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Why HART-IP is critical to Ethernet-APL success

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Let's plan for Ethernet-APL success

The new, high-speed option for field communications must coexist with current technologies for years to come. The ability to extend HART-IP to high-speed instrumentation over Ethernet-APL is an essential aspect of industry's path forward

The introduction of Ethernet-APL technology earlier this year is an important technology milestone, enabling a new, high-performance paradigm of digital field communications for the process industry.

Its dramatically higher bandwidth promises to enable a new generation of more capable field devices and Industrial IoT solutions hardly yet imagined. And, because it's based on Ethernet, it promises to unify and dramatically simplify the control and information architecture of tomorrow's plants.

But even for a greenfield facility, that fully realized tomorrow is only a few years away. A necessarily conservative lot, end users will need to test out the technology in labs, pilot plants and non-critical applications, while device manufacturers must produce a critical mass of the various field devices needed. Meanwhile, most brownfield process plants face decades during which new technologies will coexist with today's solutions. No one anticipates that otherwise functional systems will be ripped out and replaced with ones based on Ethernet-APL. Instead, Ethernet-APL will have to compete opportunistically with current technologies and present advantages that outweigh the price of change: if adoption requires unfamiliar tools and work processes, those advantages will be harder to come by.

We've been here before. Fieldbus, the last effort to fully digitalize field communications, was a technical success but a commercial underachiever. It introduced new complexity that was simply a price too high to catalyze widespread adoption. To carry the chemical reaction analogy one step further, we as an industry must aim to keep the "activation energy" of new technology adoption as low as possible.

In HART-IP, the 4-20mA analog signal is replaced with secure, high-speed digital transmission of process variables and control instructions.

Enter HART-IP

While Ethernet-APL is a triumph of technology, offering 10-Mbps, two-wire, powered communications over long distances and in hazardous locations, it's only part of the puzzle. APL stands for "advanced physical layer," which means that complementary application protocols are needed to fill out the communications stack. And since it's Ethernet, we can even use multiple such protocols over the same pair of wires at the same time.

It's both liberating and potentially confusing to contemplate the coexistence of multiple protocols in the digital field. But it's just like the network one has at home or in the office. Since it's Ethernet and Internet Protocol (IP), you can browse websites, send emails, print documents and stream video—each time transparently using a different application-level protocol over a shared Ethernet IP infrastructure.

Similarly, when it comes to the digital field, a range of "industrial Ethernet" networks are likely to play roles depending on the application and industry in question. But when it comes to the configuration, monitoring and diagnostics of process instruments and final control elements—and the process control they enable—one industrial Ethernet protocol stands alone in its ability to carry forward existing tools, work practices and workforce familiarity and to lower the activation energy of adopting Ethernet-APL. And that's HART, specifically in the form of HART-IP.

HART-IP was first introduced in 2007 as a high-speed Ethernet protocol to communicate HART data collected from WirelessHART gateways. The original HART, in turn, dates back to the 1980s when it was developed and released as an open standard for smart transmitter communications. Uniquely, the original HART protocol still communicates over the 4-20mA analog instrumentation current loops first standardized in the 1950s. Today, tens of millions of 4-20mA analog instrument with HART constitute the vast majority of installed instrumentation around the world. Even today, it dominates shipments of new instruments to the global process industries.

Future-proof evolution

In recent years, the utilization of HART data from existing devices has only continued to increase. For many end users, the primary use case for the 4-20mA version of HART was during device installation and commissioning, after which they turned to handheld communicators for periodic field troubleshooting and calibration.

But booming interest in realizing the benefits of digital transformation has more and more users seeking to continuously expand upon HART data in their instruments. In fact, more than one industrial network infrastructure provider has reported that the Ethernet multiplexers used for such purposes are flying off the shelves. This means that end users are only increasing their investments in the HART ecosystem.

Meanwhile, today's HART-IP has advanced significantly since it was first introduced. Adding an integrated security model in the latest version of the HART IP standard was key to establishing a proper cybersecurity posture on the next generation of Ethernet field devices. It's also important to realize that in HART-IP, the 4-20mA analog signal is replaced with secure, high-speed digital transmission of process variables and control instructions. In short, HART functionality is no longer limited to monitoring and diagnostics—with HART-IP it does control, too. Tests performed on Ethernet-APL indicate bandwidth that is more than sufficient for closing the loop on most process control applications. For example, even with 150 devices reporting 20 updates per second over a 10 Mbps subnet, only 30% of available bandwidth was consumed. (Visit fieldcommgroup.org/technologies/HART-IP/explained for more details.)

WirelessHART already is being used to manage data streams from quite sophisticated instruments such as vibration sensors for condition monitoring. Entire frequency waveforms are being communicated via HART-IP, and the core HART data model handles all that detail with aplomb.

But what's even more special about HART is that the protocol remains consistent across all these architectures—Ethernet-APL, WirelessHART and 4-20mA HART. And that means minmal changes to existing tools plus little training up of plant personnel on new work practices upon adding Ethernet-APL to the mix.

Indeed, the biggest beef against 4-20mA HART has always been speed, making configuration and other tasks both time-consuming and cumbersome. But with HART-IP over Ethernet-APL, it'll be like someone swapped out your old dial-up modem for a modern WiFi connection. One's desktop computer, email software and web browser are unchanged; they all work just as before—albeit orders of magnitude faster.

