industrial ethernet REVIEW

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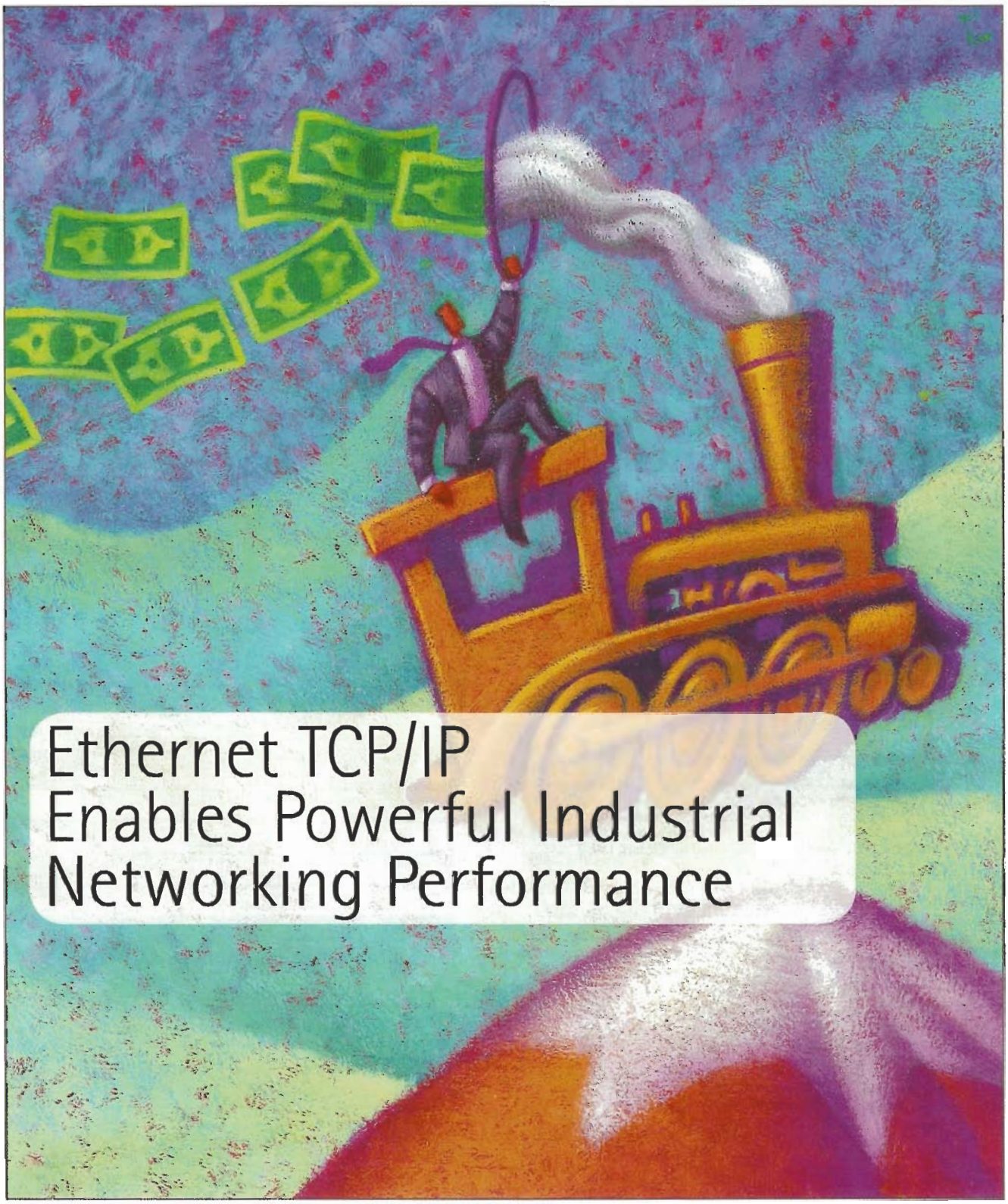

Ethernet TCP/IP Enables Powerful Industrial Networking Performance

Watch Your Ethernet Definitions

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If I mention the word "Ethernet," what's the first thing that comes to mind?

Well, you're probably wrong. Ethernet technically describes only the physical layer of the network. It encompasses the cable, connector and the lowest layer firmware needed to effect an electrical connection. When I took my first networking classes around 1987, Ethernet was barely discussed, even though it did exist at the time. It was almost a surprise when, as it seemed, Ethernet suddenly became the personal computing and client/server network almost everywhere.

