devices must speak the same language. Different plant floor devices have different tasks and different data to share. It is foolish to expect that a single massive protocol can cover all of the possible data types that might be shared on a given plant floor, now and in the future.

An illustrative analogy is the standard telephone system. The actual phone line would be analogous to the physical medium, such as Ethernet. The dial tone would be the transport mechanism, TCP/IP. Finally, the language you speak over the telephone would be the application-level protocol. No matter what language you speak through the telephone, the underlying technologies remain the same. The only requirement is that the person you choose to speak with understands the language you are speaking. Requiring everyone who uses a telephone to speak the same language would be ludicrous.

How Opto 22's SNAP Ethernet brain communicates: Physical, Transport, and Application layers

Application-Level Protocols	Data for enterprise systems	E-mail, paging	Opto 22's OptoMMP protocol	Modbus/TCP protocol	SNMP, streaming area
	FTP	SMTP			
Transport Mechanism	Transmission Control Protocol (TCP)				UDP
	Internet Protocol (IP)				
Physical Media	Physical Interface For example: an Ethernet card and cable or modem (coaxial, twisted pair, fiber optic, dial-up, wireless)				

Here is where we can take a page from the information technology (IT) side of the business. In IT, as well as in industrial automation, different tasks require different data elements and structure. For example, simple mail transfer protocol (SMTP) was designed to allow e-mail systems to exchange e-mail messages. But if you also want to transfer files, you don't need to add that capability onto the SMTP protocol. That's what the file transfer protocol (FTP) is designed to do. And FTP works simultaneously with SMTP (along with a rather large number of other task-specific protocols).

Case in Point

Opto 22's SNAP Ethernet I/O can communicate with multiple devices simultaneously, using different protocols for each device. For example, you might use the Modbus/TCP protocol to gather data from the SNAP I/O system, and at the same time use SMTP to page a technician about a problem. This simultaneous use is possible because of the enabling technology of the TCP/IP protocol suite over the Ethernet physical medium (or over wireless connections, phone lines, and other media as well). TCP/IP can handle concurrent sessions from many hosts. You don't need to develop a "standard" single protocol to accomplish both tasks.

Experience shows us that all vendors won't agree on a standard application-level protocol anyway. The market will decide which application protocols will be predominant based on the functionality of the protocol, the task it is designed to do, and its ability to coexist with other protocols. One of the most important advantages to users in adopting this networking philosophy is the inevitable issue of change. When (not "if") new or advanced application-level protocols surface, the underlying infrastructure is already in place to implement it. You aren't locked in to a top-to-bottom network technology, but instead can use the best tools for the job at the application level—the level that counts most—for the task at hand.

Summary

The bottom line is that networking should drive both automation and business systems, but the networking technology itself must have truly enabling capabilities. TCP/IP provides this capability: it is the conduit through which data can flow through multiple physical media and through multiple application-level protocols. The industrial automation vendor community will eventually recognize this—and then interoperability will happen.

An open systems approach should also provide networking technology with the ability to extend—to allow functionality at a broader level. Large corporations continually struggle with managing the plethora of critical business assets across their organization. Typically, plant-floor devices are separated and disconnected from the rest of the corporation's assets, especially from their information technology assets. But managing all these assets together allows the business to function as a unit. If we follow the philosophy of network implementation outlined above, we can bridge the management of mission-critical assets across the entire organization.

The industrial automation community can benefit in many ways by taking a close look at how the information technology industry solved the same problems of making open systems work. While interoperability and commercially available, open technology is the hope and dream for users in industrial automation, it is a reality in the world of information technology. Here is an opportunity for the industrial automation community to learn from the experience of the billion-dollar information technology community.