That's what HART-IP over Ethernet-APL promises: all the advantages of higher bandwidth without incurring the activation energy penalties that often come with technology adoption. And, if someday an even more powerful network platform comes along to complement Ethernet-APL, it's a safe choice that the proven ability to abstract network particulars from the HART protocol's data model will work there as well.

Interoperability preserved

Bringing HART along as we move toward an Ethernet-APL future also allows us to preserve what has become industry's best example of ecosystem interoperability among different suppliers' devices and systems.

Decades of effort have resulted in Field Device Integration (FDI) technology that helps to ensure proper field device management by the host—including device configuration, replacement, maintenance and diagnostics—that is standardized and usable across all systems, independent of device or system suppliers or vendor-specific tools. Today's FDI technology even allows instrument makers to create secure, application-specific web apps for their devices.

The HART protocol with Ethernet-APL doesn't just benefit end users. It also promises to ease the development burden for device manufacturers, who can spend less time on their communication stack and more time figuring out what advanced functionality they can implement with the greater power that Ethernet-APL delivers: from less than 40mW intrinsically safe power with a 4-20mA transmitter to 500mW intrinsically safe power with Ethernet-APL.

Importantly, Ethernet-APL also affords coexistence of application protocols in the same architecture, even over the same pair of wires. This means that using HART-IP to communicate with process instruments and control valves doesn't impinge on using an alternative protocol for other application domains. For example, if current tools and work processes leverage EtherNet/IP or Profinet to talk with drives and motor control centers, Ethernet-APL teamed with these protocols will make the transition for the personnel responsible for these assets just as easy as it is for the instrumentation and control personnel already familiar with HART. ■

Manage the risks, reap the rewards

Adoption strategies for Ethernet-APL will hinge on where it brings greatest value to your operations. While more speed is always a good thing, implementation thresholds will vary, especially between brownfield units and new projects

Adoption strategies for Ethernet-APL will be very much intertwined with the value proposition it represents relative to current technologies. The grassroots unit or production facility is one extreme, where, given a clean design sheet and a critical mass of available Ethernet-APL devices, the simplicity and advantages of a unified high-speed network architecture that extends from field instruments to the cloud—yet preserves existing workforce familiarity with HART—is quite compelling.

But that greenfield plant design is still a ways off, given the lead time for instrumentation and system developers to bring the necessary solutions to market, not to mention the testing, trials and tire-kicking that end-user organizations will demand before betting a new plant on any new technology.

At 3M, for example, initial laboratory tests will be followed by pilot-plant implementations plus assurance testing that the technology passes the company's rigorous internal standards for intrinsically safe operation before Ethernet-APL will be approved for a production environment or for widespread use, according to Robert Sentz, senior engineering specialist.

Bottom line, while the ultimate value proposition of Ethernet-APL will be in a greenfield facility, progressive end-user organizations will meanwhile be looking for more isolated use cases at brownfield facilities to test out and prove the new technology's worth. Testing is appropriate, but for Ethernet-APL to win on its own merits in a brownfield environment, "It's got to be a pretty specific use case that really needs that higher bandwidth or will benefit from the greater amount of power that can be delivered over APL," notes Peter Zornio, CTO Automation Solutions, Emerson. "It's a very simple rule: if you're not putting in new instruments, you're not going to broadly deploy APL," he adds.

The need for speed

Many of the most apparent use cases for HART-IP over Ethernet-APL derive from the increased availability of data that higher bandwidth affords. In a brownfield context, this is most relevant when adding complex new instruments that generate more data of diagnostic significance.

Real-time access to valve signature data from a valve controller, for example, can be used to diagnose a range of issues before they lead to unscheduled process downtime. The same can be said for Coriolis meters, magnetic flowmeters and radar level gauges (see sidebar). Process analyzers in particular will benefit from the order of magnitude increase in power made available to instruments by Ethernet-APL relative to 4-20mA,

'BEST BET' USE CASES FOR ETHERNET-APL

While industry awaits the opportunity to deploy a critical mass of Ethernet-APL devices in a new plant or unit, we'll also be looking for opportunities to verify the benefits of the new technology when adding new instruments to an existing operation. These "best bet" use cases that can begin to bring value in the absence of a full architectural shift will be those instruments that will benefit most from the dramatically faster data rates or higher power that Ethernet-APL can deliver. Here, then, a roll call of top prospects.

Digital valve controllers are among the most promising use cases for Ethernet-APL plus HART-IP in part because there's so much HART data related to their operation that it's hard to gain an accurate picture of their operation in a timely fashion via traditional HART communications. That usually means a trip out into the field with a handheld communicator or PC, but "running a detailed valve analysis might still take 15 or 20 minutes to complete," notes Kurtis Jensen, valve instrumentation portfolio manager, Emerson. "But with HART-IP over Ethernet-APL, engineers and technicians will be able to see things that they hadn't before."

Coriolis meters are similarly complex and pack a lot of localized intelligence such as for remote verification that the meter's operating characteristics have remained unchanged since installation. With today's communication technologies, most users rely on a simple pass/fail command to transmit their verification status back to the control room, but the increased bandwidth of HART-IP over Ethernet-APL would allow personnel to dig into the raw data behind the test and determine the root cause—all from the relative safety and comfort of the control room or even a remote service center.

Magnetic flowmeters also include sophisticated onboard diagnostics to verify the continued integrity of the tube, coil and electronics. Again, HART-IP over Ethernet-APL would allow a remote user the ability to dig into the raw data behind these pass/fail tests.