We use the term in this magazine in a way reflecting general usage. We not only refer to the physical layer, but also to the whole host of transmission, addressing and application layer protocols that have grown up over the years. Many grew because the early Web browsers supported the application protocols. The hypertext transfer protocol (http) that enables Web page loading and the file transfer protocol (ftp) that enables transmitting large files are a couple of examples.

The beauty of Ethernet and the standards and practices that have grown up around it lies in the network's openness and flexibility. The way it is designed, it can carry all of the protocols at the same time on the same wire—and the messages don't become garbled.

Terry Costlow does an admirable job describing a variety of these protocols and explaining their use. This is the foundation article of our new year of bringing you the *Industrial Ethernet Review*. Enjoy.

To take a deeper dive into the topic; check out the on-demand Webcast, "Ethernet-based Industrial Communication Protocols" at www.automationworld.com/webcast-5345

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Ethernet Protocols' Flexibility A Boost For Manufacturing

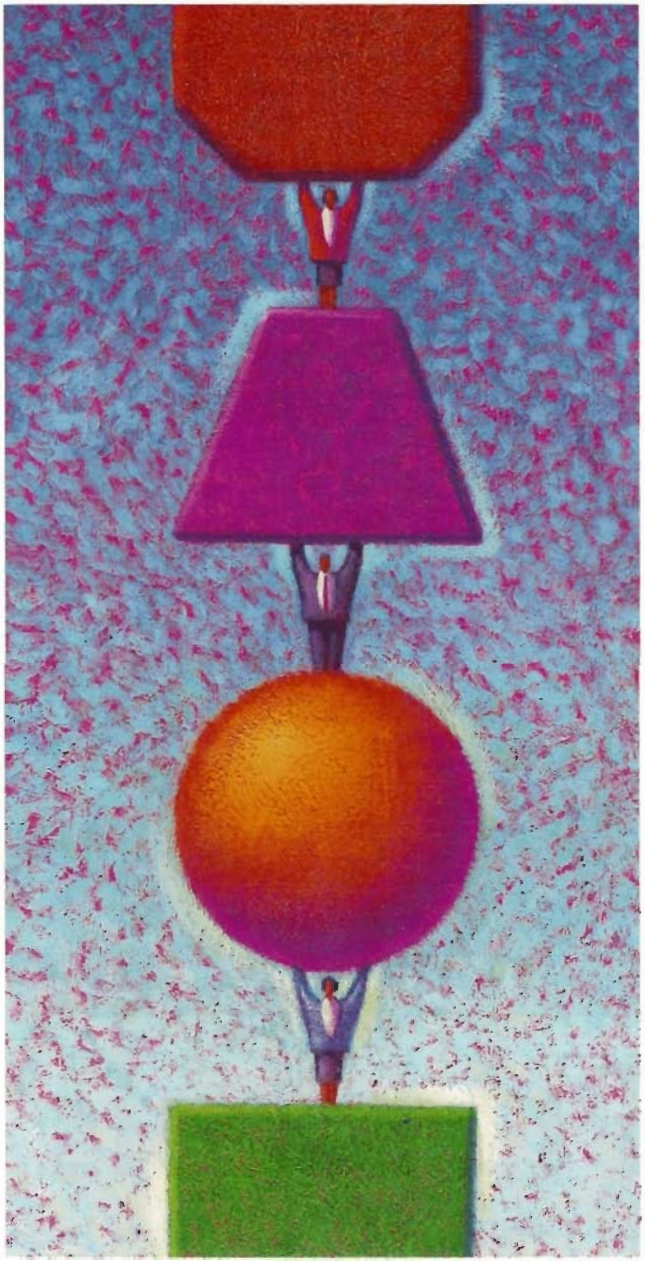
The ability of Ethernet to carry multiple protocols enables innovation in communication for effective manufacturing efficiency.

By Terry Costlow, Contributing Editor

Packaging Corp. of America (PCA) saves a lot of money by reclaiming wood chips that were once lost during the production of container board and corrugated packaging. Though it was easy for executives to see the potential savings, potential problems loomed large in the outlook of engineers tasked with stacking and reclaiming the waste material.

