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The last mile

APL standard to make field-level Ethernet a reality

by Keith Larson

It's been nearly 10 years since the process automation community first began investigating a protocol-neutral advanced physical layer (APL) that would extend Ethernet over the process industry's last mile—providing connectivity with broadly distributed, two-wire, loop-powered field instruments in potentially hazardous environments. Today, we've also reached the last mile in that decade-long journey to make high-performance field device connectivity a practical reality.

The technology was successfully tested at BASF last year, and a multi-vendor prototype network was shown at last November's NAMUR General Meeting. Automation suppliers are targeting ACHEMA 2021, to be held next in June in Frankfurt, to show commercial products. APL is a significant technical achievement in that it dramatically increases the bandwidth available for digital instrument communications, as well as simplifies the network architecture in one fell swoop. At 10 MB/second, APL clocks in at more than 300 times faster than FOUNDATION fieldbus H1 and more than 8,000 times faster than the original HART protocol. And, since it's Ethernet, APL effectively facilitates top-to-bottom cybersecurity, while eliminating the need for gateways or protocol conversion from the field device all the way to enterprise business systems and the cloud.

EXTENDED STANDARDS

APL is an offshoot of the IEEE's recently approved 802.3cg-2019 (10BASE-T1L) standard, which effectively extends the 802.3 Ethernet standard to include single-pair wiring over distances up to 1,000 meters with the optional provision of power to devices. APL is of particular importance to the process industries because its focus is on extending 10BASE-T1L for use in hazardous areas.

Importantly, the APL Project counts among its supporters three of the process industry's key communications standards development organizations—FieldComm Group, Profibus & Profinet International (PI) and ODVA—as well as a dozen process automation companies that together represent considerable clout in the global marketplace: ABB, Emerson, Endress+Hauser, Krohne, Pepperl+Fuchs, Phoenix Contact, Rockwell Automation, Samson, Siemens, Stahl, VEGA and Yokogawa.

The APL Project's new standards for intrinsic safety will be known as "Ethernet-APL." Further, the IEC PT 60079-47 technical committee is working on a technical specification called Two-Wire Intrinsically Safe Ethernet (2-WISE) to fulfill the requirement of intrinsic safety for loop-powered and separately powered devices in hazardous areas up to Zone 0, 1 and 2/Division 1 and 2.

To make engineering and verification of intrinsically safe loops as simple as possible, 2-WISE is based on the same Ex-concept as the well-established Fieldbus Intrinsically Safe Concept (FISCO). This concept is supported by successful tests executed at Dekra Testing and Certification GmbH. The final technical specification (IEC TS 60079-47) is expected in 2021.

In addition, Ethernet-APL will define port profiles for multiple power levels for use both inside and outside of explosion hazardous areas to ensure interoperability of APL field switches and APL field devices. These APL port profiles will replace power delivery via Power over Data Lines (PoDL), which is optional within the 10BASE-T1L standard.

"Compliance with this power profile concept is crucial in order to avoiding hardware variance for field devices that could be installed in hazardous as well as unclassified areas," notes Lukas Klausmann, senior marketing manager, Endress+Hauser Digital Solutions. So, devices for Ethernet-APL and for standard single-pair Ethernet (SPE) won't mix and match in the same system in part because the field devices being developed won't support PoDL functionality.

On the positive side, Ethernet-APL will deliver more intrinsically safe power to field instruments than FOUNDATION, Profibus PA or HART. "This will enable instrument vendors to design two-wire instruments that today require four wires due to high power demand," says Michael Kessler, executive vice president, components and technology, Pepperl+Fuchs.

