Data Analytics Starts with Smart Instruments

Industrial Ethernet protocols are the leading method for gathering smart instrument data and pending developments will allow improved implementation of this technique with two-wire instruments.

By Keith Riley, Endress+Hauser

Industrial Internet of Things (IIoT), the use of smart instruments to enhance industrial processes through real-time analytics, requires the generation of massive amounts of big data, which is collected and stored in host systems for evaluation. Main sources of this data are the smart instruments installed throughout plants and facilities.

These instruments transmit basic process variables—along with extended data such as calibration parameters, diagnostics and other information—over digital networks. This data becomes valuable when analyzed by end users in the context of a specific process permitting them to perform predictive maintenance, reduce downtime and make other operational improvements.

This description assumes every smart instrument is connected via a digital network, but in many instances the information present in the instruments is unavailable due to communication protocol limitations. Bridging the gap between smart instruments and data repositories is where industrial Ethernet protocols such as EtherNet/IP® and PROFINET® enter the picture.

This data-gathering aspect of analytics will be the focus of this article, which will show why industrial Ethernet protocols are so popular. It will also explain why two-wire instruments with Power over Ethernet (PoE) are not yet available, and then discuss developments with two-wire instruments to enable connectivity.

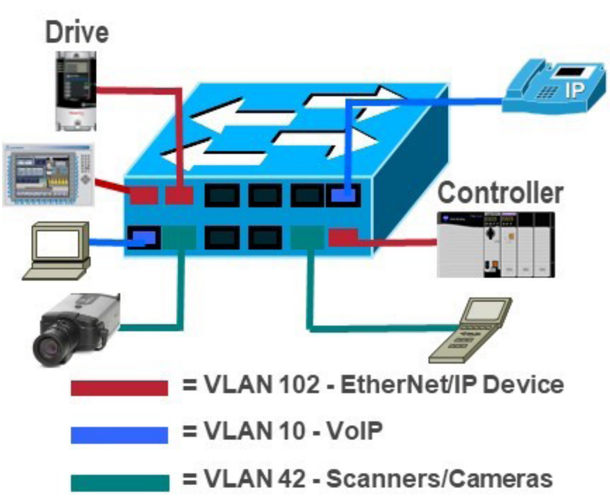

Figure 1: Ethernet switches can connect to a wide variety of industrial and commercial components.

Industrial Ethernet Leads the Way

Most end users prefer industrial Ethernet protocols over other traditional industrial fieldbus protocols for three main reasons:

1. Facilitates unification of an Ethernet infrastructure throughout a plant or facility. Single network from field to enterprise level.
2. Provides extensive bandwidth, enabling access to more information at a faster speed
3. Supports ease and economy of setup and use due to widespread familiarity with and availability of Ethernet

Will a plant be able to unify its operational technology (OT) and information technology (IT) networks using industrial Ethernet? Yes, but only with the proper network architecture. Smart switches or routers expressly designed to manage the information traffic from both networks are essential.

One example is the Stratix® family of industrial managed Ethernet switches from Rockwell Automation. These switches separate office Ethernet TCP/IP traffic from industrial EtherNet/IP traffic by using freely assignable ports (Figure 1).

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Ethernet TCP/IP is a common IT network protocol, and there are several industrial Ethernet OT network protocols. All these protocols follow the same OSI Layer Architecture model and comply with the IEEE802.3 communications specifications.

However, industrial Ethernet protocols modify the application layer. For example, with the EtherNet/IP protocol, the application layer in the OSI model is slightly different from IT protocols because it includes the common industrial protocol (CIP). CIP improves access to data used for control of network devices by separating it into implicit and explicit data packets, or messages (Figure 2).

Explicit messages are for node-to-node communication and use TCP delivery. They move large amounts of data, with variable payload sizes, only as needed. Implicit messages are for compact high-speed communication and use UDP delivery. They are most commonly used for pre-configured high-speed input/output (I/O) messaging. EtherNet/IP adds this explicit or implicit distinction to the information packets to optimize performance for these types of transmitted data.