Foremost among them was the task of getting all the equipment at the facility in Valdosta, Ga., to work together. The stacker-reclaimer at the heart of the project has to communicate with log handling cranes, debarkers and conveying systems that don't all use the same communication schemes. They all need to work together to gain the greatest benefits.

"The reclaimer's design is similar to that of a giant chainsaw, with a massive boom that rotates and then rakes wood chips back from the stockpile to load onto conveyors," says John Lewis, engineering vice president at Fulghum Industries Inc., a Wadley, Ga., forestry equipment producer. PCA's reclaimer uses



"With Ethernet, a lot of multitasking happens. Control, diagnostics and management data all ride on one network."

variable frequency drives regulated by Allen-Bradley controllers that communicate with the woodyard chipper and debarker, as well as two truck dumps, he adds.

EtherNet/IP (a standard from ODVA, formerly known as the Open DeviceNet Vendors Association) is the protocol for PCA's reclaimer, but gear from Fulghum and others uses Ethernet TCP/IP (for Transmission Control Protocol/Internet Protocol). Two separate control systems had to work together seamlessly with response times that were quick enough to sound alerts when safety issues or other problems arose. That was addressed by implementing a programmable automation controller (PAC) system that included EtherNet/IP as one of the many protocols it handles.

This ability to link many protocols together—whether they're variations of Ethernet or legacy fieldbus protocols—remains one of the biggest advances that has occurred over the past decade. Ethernet is becoming the dominant physical medium for networking, enabling communication systems to carry a number of protocols.

"Ethernet's been popular for 10 years or so, but not everyone's bought in yet," says a spokesperson for Opto 22, a Temecula, Calif.-based automation vendor. "When they do, most customers want to bring everything together under one umbrella so they can move data around the enterprise, using something like EtherNet/IP in one facility and communicating with another building that uses another protocol."

These protocols let users accomplish a broad range of tasks with few communication worries. The TCP/IP schemes widely used on Ethernet address a number of common tasks, making it possible to move many different types of data around simultaneously.

"With Ethernet, a lot of multitasking happens. Control, diagnostics and management data all ride on one network," says Marty Jansons, network consultant for vendor Siemens Industry Inc., in Norcross, Ga.

MORE SPEED

Initially, Ethernet made its way onto the factory floor because it provided more compatibility with front-office networks while also creating a flat hierarchy that reduces complexity and simplifies maintenance. But continued advances driven by the need to move more data in less time has given it another weapon that helps it compete with legacy industrial networks. The Institute of Electrical and Electronics Engineers (IEEE) committees that manage the standard continue to drive the speed of its wired and wireless versions upward.

"The biggest issue regarding Ethernet is bandwidth," says Bill Wotruba, director of networking and connectivity products for Hirschmann, an industrial Ethernet component supplier in Chambersburg, Pa. "We're at 100 Mbaud (megabits per second), compared to 2 to 5 Mbaud for Profibus. With wireless Ethernet, you drop down to 54 Mbaud, depending on the version, so you've still got a lot more bandwidth than with many other networks."

Ethernet's bandwidth and its ability to carry many different protocols provide a huge array of options for users. Being able to connect devices that use fieldbus technologies such as Modbus, DeviceNet and Profibus makes it easy to connect legacy equip-

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ment and inexpensive products such as sensors that don't need Ethernet's capabilities.

At higher levels, a number of different protocols have emerged to address the disparate requirements of different automation environments. Profinet, EtherNet/IP, Modbus TCP, EtherCat and Ethernet PowerLink are among the protocols available to industrial suppliers. For the most part, they don't employ any significant changes that impact networking switches and other communication products. "Most folks don't require switches to do anything special to send messages back and forth," says the Opto22 spokesperson. "We've steered away from technologies that do things in a different way."

However, the protocols offer a few little changes that can help plant floor managers improve efficiency. For example, Profinet mandates some protocols such as the link layer discretionary protocol. LLDP lets Ethernet ports know what devices are connected to them, making it simpler to pull data from various devices. "The most interesting thing you can do with LLDP is replicate a device that has failed without using any configuration tools, so there's no need to pull out a laptop," says Carl Henning, deputy director at the Profibus Trade Organization, in Scottsdale, Ariz. "If, say, port two had this device and you're installing the same thing, LLDP tells it what its name and IP address are without requiring any software."