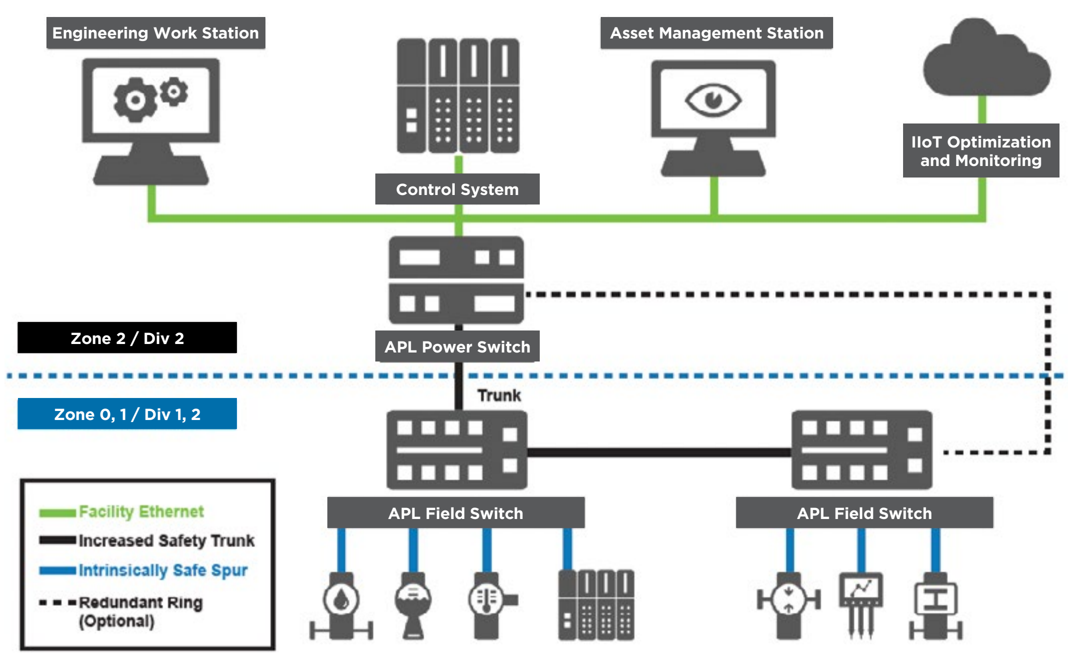
The availability of application-specific integrated circuits (ASIC) that support the Ethernet-APL physical layer (PHY) is another essential step in commercializing APL devices. The first samples are due to ship this month (June 2020) with production quantity ASICs available this time next year.

Finally, to ensure standards conformance of the implementation, the APL Project will specify APL conformance tests that will be integrated into the appropriate specifications of the relevant standards development organizations, including FieldComm Group (for HART-IP), ODVA (for EtherNet/IP) and PI (for Profinet).

"All necessary specification development is on track," notes Steve Fales, APL Project spokesperson and ODVA marketing director. "In addition to its specification work, the APL Project is working on a guideline for engineering and installation to provide the best possible support for the planning and commissioning of APL networks. The first field devices and infrastructure components are expected to be available after ACHEMA 2021, once all of the appropriate certification processes are in place."

FAMILIAR TOPOLOGY

Ethernet-APL is designed to support trunk-and-spur installations and redundancy concepts similar to the fieldbus options that came before it (Figure 1). Two general types of segments are defined: trunk lines that carry high-level power and data for distances up to 1,000 m, and spur lines that carry



APL BRINGS ETHERNET TO THE FIELD
Figure 1. Ethernet-APL dramatically increases digital bandwidth to field instruments in hazardous and non-hazardous areas.

power and signals with optional intrinsic safety for distances up to 200 m. Anchoring the trunks are APL Power Switches, each of which provides up to 60 W of power and communications for as many as 50 devices. Anchoring each spur, in turn, is an APL Field Switch that provides intrinsically safe power and communications to the field devices themselves.

Ethernet-APL requirements for IEC 61158 Type A shielded, twisted-pair cables is also in line with established fieldbus practices, notes Andy Kravitz, flow transmitter marketing manager and APL working group representative for Emerson. "The APL Working group is preparing a set of engineering guidelines to help users select the correct cabling for a given APL application," Kravitz says.

"As fieldbus cable has been designed for 31.250 kB, not all existing cable can be used for APL at the full cable length," adds Pepperl+Fuchs' Kessler. "Therefore the APL port profile specification defines for different categories supporting spur / trunk cable length of 50 m / 250 m, 100 m / 500 m, 150 m / 750 m, and 200 m / 1,000 m. Cable manufacturers have to specify their cable according to this classification."