Radar level gauges are a third group of instruments whose sensors have a characteristic signature that can be used to verify proper operation or alert the operator to problems such as an antenna coating interfering with its proper operation. Such signatures consist of a large amount of data that cannot be efficiently communicated via traditional HART and would benefit from HART-IP over Ethernet-APL.

Process analyzers are a good candidate for Ethernet-APL because the new physical layer can deliver nearly 10 times the intrinsically safe power of a 4-20mA analog loop. So, one may be able to provide both power and high-speed communications over a single, two-wire Ethernet-APL connection rather than the power wiring plus four-wire Ethernet connection traditionally required.

Multivariable measurements are yet another promising use case for HART-IP over Ethernet-APL, making it easier to power and communicate HART diagnostics from multiple related instruments, such as the multiple sensors included in a temperature-compensated, differential-pressure flowmeter. It could also allow for one Ethernet-APL spur to connect with multiple temperature sensors, obviating the need for separate transmitters.

representing a less expensive installation than the power supply plus four-wire Ethernet connections that otherwise might have been needed.

But the larger context of increased secondary data bandwidth is the ability to collaborate more effectively, and to send that more nuanced secondary data more easily to the individuals—and applications—that can make effective use of it. Think of a diagnostic application that pulls some data from the instrument, some from the computerized maintenance management system (CMMS), some from a condition monitoring system and some from the distributed control system (DCS). A beleaguered engineer might spend all day manually pulling that data into a spreadsheet before even beginning to analyze its meaning. Or think of the roaming technician who can quickly access real-time HART device data through a tablet wirelessly connected to the plant's WiFi infrastructure—access that was previously available only back in the control room, didn't reflect real-time conditions, and even then, was accessible to the technician only via walkie-talkie or a physically connected, low-bandwidth handheld.

Transitional architectures

For most end users—especially in the US, where few greenfield facilities are expected to be built in the near term—their first experiences of Ethernet-APL will be in hybrid environments that also include 4-20mA HART devices. On the positive side, with the debut of fully configurable input/output (I/O) systems some 10 years ago, industry already is on its way to moving I/O from control room environments out into field junction boxes.

Configurable I/O has delivered substantial benefits of its own, helping to decouple hardware design from system software development and taking instrumentation and control system design off the critical path of project execution. It's also reduced costs and system footprint, eliminating traditional marshalling cabinets in many newer facilities. Like fieldbus before it, Ethernet-APL effectively distributes I/O even further, relocating the transition between analog sensor signals and the digital world of ones and zeroes into the field devices themselves.

From a practical perspective, this means that the remote junction box is where 4-20mA HART and Ethernet-APL are most likely to converge. That remote junction box could relatively easily include both configurable I/O as well as an Ethernet-APL switch—both of which speak HART-IP over Ethernet up into the control system architecture. Further, a potential mix of Ethernet-APL with traditional 4-20mA HART devices will likely entail a range of network infrastructure devices designed to accommodate the transitional hybrid architectures required.

While dual devices sharing an Ethernet connection in the same box are easy to imagine, hybrid approaches are also likely. Analog Devices, one of the suppliers of chipsets for Ethernet-APL as well as the multiplexers that extract HART data from 4-20mA loops, has envisioned a device with hybrid functionality. And for suppliers like Emerson,

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> — Robert Resendez, Control Systems Supervisor, Bechtel

> "I believe true benefits tend to be sustained for a longer period when you have that ecosystem of knowledge and existing tools that are proven in use."
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> — Jason Urso, Chief Technology Officer, Honeywell Process Solutions

which uses a physical module to characterize its remote I/O channels (rather than software), a new Ethernet-APL module under development will allow these new digital channels to coexist side-by-side with their 4-20mA HART counterparts.

In all three of these scenarios, a shared commitment to the HART ecosystem and data model will ease the industry's ultimate transition to Ethernet-APL as the standard physical layer for field instrument communications

Greenfield benefits await

In the not-too-distant future, a greenfield facility or new production unit offers the most fertile ground for Ethernet-APL technology, since the baseline will involve comparing proven Ethernet-APL plus HART-IP technologies with the 4-20mA plus HART *status quo*. A greenfield design need not weigh sunk costs against new benefits. Rather, a clean-sheet design will allow end users to realize the full benefits of a secure, unified digital infrastructure that reaches from field devices to enterprise systems and the cloud.

> "With Ethernet-APL, the first thing is faster data. So, if it helps during startup and commissioning there will be a real advantage."
>
> — Jeff Konrad, Technical Solutions Team Leader, Automation Interfaces, Dow

