EtherNet/IP: fieldbus and more

EtherNet/IP takes advantage of Ethernet commercial technologies to surpass alternative solutions.

By Michael Robinson, Solutions Business Manager, Endress+Hauser

Since its invention in 1973, Ethernet has changed the world. It will continue to deliver the fastest data throughput, improve the architectures upon which it is delivered, evolve into varying electromechanical spectrums to meet the next industry trend, and penetrate down into the tiniest of microprocessors. Our world of process and factory automation is no exception to the ever-reaching technological advancements of this network.

Twenty years ago the process automation market had proprietary ways to meet the demands of remote I/O peer-to-peer communications. These approaches were successful and supportable, but users began to demand that their automation systems interface and share more data automatically with their front office systems over Ethernet.

Automation vendors began connecting their control systems via Ethernet, but there was no workable way to deploy device control requirements over a non-deterministic network infrastructure like Ethernet. As process users started to transition from traditional 4-20mA analog devices and demanded digital device communications, fieldbus networks emerged to meet the demands that Ethernet couldn’t.

Today, Ethernet communication has overcome many of the disadvantages of previous years and established its presence in field device communications. In factory automation, Ethernet-based networks are being used to connect robots, variable speed drives, actuators, etc., to automation controllers. In the process control world, EtherNet/IP now connects flow meters (Figure 1), pressure instrumentation and similar field devices to distributed control systems, programmable controllers and hybrid programmable automation controllers (see Figure 1).

While there is no network panacea, EtherNet/IP has benefits that some fieldbus architectures cannot deliver (Table 1). In this article we will explore these benefits.

![Figure 1: Process instrumentation with EtherNet/IP connections, such as this Endress+Hauser Promass Coriolis flowmeter, are becoming more common as users realize the benefits.](image)
Table 1: Advantages of EtherNet/IP over fieldbus

1. Easier to connect to a variety of host systems
2. Can communicate with multiple hosts simultaneously
3. Is instantly familiar to anyone with Ethernet experience
4. Can use all available Ethernet tools and technologies
5. Can use QoS to prioritize network traffic
6. Can use SNMP to monitor and manage the network
7. More network topology options when switches are deployed
8. Better support for wireless data transmission
9. Better security through the use of standard Ethernet tools
10. Economies of scale promise future gains outpacing fieldbus

Industrial Ethernet Protocols

Within the Ethernet frame one can place almost any application protocol. There is no one particular protocol that serves all the needs of industry. Application protocols are instead like a tool chest, with users picking the ones that support the demands of their particular automation applications to provide the required performance, security and safety.

The focus for this article will be on EtherNet/IP, the industrial Ethernet protocol supported by the Open Device Vendor Association’s (ODVA, www.odva.org). EtherNet/IP uses the standard Ethernet frame as defined by IEEE802.3 and uses ODVA’s and ControlNet International’s Common Industrial Protocol (CIP) application protocol library of objects.

Figure 2 shows how the CIP application library—the upper half of Figure 2 in blue and red—can be deployed upon several different physical network architectures, with the Ethernet physical architecture displayed in green. This is a unique benefit to users because there are no physical application interfaces between the layers. This gives the CIP library almost seamless bridging and routing among different physical networks, both Ethernet-based and others, such as CAN-based.

Ethernet and EtherNet/IP

EtherNet/IP in the process industry is definitely a technology still in development—unlike fieldbus, which has enjoyed 20 years of refinement. However, recent developments and technology breakthroughs are making EtherNet/IP a viable alternative to fieldbus.

EtherNet IEEE 802.3 can currently support data transmissions up to 10 Gigabit/second. Although EtherNet/IP enabled devices deployed over the 802.3 standard currently support only 10/100 Megabit/second transmission rates over copper and fiber, traffic through the network can still use the higher transmission rates if the network architecture supports it. And future variants of EtherNet/IP will advance along with Ethernet to support even higher transmission rates.

One advantage of EtherNet/IP is that it can support wireless transmission by using industry standard devices. When deploying EtherNet/IP over wireless, the user must take into consideration how wireless system deployment creates latency in the EtherNet/IP message timing. Note that the same latency problems exist with wireless fieldbus, but without the advantages of the latest technological developments from the Ethernet wireless world.

Cabling distances are dependent upon the 802.3 standard; i.e., 100 meters for device to device when deploying over copper and 2000 meters when using fiber deployments. Power over Ethernet (PoE) is available, so that power supplies may not be needed in the field. However, product availability varies by vendor.