"From the very outset, the ability to reuse existing single, twisted-pair fieldbus cabling was a requirement for APL due the high installation costs involved," says Michael Bowne, executive director, PI North America. "For example, the Type A cabling used by Profibus PA should work just fine for APL.

"But whether greenfield or brownfield, we highly recommend users perform a network infrastructure baseline test as part of any installation," Bowne adds. "This involves ensuring all wiring is performing as intended. Cable testers are available from various manufacturers that verify cable integrity and electrical properties. As long the wiring meets the resistance, inductance and capacitance ratings specified, users should be good to go. Confidence in the initial network infrastructure also helps relieve worries down the road if errors crop up."

Connector technology recommendations are a final point of contention for APL standards-makers as of this writing. "RJ45 and M8/M12 connectors and pinouts are still in discussion," explains Jason Norris, manager of process automation portfolio and global market development, I/O and networks, Phoenix Contact.

MIGRATION AND ADOPTION ISSUES

As with any new technology aimed at supplanting "perfectly good" operational devices and entrenched work practices, the adoption of APL—for process facilities both greenfield and brown—will likely take time to gather momentum, even with the most compelling of value propositions.

"Where FOUNDATION fieldbus and Profibus PA are currently used, we don't believe that end users will start ripping out field Instruments to install APL," says Paul Sereiko, director of marketing at FieldComm Group. "We doubt a refinery unit will consider upgrading until their existing assets are at end of life. Early adopters are much more likely in more flexible process applications, such as life sciences, and food and beverage."

"Any protocol that runs on Ethernet today can be used over Ethernet-APL," notes Emerson's Kravitz. And that includes HART-IP and Profinet as well as EtherNet/IP and other industrial Ethernet variants once generally excluded from hazardous-area duty. "Ethernet-based protocols such as these have provisions for using I/O that can communicate with devices using legacy digital protocols such as analog HART, Profibus PA and FOUNDATION fieldbus. Initially, we expect customers to continue to make decisions based on comfort, cost and capability—and their selection of devices will likely not change due to the release of a new technology such as Ethernet-APL."

"But over time, as instrumentation and system vendors provide more support for Ethernet-APL," Kravitz continues, "we expect customers will select Ethernet-APL devices due to the potential for increased capability, security and flexibility."

"FOUNDATION fieldbus and Profibus PA will be first to lose with the appearance of APL," predicts Taro Endoh, Yokogawa representative on the APL working groups. "APL with industrial Ethernet protocols will replace conventional digital protocols first, then 4-20mA + HART in the not so distant future."

But APL vs. current fieldbus protocols doesn't have to be an all or nothing proposition, according to Michael Kessler of Pepperl+Fuchs. "Ethernet-APL switches have been demonstrated to provide Ethernet-APL spur interfaces with dual functionality, e.g., Profinet-APL and Profibus PA," Kessler says. "Theoretically, this is also feasible with a FOUNDATION fieldbus instrument where its data can be mapped on any Ethernet-based, real-time protocol. This dual-functionality is important to migrate existing plants to Ethernet-APL-based infrastructure. During the first years of market introduction of Ethernet-APL, existing FOUNDATION fieldbus or Profibus PA instruments may fill the gap of missing instrument functions with an Ethernet-APL interface."

It's also important to note that the non-fieldbus, analog + HART segment of the market is also currently the largest—both in terms of installed base and current greenfield plant design and construction. Indeed, a wholesale shift to APL will require revamped systems and engineering practices away from the now widespread practice of configurable I/O in which DCS suppliers have invested so much money and effort over the past 10 years.

And of the three standards development organizations currently involved in the APL Project, ODVA and its EtherNet/IP protocol may stand to gain the most from an APL standard. “Today, EtherNet/IP is commonly used in process automation within ‘islands of automation’ for applications such as valve piloting where a PLC, that also serves as a gateway to a DCS, controls a bank of directional control valves,” explains Steve Fales of ODVA.