Some benefits are universal. Regardless of the protocol that users pick, all Ethernet derivatives make it much simpler for managers to check on their networks, even when they're far from the factory floor. Ethernet's capabilities protect data and networks even when managers enter the network from remote sites. "You can use VPN (virtual private network) methodologies for secure remote access," Jansons says.

REMOTE MAINTENANCE

This capability is also impacting the way that equipment suppliers maintain products in the field. Hypertext transport protocol (http) and file transfer protocol (ftp) familiar to Internet users make it possible for manufacturers to set up Web sites that have a wide range of tools and downloads, as well as places for operators and technicians to chat. That can be far more efficient than sending maintenance personnel out to remote sites.

"Many control devices like PLCs (programmable logic controllers) and switches have Web servers built in," Henning says. "That lets you use Web browsers to configure equipment or get diagnostic information without being local. That's an exciting idea for original equipment manufacturers (OEMs) that want to eliminate travel costs but still help customers maintain equipment."

Another benefit is the ability to leverage existing graphical user interfaces (GUIs) and other control programs. Equipment makers spend a lot of effort developing human machine interfaces that meet customer demands and give several different machines a similar look and feel so they're easier to use. "Rather than leaving their environment, users can configure pertinent parameters from their GUIs," says Jim Laurita, technical services supervisor for Hirschmann Networking Technology, a Milwaukee-based supplier.

The shift to Ethernet also makes it simpler for companies to add wireless capabilities. Wi-Fi, for wireless fidelity, is an extension of the IEEE 802.11 Ethernet standard that dominates modern networks. It's seeing increased usage in industrial applications. Reliability has been proven in harsh industrial sites around the globe, removing user concerns that packets might be lost if electrical interference disrupts over-the-air transmissions. Wireless Ethernet is also getting a significant boost from the powerful infrastructure that supports consumer and business products.

Last fall, the IEEE 802.11 committee approved a new version, 802.11n, which pushes the theoretical speed up to 600 Mbytes/second. That's more than a tenfold improvement over the 54 Mbps that the 802.11g standard uses in current-generation products. The upgraded version is expected to have solid growth in consumer and business applications. ABI Research, of Oyster Bay, N.Y., predicts that more than half the Wi-Fi shipments in 2012 will be based on the 802.11n specification. As industrial networks adopt this new version, Wi-Fi is expected to begin putting more pressure on alternative wireless protocols used in automation.

"A lot of wireless networks in industrial facilities have used proprietary protocols optimized for speed, throughput and reliability," says Cliff Whitehead, manager of strategic applications for Milwaukee-based supplier Rockwell Automation Inc. "That may change now that 802.11n has been ratified. It's more reliable and it has features like multiple input, multiple output and the ability to use multiple-band radios."

These changes make it easier for wireless links to carry the full range of protocols and communicate with many different types of equipment without seeing bottlenecks. Most observers note that protocol capabilities and potential issues are not any different with wireless than they are with wired networks. The biggest change is on the hardware side, where wireless communication makes it easier for engineers to put compact cameras and other sensors in locations that would be difficult to reach when wire tethers are required. "More and more end-users are realizing they can install other things like IP cameras near machines or inside vessels to see what's going on in areas," says Mike Hannah, NetLinx product business manager for Rockwell Automation, in Mayfield Heights, Ohio.

Though wireless is making inroads in many different areas, it isn't expected to displace wired connections. That's particularly true in real-time applications that require more precise timing than wireless networks can provide. "Any application that uses Profinet can use wireless, except motion control," Henning says. "Wireless is a shared medium so there's no determinism, and you may see some latency."

Until 802.11n makes its way into the industrial world, implementers will have to pay attention to the issues that come with the comparatively low bandwidth of wireless links. This lack of speed is exacerbated by the node-to-node technique often used to carry data throughout the entire wireless network. If a node that handles a lot of data movement is down, it can cause band-

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width problems anywhere in the network as other nodes take over transmissions. Together, these bandwidth issues can cause bottlenecks, particularly with EtherNet/IP.

"If you try to send EtherNet/IP over wireless, you can get intermittent problems when a lot of things start responding," says Ira Sharp, wireless specialist for automation supplier Phoenix Contact Inc., of Middletown, Pa. "You can slow down its request packet interval (RPI) if it's not set for wireless. Users need to look at RPI when they pull a PLC out of the box."