A standard IT Ethernet TCP/IP network communicates information upon request. Managing this traffic without negatively impacting the speed of the network or resulting in significant delays is relatively easy through the strategic use of the switches and routers commonly applied in IT networks.

However, OT industrial Ethernet networks are used for both I/O and control, with information broadcast continually. If a system is attempting to transmit both Ethernet TCP/IP and industrial Ethernet messages on the same network, it would quickly become overwhelmed and the speed would degrade to an unacceptable level.

Therefore, proper management of the available bandwidth through the use of special managed switches or routers is crucial. Routers can be used to segment networks, and managed switches can be used to manage traffic on each segment.

Plug and Play: Not Yet

Industrial Ethernet protocols such as EtherNet/IP are very useful for transmitting large amounts of data quickly, making them a good fit for smart instruments. While an EtherNet/IP network is user friendly, it has not yet reached the same level

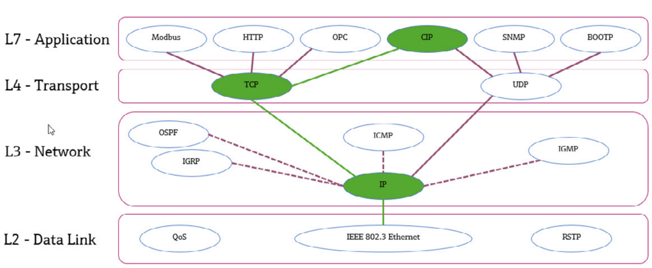

Figure 2: The Common Industrial Protocol (CIP) improves access to data by separating packets into Implicit and Explicit messages.

of functionality most people have come to expect from a standard home or office Ethernet TCP/IP network.

Compared to the maturity of Ethernet TCP/IP, industrial Ethernet networks are still relatively young, meaning the critical mass necessary for the market to provide expected true "plug and play" functionality has not yet arrived.

If a plant has an EtherNet/IP network installed, the physical connection of four-wire smart instruments into the network is much like any other Ethernet device. The host system is also connected to this network and is capable of obtaining process data from the instruments. Hosts can include control systems, asset management systems, process historians and others.

Integration of smart instruments directly into a host system requires coordination among the smart instrument, the host system and the smart switches. For example, three main tools are needed to easily integrate smart instruments into a Rockwell Automation PlantPAx® control system based on a ControlLogix® hardware platform:

1. An **Add-On Profile (AOP) Level 3** is required data integration. AOPs are software packages loaded into the control system and are:
   - specific to individual instruments
   - developed in coordination with the control system manufacturer
   - supplied to the end user or system integrator by the smart instrument manufacturer

2. **Add-On Instructions (AOIs**) are supplied as pre-engineered function blocks, and each must be configured by the end user. AOIs are used to define data, arguments, parameters, algorithms and other functions required for processing data from the instruments.

3. **Instrument faceplates** and **Global Objects** are supplied to provide human–machine interface (HMI) visualization of instrument data, transparency of extended field instrument information and assistance with diagnostics. These are typically supplied by the control system manufacturer.

If multiple instruments from more than one instrument manufacturer are connected, then AOPs, AOIs and faceplate software will need to be loaded and configured for each type of smart instrument. In addition to the software requirements listed above, hardware connectivity considerations arise with two-wire instruments.

Connecting Two-Wire Instruments with Industrial Ethernet

Most users have heard of PoE, and many question why manufacturers have not implemented this functionality into their smart two-wire instruments. A PoE standard exists in the form of IEEE802.3 AF/AT, and there are also commercially available switches on the market to manage and distribute PoE.

IEEE P802.3cg	
5–7: Session/ Presentation/ Application Layer	PROFINET® HART-IP EtherNet/IP™
4: Transport Layer	**TCP**
3: Network Layer	**IP**
2: Data Link Layer	**Ethernet** (real-time, non-real-time, TSN)
1: Physical Layer	**Ethernet PHY** (according to IEEE 802.3 cg) **Frontend for Advanced Physical Layer**

APL ONLY modifies PHYSICAL Layer

Figure 3: IEEE P802.3cg 10 Mb/s Single Pair Ethernet is a physical layer specification and management parameter for 10 Mb/s operation and associated power delivery over a single balanced pair of conductors.