With APL, Fales predicts that EtherNet/IP will be used more broadly across process networks—without gateways—for control, diagnostics and commissioning. “EtherNet/IP is well positioned for success in process automation as evidenced by being named as one of the minimum binding requirements by NAMUR for Ethernet communication systems between the field level and higher system levels, integration of HART device translation services, and the addition of NAMUR NE 107 diagnostics.”

Adds ABB’s Tilo Merlin, platforms manager, ABB Measurement & Analytics: “Since most DCS systems already support Profinet and EtherNet/IP today, adoption of Ethernet-APL based on these protocols will be straightforward. As direct usage eliminates the use of gateways or other protocol conversions, it will significantly reduce complexity, cost of ownership and improve usability and robustness compared to traditional fieldbus solutions.

“Beyond applying those established Ethernet-based protocols,” Merlin adds, “APL enables use of new protocols such as OPC UA, offering new levels of security and semantics, and so breaks the border between IT and OT.”

And that may be just the value proposition needed to speed APL uptake.

AN ONRAMP TO SECURE DIGITAL TWINS

Even as the APL Project has been working to extend an IIoT-sized expressway to field instruments, work has progressed on complementary standards from the software and systems side of the world that are poised to take full advantage of that new bandwidth. Notable among these are FDI, PA-DIM and OPC-UA—all of which promised to bring new order and value to the digital field.

“FDI and PA-DIM are all about making it easier for software systems throughout the enterprise to consume information provided by instruments,” explains Sereiko of FieldComm Group. “Ethernet-APL is all about replacing gateways and remote I/O with Ethernet switches to facilitate the routing of the information from the device to the enterprise system. Ultimately, it's possible that the higher speeds enabled will lend themselves to feature enhancements for FDI and PA-DIM that further simplify device integrations."

"As a technology, FDI and PA-DIM are designed to help lower the bar for pulling information from field devices," adds Emerson's Kravitz. "Given that Ethernet-APL increases the bandwidth to individual devices, we expect the combination of all of these technologies will help drive customers to more fully utilize the capabilities of our devices more easily than ever before. This will enable field devices to easily integrate with every level of the process data ecosystem from the control system all the way to the cloud."

Ethernet-APL and PA-DIM in combination offer the possibility to access data from the field in a parallel communication path to the control integration, notes Lukas Klausmann of Endress+Hauser. "This second-channel approach supports the concept of NAMUR Open Architecture (NOA) without influencing core automation processes," Klaussmann says. "This is the basis of plant-wide availability of data, and its easy interpretation without need for device-specific drivers. The possibilities of such digital services are numerous, and offer extensive support for optimization efforts and efficiency improvements in a process plant."

Ethernet-APL is the key enabling technology to deploy OPC UA and PA-DIM in the field devices themselves, adds Pepperl+Fuchs' Kessler. "This will finally allow real plug-and-play since the device will come with an embedded information model—that means no need for any kind of device description. FDI, meanwhile, will allow the use of PA-DIM for legacy instruments. This will help with plants migrating from HART or fieldbus to Ethernet-APL."

Models and standards such as FDI are important tools for customers and vendors, but adoption rates are always slower when speed, infrastructure and connectivity to higher level systems requires new cabling or even gateways, says Scott Saunders, president/CEO of Moore Industries. "Ethernet-APL goes a long way by removing all these issues. Supporting most existing installed, twisted-pair cabling with speeds of 10 Mbps and supporting most all other TCP/IP-based industrial protocols simultaneously, helps assuage the concern end users typically have that hamper new and emerging standards introduced in our industry."

"A whole world of new use cases become possible with APL," adds Bowne of PI North America. "It plays directly into the IT/OT network convergence that's occurring across industries. With a common Ethernet-based physical layer, vendors are free to implement multiple protocols on their instruments, a feature long established in factory automation. It also helps enable concepts like NAMUR Open Architecture for unidirectional communication to higher level systems outside the traditional automation pyramid."

The fact that Ethernet-APL supports the full Ethernet stack means that all the additional features of the IEEE world are available to increase usability, says ABB's Merlin, citing Link Layer Discovery Protocol (LLDP), an out-of-the-box tool available once you're part of the Ethernet ecosystem.