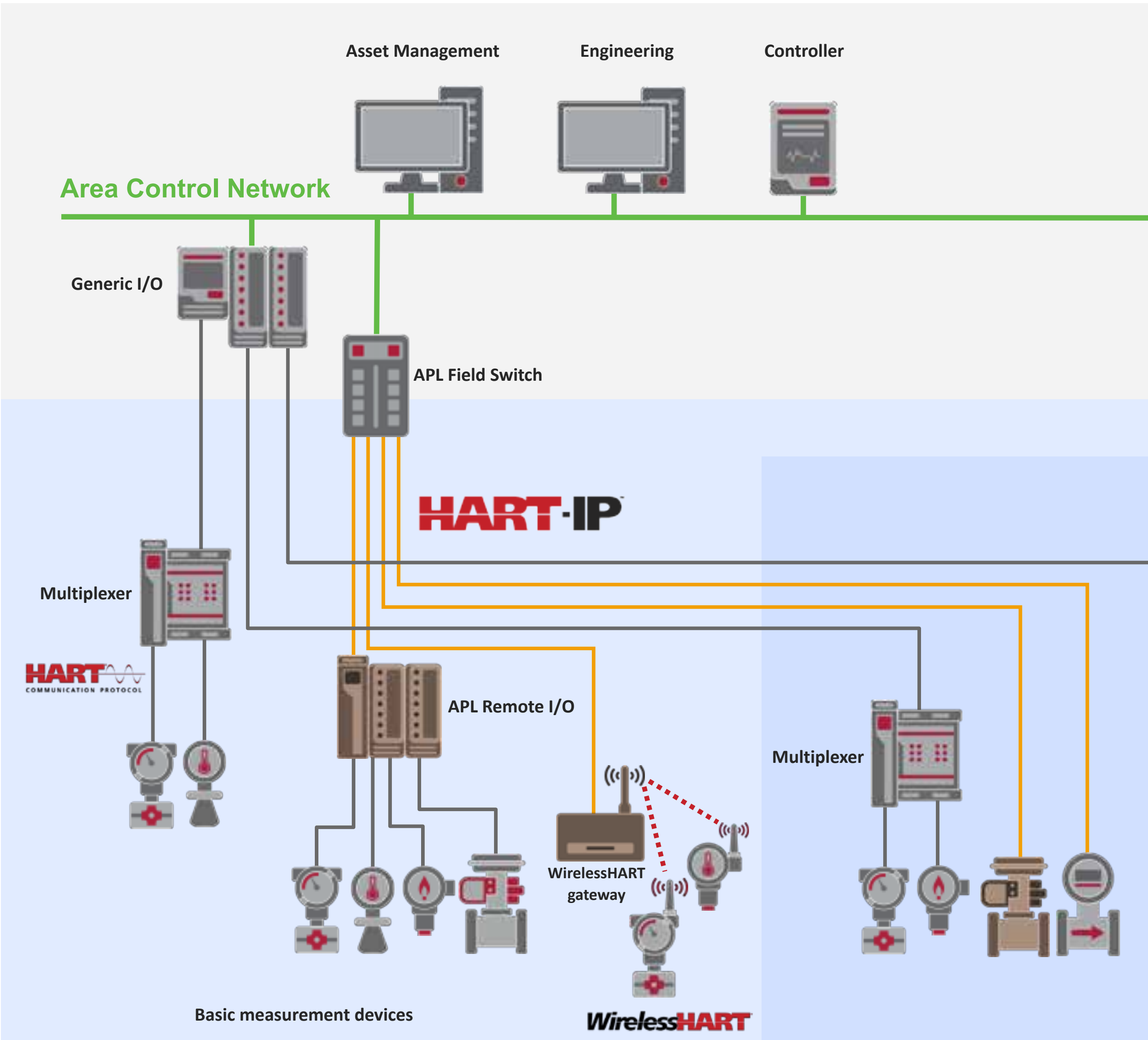
Having a critical mass of instrument types available that support Ethernet-APL will be critical for greenfield designs to succeed, believes Robert Resendez, control systems supervisor for the oil, gas and chemicals division of Bechtel. "I remember finding all the instruments we needed being a challenge in the early days of fieldbus," he says. "We try to give our customers one standard protocol throughout the plant design, and HART is pervasive. Everybody has HART—even some of the smaller PLC (programmable logic controller) manufacturers."

From an architecture perspective, tomorrow's Ethernet-APL systems won't look all that different from the remote, configurable I/O systems that Bechtel advocates today, Resendez adds. Indeed, replacing remote enclosures filled with configurable I/O with remote enclosures filled with Ethernet-APL switches may even allow system designers more flexibility when it comes to how many devices can be connected through a remote enclosure of given dimensions.

In any case, the transition to Ethernet-APL spurs (out to individual instruments) should be a relatively straightforward adjustment from a design perspective. The addition of the APL trunk concept will allow for new distribution models in areas lacking infrastructure for power and communications. And when it comes to installing and commissioning this new breed of devices in a greenfield facility, users will really begin to benefit from the dramatic improvements in communications speed that the move to Ethernet-APL represents.

Dow has used "smart" instruments ever since they were first available, but only relatively lately begun to rely on continuous monitoring of its instruments' HART data for predictive diagnostics applications, says Jeff Konrad, technical solutions team leader in the realm of automation interfaces. "So, with Ethernet-APL, the first thing is faster data," he says. "My first questions are during commissioning and startup. We know sometimes it's hard to communicate via traditional HART—sometimes it's slow, sometimes we have interruptions. So, if it helps during startup and commissioning there will be a real advantage."