The main issue is that IEEE802.3 AF/AT compliant switches are rated for up to 52 Vdc at 2.5 A. This relatively high level of power makes it very difficult to use these switches in the hazardous areas commonly found throughout process plants and facilities. This is true regardless of whether the installation is designed using an intrinsically safe or explosion proof concept.

Therefore, only areas classified as non-hazardous are viable for PoE installations, but even here challenges exist. Per NEC 500 (National Electrical Code®), working on live energized parts operating with a voltage greater than or equal to 50 V is a safety issue and requires the use of personal protective equipment. In many instances, the benefits of PoE implemented in compliance with IEEE802.3 AF/AT simply do not provide sufficient value to justify the effort or expense required for design, installation and maintenance.

Addressing the Two-Wire Instrument Issue

The problem of not being able to directly use two-wire smart instruments in industrial Ethernet networks has been recognized. A consortium of organizations including FieldComm Group, ODVA™, PROFIBUS®, PROFINET International and manufacturers of process instrumentation and control systems have joined to build upon the work of the IEEE P802.3cg 10 Mb/s Single Pair Ethernet standard. This consortium is referred to as the Ethernet Advanced Physical Layer (Ethernet-APL) Project. IEEE P802.3cg 10 Mb/s Single Pair Ethernet is a physical layer specification and management parameter for 10 Mb/s operation and associated power delivery over a single balanced pair of conductors (Figure 3). Implementation of this standard will make Industrial Ethernet protocols suitable for use in hazardous area locations.

Ethernet-APL is exactly what the name implies: a new physical architecture designed to work in conjunction with industrial Ethernet technology (Figure 4). Ethernet-APL will not impact the protocol stack, so it will be suitable for use with PROFINET, HART-IP or EtherNet/IP Industrial Ethernet protocols, and open their use to two-wire topologies.

Together, Ethernet-APL and IEEE P802.3cg 10 Mb/s Single Pair Ethernet will enable industrial Ethernet-based communication protocols for two-wire field instrumentation by:

- Allowing power and data to be carried on the same two-wire shielded cable
- Permitting installation in plant areas classified as hazardous
- Providing high bandwidth of 10 Mb/s

The work being conducted by the Ethernet-APL Project is ongoing and expected to be finalized soon. Once this work is completed, instrument manufacturers and component suppliers can respond with the equipment necessary for a complete network.

Until this solution is available, the alternate method for integrating legacy two-wire instruments to an industrial Ethernet control system is through a gateway. While highly functional, this method does limit the data available from each instrument to typical primary or HART values. One example of a device with Industrial Ethernet gateway capability is the RSG45 from Endress+Hauser (Figure 5).

The RSG45 is available with either EtherNet/IP or PROFINET slave functionality. This allows a user to easily incorporate

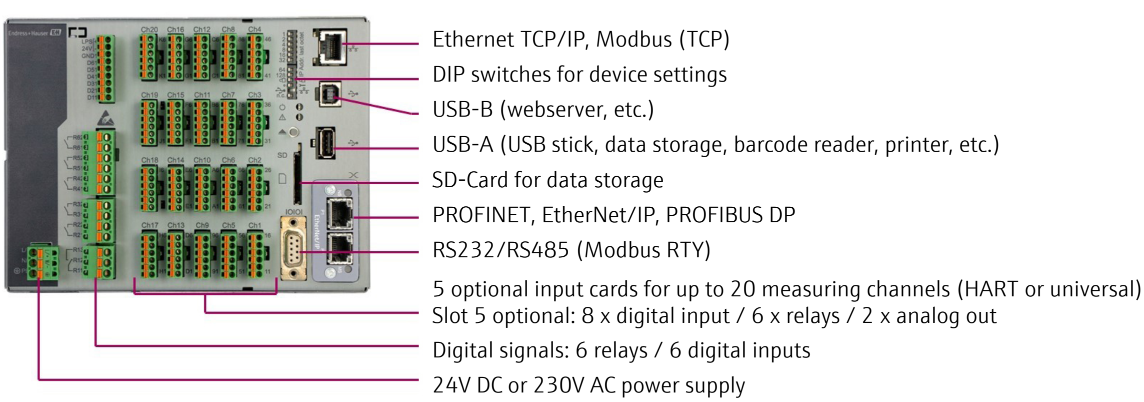

Figure 4: The advanced physical layer will allow two-wire instruments to directly connect to the industrial Ethernet.