"The general multi-protocol capability of Ethernet is far-reaching," Merlin says. "It makes the secure bridging between OT and IT world a lot easier. And due to universal applicability of OPC UA from field level to cloud, APL is a cornerstone to connect physical assets to their digital twins."

Plantwide I/O approach streamlines plant start-up

Sour gas plant shaves three months from schedule despite onrush of late design changes

by Keith Larson

Companies have long complained about automation budget over-runs and schedule delays, often due to late changes in project design. Traditional, hard-wired input/output (I/O) systems were a primary culprit because hardware procurement and software development necessarily proceeded sequentially. Design changes requiring more or a different mix of I/O resulted in expensive and time-consuming re-engineering that affected both budgets and schedules. These impacts, of course, got progressively worse as the project neared completion.

But gas processor SemCAMS Midstream (now part of Energy Transfer Canada) bucked that trend, beginning production at its greenfield Wapiti sour gas processing plant in northern Alberta in late January 2019—under budget and three months ahead of original schedule—despite late changes and additions to project scope.

How, you might ask? Project principals credit in part the plant's pioneering use of ABB Select I/O, the Ethernet-based single-channel I/O system for the ABB Ability System 800xA control system. Importantly, Select I/O relies on industry-standard Profinet as the backbone of its plantwide I/O network. Use of this standard protocol dramatically streamlined the integration of even third-party I/O on skids that came late to the party. Indeed, changes during the engineering process had increased the I/O count from 1,200 to 2,400 as more gas streams and equipment were added.

Gas processor SemCAMS Midstream (now part of Energy Transfer Canada) began production at its greenfield Wapiti sour gas processing plant under budget and three months ahead of original schedule— despite late changes and additions to project scope.

The Wapiti plant also marked a successful effort by system integrator Blackrock Automation, which has earned a reputation for tackling tough automation assignments with skill and precision. The fact that project startup came when temperatures were dropping to -42 °C was another of the challenges for the project team to overcome.

ELIMINATING DEPENDENCIES

ABB's Select I/O was designed to eliminate the traditional, controller-centric methodology that made late changes so difficult to accommodate. Called xStream Engineering (now part of the ABB Adaptive Execution methodology), the approach provides multiple workstreams and late binding principles to promote engineering efficiency. At Wapiti, this enabled remote I/O cabinets to be installed and wired in the field while the Blackrock team configured the system at their Calgary office. Decoupling project tasks reduced the impact of late changes, and activities such as functional wiring and loop checks could be done much earlier.

"We designed, built and installed 27 identical remote I/O cabinets each with 96 I/O per cabinet," says Galen Wilton, senior programmer at Blackrock Automation. "As a result, we were able to field-test all the cabinets in just two or three hours. Select I/O also saved a lot on cable by allowing us to use more flexible switching devices between panels and reassign them as needed. That meant most changes were no longer about asking for money, but were about new ways to save money."

Each of the Class 1, Div. 2 remote cabinets was assigned a device address on the Profinet network as it was added, enabling last-minute changes throughout the process. The project also featured motor-control-center (MCC) communications with more than 40 Multilin relays and 76 variable frequency drives over Profinet.

"Select I/O is perfect for remote I/O applications as it moves the I/O from the motor control center and electrical rooms into the field," explains Brad McDonald, product marketing manager for ABB. "Extra I/O can simply be ordered and installed as needed since field wiring doesn't have to be brought back to the central control room. This eliminates marshaling, junction boxes, cabling and cable tray, ultimately reducing project costs by 30-40%."

The control and network architecture at Wapiti includes two virtual servers, two servers working as historians, four operator stations, three engineering stations, PLC interfaces and two AC 800M controllers connected to the remote I/O cabinets. In addition, there were two local S800 I/O cabinets connected via Profibus for remote MCCs.

REDUNDANCY REQUIREMENTS

"In addition to the virtual servers hosting redundant server functions, the system also included software-based controllers, which meant we could set up, simulate and test the entire project at our office in Calgary and even use them for training," says Wilton.