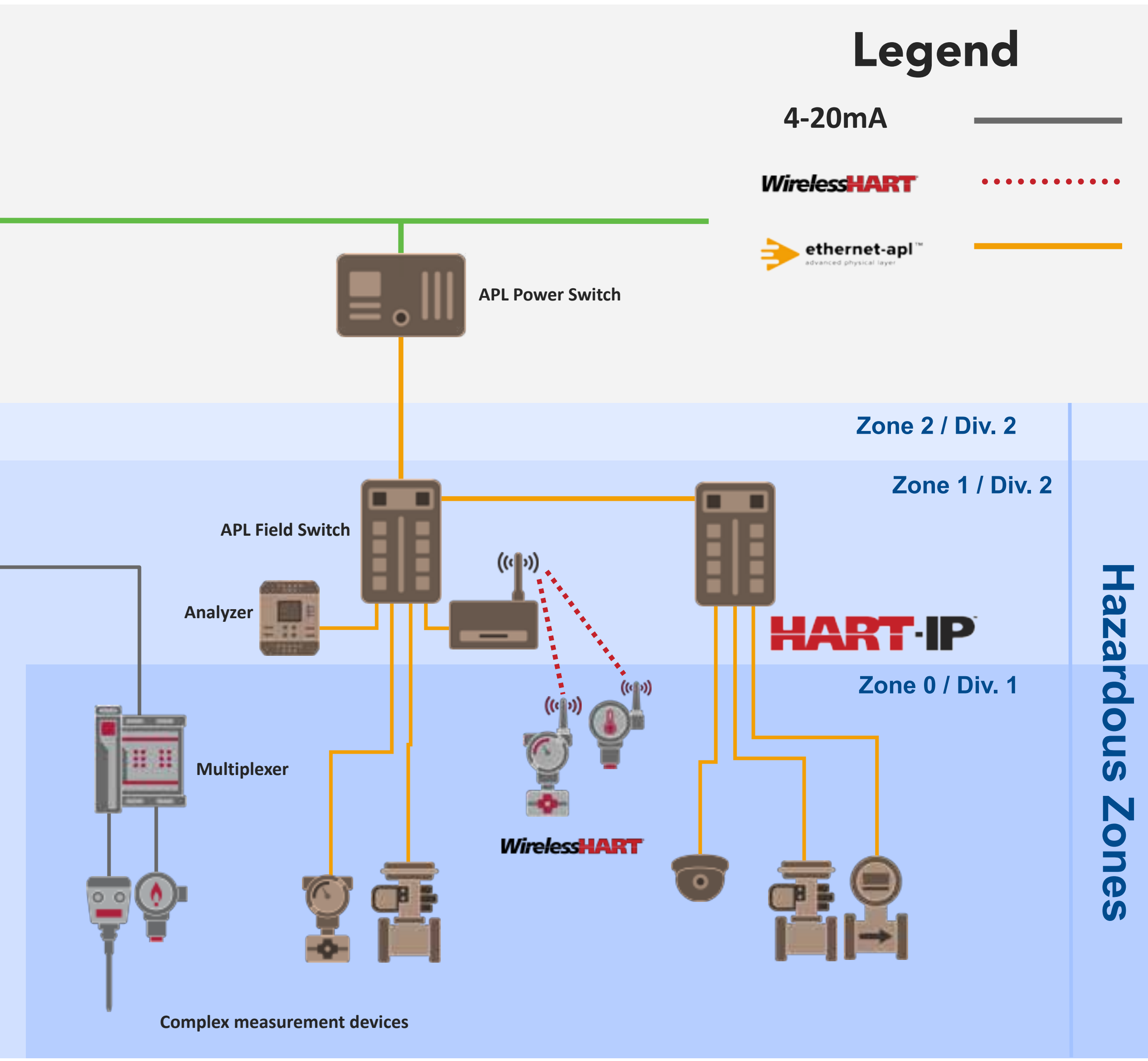
Jason Urso, chief technology officer for Honeywell Process Solutions, cautions that we as an industry really need to focus a bit less on how great it will be to get more data faster and instead figure out just what we'll do with even more data once it arrives. "I'm a big advocate of APL," he says, "and I think we've got to continue moving in that direction. But let's also figure out what we're going to do with all that data now that we're collecting it."



MIGRATION ROADMAP

Today's HART-based control architecture relies on devices using the 4-20mA (grey connections) or WirelessHART (dotted red connections) physical layers. Often, the WirelessHART gateway connects to the control network with HART-IP over 4-wire standard Ethernet. Additionally, multiplexers and remote I/O may use RS 485 and Modbus to communicate data back to the area

Urso also agrees that standardizing on HART-IP over Ethernet-APL will help instrument and system suppliers get to market more quickly with the product offerings that end users need to take advantage of this new field networking technology. "HART's well known to us in part because it's used extensively used by our customers," he says. "They have the knowledge. They have the competence, the expertise and the track record. And I believe true benefits tend to be sustained for a longer period when you have that ecosystem of knowledge and existing tools that are proven in use."



control network. As Ethernet-APL instruments become available, they can be connected to the area control network via HART-IP (orange connections) though a simple APL field switch. And as confidence grows, an APL power switch can be added to bring power and communications to multiple field switches that power many instruments, including new instrument types like video cameras or thermal imaging systems.

Novel devices and new superpowers

Ethernet-APL promises to open the digital field to entirely new types of devices. The higher power and faster bandwidth of HART-IP over Ethernet-APL will also make possible a host of new capabilities in the field instruments of tomorrow

The first leg of the journey to Ethernet-APL is to fully liberate all that secondary instrument data that has long gone underutilized across the process industries. Indeed, a growing number of progressive process manufacturers are using multiplexer technology to extract all that rich, digital HART data from their 4-20mA analog loops—and already are using that data to effectively advance their digital transformation initiatives. HART-IP over Ethernet-APL will just make that access simpler, faster and easier.

Over the past several years, network infrastructure specialist Phoenix Contact has seen a significant uptick in the number of users retrofitting their plants to bring previously stranded HART data up into asset management and other monitoring systems, according to Garrett Schmidt, senior product manager.