Ethernet switches are also available for use in hazardous locations. Some switches use Intrinsically Safe Power over Ethernet (PoEX) for connecting to field instruments in Zones 1 and 2. Unlike fieldbus, which can handle multiple devices in hazardous areas, one switch vendor recommends putting only one device on a single cable, which is becoming less of an expense as Ethernet switch prices rapidly decline. Again, product availability will vary by vendor.
Typical Ethernet network topology is trunk-star; however, device manufacturers are starting to embed micro Ethernet switches into their devices, allowing for linear and ring topologies, reducing the need to create star network topologies. Redundancy can be achieved through the appropriate switch architecture and in some instances by adding a communication interface to allow a single fiber or copper port to be a node on a redundant ring infrastructure. In other words, it is possible to put multiple instruments and devices on the same cable (Figure 3) and to provide redundancy when needed.

Process Instrument Perspective
Looking at the EtherNet/IP protocol from the perspective of the process instrument, who and what does an instrument have to report to? Primary responsibility is to the automation or host system. Historically this involves the primary process variable. Secondary responsibility will be instrument diagnostics, and last will be instrument configuration data.

Each of the users or consumers of the data that the instrument produces, has different tools and mechanisms to acquire the data. Each has their own unique requirements for the use of the data. Considering each of these areas—and how EtherNet/IP not only serves their unique requirements but also creates commonality and convergence in the process—will help us understand how EtherNet/IP is not only a very capable fieldbus-type network, but also provides benefits beyond what typical-level fieldbuses deliver today and in the future.

Process variables
EtherNet/IP communicates process variables or I/O data back to the host system at a requested packet interval rate (RPI). This RPI is defined by the user. Typically RPI is set based upon application requirements. RPI rates for EtherNet/IP enabled devices will vary based on the manufacturer of the device and the applications they serve.

Typical RPI times for process instruments, such as Coriolis and electromagnetic flow meters, on EtherNet/IP networks are from 5 ms to 10 seconds. The device will communicate I/O data to the automation system at the RPI rate established when the device is configured in the system. This variability in selection of the RPI data rate enables the user to optimize the flow of I/O data through the process and optimize the data crunch through the microprocessors in the data chain without relying on the actual network bus rate or frame size specifications.

I/O data can also be provided simultaneously to multiple consumers (processors, devices, etc.) in the architecture. In addition to the primary process variable, multivariable devices—such as mass flow meters—can transmit multiple variables such as flow, volume, temperature, etc. at the same time, similar to traditional fieldbus architectures.

Configuration of what variables will be transmitted in the I/O data structure is typically determined by the manufacturer of the devices. Some manufacturers allow user configuration of the I/O data structure. Device vendors deploy device profiles which will interface with the automation system and define what these variables are.

If profiles are well defined, the process control engineer has very little work to do to get devices on line, and communicating data throughout the system. Typically, just verifying the actual device, revision of device, RPI and the Ethernet address of the device is all that is required to get a device up and running.
Diagnostic data

Diagnostic data can be a very general term and is defined by the task that is being performed by the technician or operator requiring it. From the device perspective, the device can provide diagnostic data to the automation system, operations personnel, maintenance personnel, reliability personnel, and information technology (IT) personnel, to name a few.

Some of this diagnostic data can be included in the I/O data structure. For example, diagnostic data for a Coriolis flow meter includes empty pipe detection, sensor drift, sensor error, electronics error, inhomogeneous mixture error, ambient and process temperature errors, and other information. Whatever data is considered critical can be included in the I/O data during configuration.

Devices also need to provide diagnostic data to technicians operating outside the control area, and the automation system’s operator interface tools. One example is an E&IT technician using device configuration software to reference the voltage delta between the measuring electrodes in an electromagnetic flow meter. With appropriate software, the technician can access the necessary data without interfering with process control operations.

Devices on EtherNet/IP can also be polled by a condition monitoring system to determine if there are any diagnostic messages that need to be sent to maintenance personnel as an alert. An industrial PC equipped with asset management, maintenance, condition monitoring or HMI/SCADA software can access all the I/O and diagnostic information it needs directly from the devices via the Ethernet interface (Figure 4). With fieldbus, the same software has to access the information from the process historian or data base in a DCS—at considerable extra cost.

Most EtherNet/IP enabled devices support Simple Network Management Protocol (SNMP). This enables IT technicians to monitor, troubleshoot and administer network devices using standard network management tools. For example, let’s say IT is monitoring network traffic using an SNMP-enabled tool. The software tool reports that an EtherNet/IP device has exceeded its normalized packet transmission rate, and an e-mail alert is created and sent to a technician. The technician can then use the internal web server of the device for troubleshooting.

This leverages the investments a company has made in their IT support infrastructure, and minimizes the burden on the process control engineer to also be an IT support engineer.

Fieldbus, on the other hand, requires detailed knowledge of the fieldbus architecture and cannot leverage a company’s IT infrastructure; the burden is still placed on the process control engineer to be a network expert. Fieldbus requires specialized training and knowledge, while EtherNet/IP is instantly familiar to process automation and other professionals that have worked with Ethernet.
EtherNet/IP has two main messaging connections: I/O Data and Explicit Connections (Figure 5). Explicit Connections are messages that are not scheduled as with I/O data, but are delivered on demand. While the device is handling I/O data requests it can simultaneously handle on-demand requests. Figure 5 illustrates the mechanism—UDP/TCP in the TCP/IP suite of Ethernet—to simultaneously deploy the I/O data and messaging data for the CIP library.