Plant availability, and hence redundancy, was a top priority for control and communications. The plant processes about 200 million cubic feet of sour gas every day, so it's critical that plant personnel are able to keep tabs on the process at all times to assure that hydrogen sulfide, propane, butane and other impurities are being properly removed from the final product.

For maximum uptime and visibility, the System 800xA's redundant controllers were connected to the Select I/O cabinets and drives via Profinet utilizing a fault tolerant, redundant, fiber-optic ring of stars architecture. Profinet network designs are relatively straightforward, since standard, off-the-shelf Ethernet switches can be used. An optimized ISO model enables Profinet to connect with more than 1,000 remote I/O drops for communication over one network, along with millisecond performance and seamless failover on both ring and redundant architectures.

OPERATIONAL TRANSPARENCY

Having various field equipment connected via Profinet—all tied back to one common platform—provides for effective facility-wide monitoring and maintenance on an ongoing basis.

"The diagnostic capabilities of Profinet make it a very good tool for information and analysis," adds Rob Remeika, lead automation manager and safety system expert at Blackrock. "You can get more information faster, and you can plug in anywhere." Wilton says operators at the plant also like Profinet's trending and alarming system. "It is quite simple and yet effective. We hardly had to do any training. They were able to run tasks and reorder them while the software was using the analysis tool, which enabled instant changes with quick results."

Is redundancy still redundant?

Contemplating field network redundancy requirements for an 'EtherBus' future

by John Rezabek

"Someone hustle to the nitrogen plant and hit the blue button" came the message over the plant radio. A power interruption, although brief, left the facility's operators scrambling to bring their plant to a safe and quiescent parking place with hopes for a quick resumption of production. To everyone's dismay, the decades-old nitrogen separation plant was never equipped with any provisions for an automatic restart after a loss of power. Total power outages were thankfully rare, but the end user's chemical facility spent some time and effort to detect that its nitrogen and air supplier's PLC needed a reset, and to locate that blue button. Oy vey.

Their petrochemical plant had been constructed according to specifications adapted from their petroleum-refining-heritage neighbors; in both cultures, high availability was crucial. So, how did their plant end up with this single point of failure that corroded their plant's reliability? Conserving capital is irresistible, so outsourcing a utility like compressed air and nitrogen was attractive. The degree to which the owner's standards could be instilled in the third-party's cookie-cutter air separation plant was limited. Some incentives and penalties for reliability or lack thereof could be negotiated into the supplier's contract, but these did little to inspire investment in reliability.

With emerging technologies to enable digital integration of field devices, how much capital and engineering effort should one spend making their new networks "bulletproof"? New fieldbus solutions like IEEE 10BaseT1L or Advanced Physical Layer (APL) promise to become practical for real-world deployment—so do we need to conceive innovative architectures that support improved availability levels? Conventional Ethernet installed to integrate PLCs, motor controls, analyzer networks and similar appliances can typically tolerate service outages of minutes, hours and even days, as connected devices can function adequately, maintaining safe production of product, without digital communications with the host DCS. With long-available ring topologies a degree of redundancy is achieved, primarily for cable/fiber and media converters. These solutions are not without their own risks, and may themselves rely on intelligent switch firmware—whose execution may not be as fault-tolerant as we'd like.

In the early days of DCS imaginings, the concept of single-loop integrity was bandied about. Simply put, the idea is that no single fault shall affect more than one loop. Since the distribution of the DCS was less than distributed (many control loops executed in one controller), this led to redundant controllers and redundant I/O, which we largely take for granted.

Fieldbus deployments, with multiple devices communicating on the same twisted pair and power supply, compelled us to reimagine redundancy. Redundant-ring topologies in FOUNDATION fieldbus and Profibus PA networks are possible but rarely deployed; we conceive of the single-pair trunk in the same vein as its conventional multi-pair counterpart. And many early adopters took pains to carefully segregate critical loops onto more highly managed segments. But on the field side of the fieldbus trunk, few active devices had an impact on overall network functionality.