"We know that most of these devices are going into brownfield facilities," Schmidt explains. "They're connecting to 4-20mA HART instruments with the highest value data first—typically more complex instruments such as valve controllers and flowmeters—then building out from there." A confessed IoT junkie, Schmidt attributes the growing interest in continuous, full-time access to HART data to organizations' digital transformation initiatives.

3M is among those end-user companies that has placed a new emphasis in recent years on the value it can derive from continuous access to HART data, according to Robert Sentz, senior engineering specialist. "We are using more and more of that the available diagnostic data from smart valve positioners, smart pressure, temperature and flow instrumentation," he says. Indeed, the company is betting its operational future on digital technologies such as performance-driven analytics and prescriptive maintenance enabled by instrument data. "All that

HART information is getting to be almost as critical as the process measurement, the process control piece itself," Sentz says.

"HART over analog loops is very robust, but it's also slow," Sentz adds. "So, I'm very intrigued by the potential to further improve plant performance and availability with Ethernet-APL and HART-IP."

And while HART-IP over Ethernet-APL will dramatically improve the accessibility and utility of data in today's instruments, the second leg of the Ethernet-APL journey will pair that new speed with higher instrument power and protocol independence to launch a whole new world of transformative possibilities.

Enhanced capabilities

Higher bandwidth and more available power will allow makers of today's process instruments to create new sources of value in their next-generation, Ethernet-APL-enabled devices. Future pressure transmitters, for example, may include multiple, automatically ranging sensors, which would allow a given transmitter to cover a broader range of pressures without sacrificing accuracy, envisions Jonas Berge, senior director, applied technology, Emerson. Notably, this would solve the problem of needing to stock a large inventory of pressure transmitters for various applications.

Similarly, more available power will allow makers of two-wire flowmeters to increase the excitation signal of Coriolis or magnetic flow-tubes, enabling higher turndown ratios—and more accurate measurements at low flow rates. It will also allow two-wire, Ethernet-APL flowmeters to handle larger pipe sizes than currently possible.

More available power would also allow two-wire flowmeters to continuously perform a broader range of process diagnostics, for example, detecting corrosion in Coriolis meter tubing and adjacent piping, says Andy Kravitz, senior product manager, connectivity solutions, Emerson. Currently, the negative effects of corrosion can be detected by initiating a Smart Meter Verification test, but that test only gives a pass/fail result—not a clear indication of the source of the problem. "In effect, the ability to measure corrosion in real-time would be an added feature of my Coriolis meter," Kravitz explains.

Process-induced measurement noise is a problem for many sensors today, adds Berge. But with more power for the microprocessor, future sensors may feature more advanced signal processing to overcome the effects of noise. And in extreme cases, the sensor may be able to leverage the capabilities of a remote server to provide further analysis. "Perhaps next-generation, non-intrusive ultrasonic flowmeters will perform at a level high enough to calculate mass and energy balances on heat exchangers," Berge says. "This would solve the problem of having to cut and weld pipes or otherwise disrupt the process to get a reliable flow measurement."

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Pressure drop, flow, vibration and acoustic noise are useful inputs in detecting and predicting control valve failures, but typically go unmeasured on a routine basis. With Ethernet-APL networking, it will be more practical to measure and integrate such external variables into valve diagnostics to provide more predictive and prescriptive analytics.

The scope of diagnostics for instruments such as digital valve controllers will also begin to include other related data from "peer" devices on the network, predicts Kurtis Jensen, valve instrumentation portfolio manager, Emerson. "Instruments will become more process aware," he predicts. "If my valve controller shows the valve is closed, yet there's still pressure drop across a downstream orifice plate, it can tell me there's a problem."

More broadly speaking, Ethernet-APL will make it possible to utilize instruments' auxiliary variable measurements more fully. For example, measures of ambient temperature across all instrumentation points in a plant could be used to create a thermal map of the entire facility, providing early detection of a fire or fire hazard. Most field instruments already include such auxiliary measurements today, but they usually go unutilized.

Another transformative aspect of Ethernet-APL technology will be to replace the patchwork of application-specific networks used in process environments, building toward a single, unified network architecture. For example, today's addressable fire and gas (F&G) detectors use proprietary application protocols and therefore require dedicated networks. In the future, F&G detectors of various kinds may share the same Ethernet-APL/HART-IP network with the rest of a plant's instrumentation. Such solutions will likely be more economical to deploy, allowing more detectors for better coverage in tight spaces such as offshore rigs and production units. The units will be safer, and the systems easier to maintain as a result.

One significant new capability of Ethernet-APL instrument networks actually has nothing to do with the instruments. Rather, it's built into the network itself. Sometimes referred to as intelligent networking, the communications chips provided by Analog Devices continuously measure noise levels on each network segment and can alert if link quality degrades. Devices can be configured to run such link quality diagnostics on a regular basis, and if there is an issue, the diagnostics can even indicate the location of the problem, explains Fiona Treacy, marketing manager, Analog Devices. "We can pinpoint the location of a problem to within 1%," she says. "So, for a kilometer of cabling you can tell where a short is to within 40 meters."

Novel devices, complementary protocols

Some in industry envision a real-time digital field network as just a replacement of 4-20mA process variables, control commands and secondary diagnostic and configuration data using digital HART-IP signals. But the possibilities are much greater than simply enhancing the capabilities of current field instruments and rapidly sharing their data with the people and applications that can put it to work. Rather, we should also recognize the potential for Ethernet-APL to enable entirely new kinds of field instruments solving previously unsolved problems.