Though the leading Ethernet-compatible protocols are largely compatible, observers note that there are some differences. Some versions can multicast messages to several nodes, while others require a slightly different approach when users want to send one message to many nodes. "EtherNet/IP is a bit different because it broadcasts, but it can still coexist on the same cable with Modbus TCP, Profinet and other protocols," Henning says.

Many equipment makers address these subtle differences in the switches that handle traffic flow. Often, many of these switches provide some management functions. That gives network managers more capabilities. "We embed the ability to do Profinet and EtherNet/IP-compliant processes, letting people access network variables from switches," says Hirschmann's Wotruba. "That gives you powerful tools like secure I/O (input/output) recovery."

SATURATION WATCH

When problems arise or loom on the horizon, Ethernet networks offer other useful protocols that fit under this "powerful tools" umbrella. One of the most popular is the simple network management protocol. SNMP lets network managers look at a range of performance parameters and check traffic flow. It can help them avoid problems by showing data that is useful in determining when the available bandwidth is close to saturation.

"SNMP lets you monitor traffic levels so you can see if you're getting a bottleneck or if bandwidth demand is exceeding the comfort level and bringing network performance down," says Rockwell's Hannah. "Then you can decide if it's time to improve performance by better segmenting your networks."

The management tools can access data from a range of inputs. Some data comes from PLCs and other control equipment. Much comes from the switches used in Ethernet schemes, particularly when managed switches are employed. When they're handling packet flow, collecting important data is an inherent benefit. "If you're using managed switches, they're collecting a lot of data you can use for troubleshooting," Henning says. "SNMP makes of a lot of information in the switch available; you can bring it into the HMI and do a lot of analysis."

SNMP's use of this data underscores the importance of switches in Ethernet's structure. Proper placement of switches is a critical element of successful implementations.

"System design and layout is the most important facet of TCP/IP as it relates to the placement of managed and unmanaged Ethernet switches within a system," says Chris Vitale, senior product manager at Turck Inc., a networking and sensor supplier in Minneapolis. "Getting the physical layout of a system laid

out prior to installation is very important, as all devices must be routed through switches. The placement of these switches is integral in creating a system that is easy to install and integrate."

Once these switches are put into place, the ongoing focus returns to the day-to-day benefits that come from various protocols. SNMP is part of the User Datagram Protocol (UDP) that is an alternative to the common TCP/IP approach. The two approaches can be used together. UDP is employed by the popular Domain Name System naming system used for network-attached devices.

UDP is connectionless and it doesn't perform retries when packets are lost. That makes it useful in applications that value speed more than reliability. Some network developers use UDP when they need more determinism than TCP/IP offers.

"The transport layer has two standard protocols, TCP connections for messaging and UDP for applications where you need real time," Hannah says. "UDP is a connectionless protocol so you don't need to establish point-to-point connections, overhead is reduced, and it provides the performance required to do real-time control."

Real-time capabilities are provided by a number of protocols. Most of the popular Ethernet-compatible protocols have variants that provide more determinism than the basic connection. These techniques provide a range of speeds and capabilities. "Profinet's real-time protocols can provide media redundancy and response times under 200 milliseconds," says Siemens' Jansons.

The Common Industrial Protocol is another tool that's helpful in applications that require more speed. CIP, now managed by ODVA, was created to integrate I/O control, motion and synchronization, device configuration and data collection across multiple networks. It's widely used to make sure that the many facets of industrial communication schemes are synchronized. "CIP comes into play when you need to insure that motion, safety and certain I/O occur on time," Hannah said.

Though CIP brings a lot of capabilities to industrial automation companies, gaining those benefits doesn't require a huge amount of

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effort. No additional hardware is needed to read CIP commands.

"Technology is built into Ethernet frames so things like CIP can be decoded," Wotruba says. "It's all done in software so you don't need extra pieces of hardware."

Decoding the many types of data that are carried on an Ethernet cable is fairly straightforward, but that doesn't mean it's always easy. Organizations are creating techniques that help their users employ the right pieces, ensuring that everything works together without requiring network managers to install equipment and software that isn't needed in their specific environments.

"We're developing profiles that arrange data in a particular way that provides consistency and prevents errors," Henning says. "These profiles use specific protocols to simplify the way data is handled."