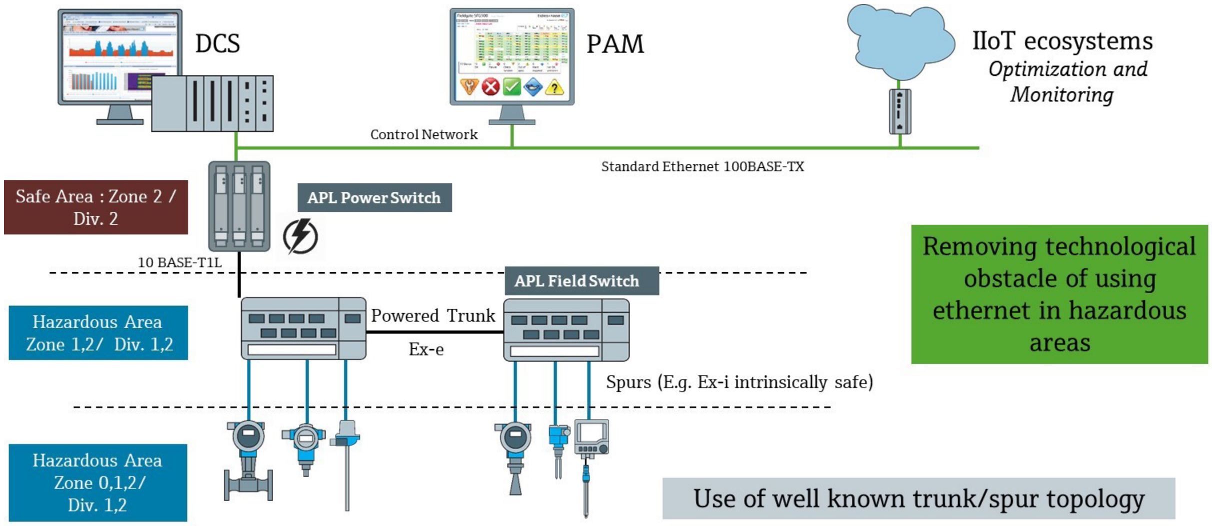

Figure 5: The RSG45 industrial Ethernet gateway from Endress+Hauser allows two-wire instruments to connect using the EtherNet/IP or PROFINET protocol.

up to 20 traditional two-wire HART, analog, thermocouple or RTD instruments into an industrial Ethernet system. The existence of a second industrial Ethernet port, separate Ethernet TCP/IP port and integral webserver means a user can also access individual HART-capable instruments directly over the network for additional diagnostics or setting adjustments.

Summary

Smart instruments are a vital component for process owners to implement IIoT strategies. However, users can only realize the full value of these devices and the subsequent potential of IIoT analytics when their systems can quickly and easily access the growing amount of available data.

Industrial Ethernet enables this digital transformation by providing simple and fast access to the required real-time instrument and process data. Today, four-wire instruments can easily connect to industrial Ethernet networks, and traditional two-wire instruments can be integrated with gateways.
In the future, two-wire instruments will be able to connect more directly as a result of Ethernet-APL and IEEE P802.3cg 10 Mb/s Single Pair Ethernet. This will enable improved operations through the use of analytics applied to data gathered using industrial Ethernet networks.

About the Author

Keith Riley has been a Product Business Manager with Endress+Hauser since April 2008. Prior to this, he was a Product Manager and Regional Sales Manager with L.J. Star Incorporated, as well as a Product Manager for Penberthy (Tyco Valves). He has over 20 years of sales, marketing and instrumentation experience in the process industries.

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