Setting the range in a pressure transmitter without applying an input might have been impressive 30 years ago. But today we expect far more from a "smart" device. We should expect other time-consuming tasks to be eliminated or simplified in similar ways. And with 4-20mA signals replaced by HART-IP over a fully digital Ethernet-APL infrastructure, field instrumentation will finally be able to benefit from the dramatic technology advances that have transformed computing and communications in our personal lives.

Indeed, today's expectations for new smart devices for industry should model the breakthroughs brought about by the mobile phone network. Once the GMS network supported GPRS data, it wasn't long before the first smartphone appeared. Little did we realize; the smartphone was a full-fledged pocket computer and communicator that coincidentally made phone calls. So, expectations for industry's future should not be just better transmitters, but also new classes of field devices.

Among other implications, digital transformation of plant operations means that many monitoring tasks which have until now been done manually by operators on rounds with portable testers will instead be done continuously and automatically by permanently installed sensors.

"Instruments will become more process aware. If my valve controller shows the valve is closed, yet there's still pressure drop across a downstream orifice plate, it can tell me there's a problem."

— Kurtis Jensen, Valve Instrumentation Portfolio Manager, Emerson

Common examples of this include vibration, temperature, acoustic noise and corrosion (wall thickness) measurements.

Audible noise sensors (microphones) that share the common Ethernet-APL backbone may be used to identify noisy hotspots, helping to assure protective measures for employees, the tranquility of neighboring communities and compliance with ever more stringent regulations. The abundant power and high bandwidth of Ethernet-APL networking may also enable noise spectrum analysis, identifying sources of noise and possibly diagnosing process and equipment problems from changes in noise patterns.

Machine vision has been used in discrete manufacturing for years. In the future, perhaps there will be two-wire infrared cameras for liquid leak/spill detection sharing the same Ethernet-APL network as other devices. And instead of portable thermographic cameras to measure equipment temperatures, there may be permanently installed two-wire thermographic cameras to automate manual inspection. Other possible applications include flare monitoring and smoke detection, recognition of unauthorized intruders as well as proper use of personal protective equipment by authorized personnel. All these measures could reduce hazards and improve security and safety.

A field-mounted two-wire vibration transmitter sharing the same HART-IP over Ethernet-APL network as other field instruments may in the future support sophisticated, fast-Fourier-transform (FFT) edge analytics to head off quickly developing problems with pumps, fans and other rotating equipment. Operations, maintenance and reliability personnel may even collaborate over a livestreamed vibration spectrum, including waveforms and orbits, to better understand potential issues.

While HART-IP over Ethernet-APL is suitable for many of these new devices, others will operate best through other Ethernet application protocols often developed specifically for that type of device. A key attribute of Ethernet-APL is that contrary to previous field device communication alternatives, it is non-exclusive. That is, a mix of application protocols can be used simultaneously,

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> — Garrett Schmidt, Senior Product Manager, Phoenix Contact

even on the same pair of wires. On the industrial side, HART-IP can co-exist with Profinet, EtherNet/IP, OPC UA and others. Meanwhile, it can also coexist with non-automation protocols such as RTP or RTSP for digital video.

So, all devices on the network need not use the same protocol. Not even all the instrumentation. A transmitter using HART-IP and a valve using Profinet can even participate in the same control loop—but the controller in between must be able to handle both protocols.

A more transparent future

A key advantage of implementing Ethernet-APL together with HART-IP is the extensive, global interoperability ecosystem supporting HART together with industry-wide familiarity with HART and the tools and work processes that support it. Preserving this common ground will be critical to easing industry's transition to an Ethernet-APL future.

Longer term, higher bandwidth and more powerful devices will make understanding the underlying protocols less significant for end users, predicts Peter Zornio, CTO Automation Solutions, Emerson. "Eventually, talking about whether a particular instrument is using HART-IP, Profinet or EtherNet/IP will be like talking about whether our cell phones are using CDMA or TDMA." Similarly, intelligent device management software promises to abstract the management of field devices from the details surrounding Field Device Integration technology and underlying profiles.

In the near term, however, what doesn't go away is the interoperability ecosystem that underlies the HART configuration and management tools in every distributed control system (DCS) and asset management system on the market, Zornio stresses. "When you sit down at the DCS to configure a new Ethernet-APL device, you don't have to care about the new physical network or the protocol—it's just a HART device like 4-20mA HART and WirelessHART devices," he says. "Granted, a lot more data comes out a lot faster than it used to. And if we can deliver that impact without changing a lot of processes along the way, we'll have accomplished our goal."

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— Peter Zornio,
CTO Automation Solutions,
Emerson

A secure yet familiar path forward

To reap the benefits of Ethernet-APL, potential barriers to industrywide acceptance must be minimized. In the process industries, only HART-IP delivers both the built-in security and comfort level needed to achieve that reality

Bringing Ethernet technology that last mile to the field instrument represents perhaps the ultimate convergence of information and operational technology (IT/OT) for the process industries. For operational technologists, it's an opportunity to fully capitalize on the dramatic advances in networking technology that have already transformed the architectures of the automation and information management systems upon which they rely. But it's also like facing the loss of a familiar old friend in the form of the 4-20mA analog loops that have served industry so well for so long.

Yes, HART-IP over Ethernet-APL replaces that analog signal with fully digitalized process variables and control signals. But it also brings forward HART's industrywide familiarity, unrivaled interoperability ecosystem and proven utility when it comes to instrumentation monitoring and diagnostics data.