If the paradigm is to use existing, nominally 18 AWG twisted-pair fieldbus cable for APL, the inherent limitations of Ohm's Law will likely dictate a smaller basket of eggs—i.e., it remains to be seen how many devices we'll be able to power on a single pair in a hazardous area. Power-hungry devices like Coriolis flow or mag meters want to offer two-wire solutions. Perhaps worrying how to construct a network that supports dozens of field devices on a single pair (or single redundant ring) won't be necessary.

That there will be a proliferation of active devices, e.g. APL switches, field power supplies, and more, still seems to loom in the future; perhaps we'll have one switch for every 12-16 devices. If the hope is for a single, unified twisted-pair fieldbus (finally), it will need to support critical controls as well as equipment diagnostics. Let's hope network infrastructure reliability doesn't need to be compromised for the sake of conserving capital.

What can chemical-based networks teach us about industrial networks?

Plants, fungi, slime and other chemical-based networks may have much to teach electronic, industrial networks and their human users

by Jim Montague

JusT like the few other homeowners who still mow their own lawns, I'm certain the dandelions are conspiring against me. I used to think it was just a (sub)urban legend that they ducked down to avoid lawnmower blades. However, I learned that when one dandelion is cut, the sap released into the air trigger its surviving neighbors to hug closer to the ground to avoid similar trauma.

I should no doubt research this particular accusation further, but ever since I formed my sporting interest in dandelion strategy and tactics, I've organically run across so much supporting information that added inquiries weren't needed. Of course, because Control and I continue to cover industrial networking, I keep noticing many of the methods used to site assess, design, setup and maintain Ethernet, wireless, Internet, cloud-computing and other electronic networks are eerily similar to the biological connections and systems running in literal fields and forests.

As usual, I'm no expert, but that many parallels means one side probably has lots to teach the other. It wouldn't be the first time people and industry learned from biology and nature, but it still requires a willingness to look and see. Jet engines were flying for decades before someone added feather-shaped, scalloped edging around their exhausts to reduce noise.

Anyway, I first confirmed my suspicions about weed communications thanks to a PBS

Nature documentary, "What plants talk about," which detailed their quests light and nutrients (**www.youtube.com/watch?v=yUwzxE648uo**). It reported how plants and trees emit compounds and odors when they're stressed or attacked, but it also described how their root systems interact with and respond to other plants, insects, animals, fungi and microorganisms in their neighborhood—and initiate chemical-based identification, defense or attacks. Sounds like the basic sense-decide-act model for process control to me, complete with a cybersecurity component.

Plus, rather than simply competing (or conforming to transplanted human ideas), many tree-root filaments and mycorrhizal fungi in the ground actively complement each other, and form long-term, mutually beneficial relationships, vast systems and nurturing communities that allow each participant to secure the nourishment they need more successfully. In the "What plants talk about" documentary, Dr. Suzanne Simard, forest ecology professor at the University of British Columbia, reports that roots provide fungi with carbon-based sugars that can't make themselves, fungi give back nutrients that trees can't produce. She goes into more detail in her TED Talk, "How trees talk to each other" (**www.youtube.com/watch?v=Un2yBgIAxYs**).

What's more remarkable is all this tree/fungi coordination occurs without brains or central nervous systems. Simple chemical sensors, triggers and genetic predispositions drive plants, fungi and other organisms to survive. Slime molds are reported to be even more basic than fungi, but just check out their networking in this clip from the PBS Nova documentary "The secret mind of slime" (**www.pbs.org/wgbh/nova/video/slime-mold-navigate-maze**). It's not likely conscious, but what is? And who cares, as long as your belly is full, whatever form that belly takes?

I used to be skeptical that indirect networking or communication by inference weren't truly networking and communication. However, even though radio frequency identification (RFID) tags on tubs of ice cream don't measure and relay temperatures, using the tags to verify location and time still lets users correctly assume they've remained frozen. Likewise, there isn't a garden gnome texting the dandelions when I start the lawnmower, but they still get the message. Whatever works.

In many Control articles, I'm repeatedly reminded of the need to make industrial networks simpler and easier to program as they progressed from point-to-point hardwiring to fieldbuses, Ethernet, wireless and the Internet. I'd bet the longer-evolved, chemical-based networks of plants and microorganisms can offer useful clues to their electronic counterparts.