These examples demonstrate a few of the various requirements of device diagnostic data and the varied locations to which this data is sent. The ability of Ethernet to allow this simultaneous collection of data from the devices is a key benefit.

Compared to traditional fieldbuses, EtherNet/IP has minimal need to create additional configuration code in the host system. This reduces the footprint of the process configuration on the host. There is no need to have an additional software configuration package for the network or to add additional network interfaces, thus reducing hardware and software costs.

Some of these benefits are derived from the mere use of Ethernet and cannot be wholly attributed to the EtherNet/IP protocol. However, implanting these functions often make fieldbus installations expensive, cumbersome, difficult to support and sometimes unappealing. Deploying an Ethernet-based protocol is thus useful in overcoming fieldbus difficulties and objections.

**Configuration data**

Configuring and documenting a process device in an automation system can be a very time intensive task. EtherNet/IP gives users of these devices several options for configuration and documentation by giving them different access points and letting them use different tools to configure and maintain device configurations.

802.3 Ethernet provides a large data packet—up to 1500 bytes—that opens up a large chunk of data in a frame, enabling device vendors to serve up more device attributes than can be communicated over typical fieldbus protocols. This configuration data for a process device is communicated at the I/O Data level to the automation system.

This gives the automation system access to the configuration parameters of a process device, allowing the user to determine which, if any, configuration parameters can be accessible to system programmers or operators at the operator workstations. This provides flexibility during start-up and commissioning for personnel to monitor or change parameters while working from within their system configuration programs.

Using EtherNet/IP does not require all users to use the same set of tools. Most devices on Ethernet have a web server built in which gives users access to device parameters. This is useful for the IT technician who may not have access to or training for process control software or device configuration software tools.

Because the Ethernet/IP protocol uses the standard OSI model, other toolsets become available, and can coexist and function synchronously throughout the architecture. Maintenance personnel also have at their disposal their own tools, such as asset configuration software and asset management software, for documentation and change management requirements. All this software can reach devices throughout the EtherNet/IP network.

**Network Optimization**

EtherNet/IP provides network access beyond the Local Area Network to a Wide Area Network. I/O data can now traverse from one network to the other through standard IT hardware. This gives support personnel access from virtually anywhere in the world, allowing manufacturers and vendors to support their customers remotely.

It also provides segmentation and optimization of networks using tools that IT companies commonly provide to the marketplace. Traditional fieldbus implementations constrain data to their physical network; that data must be accessed through the host or a 3rd party communication interface.

The volume of data on the network is increasing as users begin to merge their business/financial networks to the plant automation system network. This creates an ever increasing need to segregate, constrain and secure the traffic so that it does not impact the data throughput of the automation networks. IT suppliers have been providing the hardware and tools to support these needs, and that technology is now employed on industrially hardened Ethernet-based devices.

Some IT vendors are also providing switch diagnostic data as I/O data in the CIP library. This commercially available technology allows the engineer to segregate network traffic inside the common hardware appliances, allowing for even faster propagation of critical data inside the network topology.
There will be some applications where a user may not be able to completely segregate or constrain the data to a virtual LAN or local subnet. The issue now becomes being able to compete for the data packets to be processed in the switches throughout the network. EtherNet/IP has identifiers in the CIP library to allow a switch, configured for quality of service (QoS), to prioritize these packets over the voice, data and media packets on the network. Being able to perform these QoS tasks within the network provides the best optimization of the network for the automation network data.

Security is a wide and deep topic and is not addressed in this article other than to note that EtherNet/IP is able to leverage all of the commercially available security features that are delivered in the IT market today for Ethernet-based networks. There are several publicly available documents for securing converged networks, and the ODVA website has a publication that discusses securing Ethernet networks.

**Looking Ahead**

Ethernet has been the dominant commercial network for the past 40 years, and will continue to be in the future. As the convergence of the plant floor to the front office continues its progress, leveraging this future in automation devices will be essential. Process devices will get more intelligent—the past and present demonstrate this. A process device will have a lot of information to share, and will need ever more network capacity and capabilities.

EtherNet/IP will meet these needs by leveraging Ethernet advances, taking advantage of Ethernet’s huge economies of scale. More Ethernet nodes will be connected this or any other month than will have been connected in the entire history of fieldbus. This economy of scale and the tremendous technological advancements that go along with it is what makes EtherNet/IP more capable than a fieldbus network, now and especially in the future.

Michael Robinson is director of solutions for Endress+Hauser Sales Center USA. He has 18 years of experience in factory and process automation as a project engineer, product manager, and business development manager. Robinson has a BS in agricultural engineering technology from California Polytechnic State University, San Luis Obispo, California.