More than 30 years ago, HART was created as a command/response protocol, in which a host issues a command, and a device responds. When there are many devices in an installation and a host is communicating with many of these devices, the host needs to know the name or address of the device it wants to issue a command to. This addressing scheme is defined in the HART protocol specification.

But when HART was adapted to Internet Protocol (IP) back in 2007 to backhaul data from WirelessHART gateways, the addressing scheme defined by HART was no longer required. Rather, IP-addressing is used, and each device is assigned an IP address. It's as simple as that: HART-IP is the same as HART, but with IP addressing. It's the Ethernet-APL physical layer that makes it dramatically faster.

Inherent security

While Ethernet and IP represent much of what's good in the networking world, IP-addressable devices also come with the need to address potential security concerns. "If you're going all digital with an IP-routable protocol, you have to ensure security," says Peter Zornio, CTO Automation Solutions, Emerson. "And with HART-IP, these security features are mandatory, not optional as they are with some other device protocols for Ethernet-APL."

So, with the 2020 revision 7.7 of the HART specifications, requirements for specific security suites are now specified to provide communication security, audit logs and syslogging.

Communication security requires that new devices support the industry standard Internet Protocol Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS) suites. HART commands have been added to simplify security deployment and aid users in navigating multiple security options. Additional diagnostics and forensic requirements are also included.

Devices are required to capture audit logs that summarize communications activities, including records such as client identification, connection start/stop times and whether the device configuration was changed in that session.

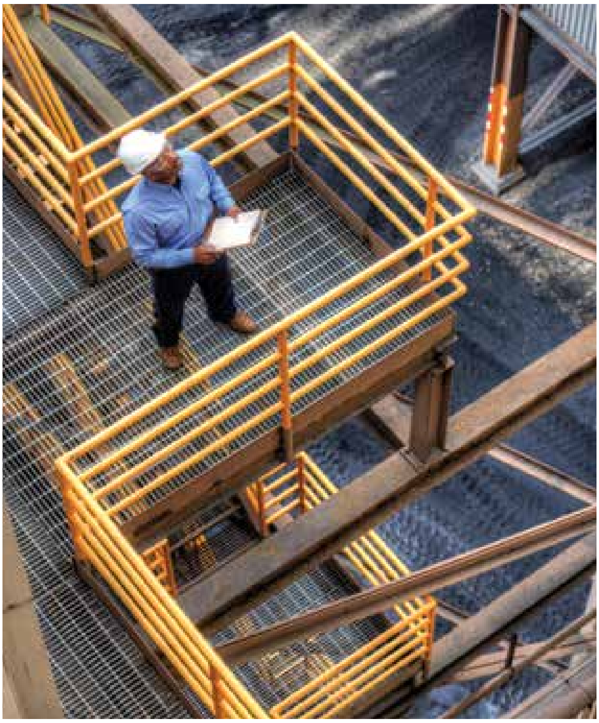
Finally, HART-IP devices also must support syslogging, an industry standard means of publishing device events to a network's security information and event management (SIEM) system. All HART-IP devices must support network time using either Network Time Protocol (NTP) or Precision Time Protocol (PTP). Consequently, all syslog messages from all network devices are time synchronized, enabling forensics on network-wide behavior and activities.

Combining communication security, audit logs and syslogging results in robust security for HART-IP enabled products.

“With Ethernet-APL, operators will have the need to really be up to date with all the of the firmware and the software they’re using,” says Thomas Rummel, senior vice president of engineering and product management, Softing Industrial Automation. “In the past, the attitude was ‘it’s running now, so never change it,’” Rummel explains. “But in the future, you’ll have to ensure that all security patches are kept up to date and no back doors are left open.”

These new requirements for intelligent device management, switch configuration and other similar tasks may well present the opportunity to have IT-trained personnel contribute more directly to the support of process operations.

“For years, we’ve talked about the convergence of IT and OT,” notes Wally Pratt, director of field communication protocols for FieldComm Group. “And while there’s sometimes been resistance from the operational side of things, it’s in the IT group’s wheelhouse to take to care of tasks like network security management, patching, firewall configurations and the like. Let the IT people do what they do best.”



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Easy does it

And with HART-IP, securely commissioning a new Ethernet-APL device can be just as easy as it is to securely commission a WirelessHART instrument, Pratt continues. "Take it out of the box, put it on the bench, hook up a handheld and enter a network ID and join key. Then just put it out in the plant and it works. We're trying to do the hard stuff inside to make it simple on the outside."

Both Dow's Jeff Konrad, technical solutions team leader, automation interfaces, and 3M's Robert Sentz, senior engineering specialist, envision that Ethernet-APL field network security would be an extension of the long-established IT security practices now used at the higher levels of their companies' Ethernet-based automation and information networks.

And when it comes to 3M's first adventures in Ethernet-APL, "it might be nice start with something that looks very familiar," Sentz says. "I expect that we might want to add to what's available in HART-IP, but starting there with the ability to grow would allow for a smoother transition."

Jason Urso, chief technology officer, Honeywell Process Solutions, agrees that industry shouldn't waste a lot of time worrying about how devices talk to one another. "Let's build on a widely adopted and pervasive infrastructure where we have lots of people that understand it and know how to maintain it. We may find that new devices and different industries are better suited to other protocols than HART-IP, but Ethernet-APL doesn't preclude us using them as well."

"So, let's get this technology out to our customers as quickly as we can," Urso says. "So we can learn from it, adopt and adapt." ■