2017 STATE OF TECHNOLOGY: INPUT/OUTPUT SYSTEMS
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You’re ready for final commissioning (this is where you drop the mic)!
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Industrial-Strength Ethernet I/O With High-Density Efficiency

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Interfacing solutions for signal conditioning and network I/O

Signal Conditioning & Network I/O Solutions
All industrial processes are analog in nature. As such, one of the foundational requirements of process automation is the translation of analog process variables into the bits and bytes that today’s digital controllers can understand. A controller’s digital decisions, in turn, must at some point be translated back into analog action such as a change in valve position or an adjustment in motor speed.

Not so long ago, this input/output (or simply I/O) function was the exclusive province of fixed-functionality, multi-channel I/O modules that bridged the divide between the digital process automation system and each of the hundreds or thousands of analog field devices in a typical process plant. As discussed earlier in this volume (see “The Problem with Projects”), the wire pair from each field device had to be physically marshalled to a specific type of I/O channel, which in turn had to be connected to the controller responsible for that particular variable. These serial design interdependencies made for inflexible I/O subsystems that could not gracefully accommodate change, resulting in redesign, rework and ultimately late projects that ran over budget as well.

**MAXIMIZE I/O FLEXIBILITY**
Moving automation engineering off the critical project path starts with accommodating even late changes in instrumentation requirements by CONTROL staff.
technology increase system flexibility by effectively eliminating the need for traditional I/O hardware altogether. Any new measurement points or outputs added to a project must still be digitally mapped to the broader control system strategies, but that can be done relatively late in the project via software—an approach that’s always less disruptive than reengineering, reordering and/or reinstalling multiple new hardware components.

The second means by which process plant designers have kept inflexible I/O designs from derailing project delivery is by leveraging modularized process units and other higher level subsystems such as intelligent electrical devices (IEDs) where possible and practical. These subsystems arrive at the project site not with a bundle of analog wires to physically marshal into the main automation system, but with a single (or redundant) Ethernet cable connection. The subtleties of lower-level field device connectivity are left to the subsystem supplier and the measurement and control parameters digitally mapped to broader strategies in the main control system. By some estimates, more than 50% of today’s measurement and control points are wired not at the project site, but come already embedded within larger pieces of equipment and skids.

**CONFIGURABILITY TAMES REMAINING I/O**

Despite these innovative ways of eliminating traditional I/O engineering dependencies, old habits die hard. Indeed, a recent survey of Control readers indicates that analog instruments still account for some 55% of capital project I/O points, whereas 38% is connected via fieldbus and 7% by wireless (Figure 1). Clearly, the process industries still appreciate the simplicity and familiarity of analog instrumentation. So, a third innovation was needed to free project engineers from the rigid tyranny of fixed-functionality I/O modules:

**Figure 1: Despite the inherent advantages of digitally networked field instrumentation, a survey of Control readers indicates that more than half of new project I/O relies on analog signal transmission.**
While any number of unexpected developments can throw a project off track, automation is uniquely positioned to either absorb project risks—or to amplify them.

single-channel, flexible I/O such as ABB’s Select I/O offering.

Available for process automation and safety applications, this extension to the System 800xA family of Flexible I/O Solutions allows for each I/O channel to be individually characterized using a plug-in hardware module. This approach streamlines project execution in a number of ways.

First, because the base hardware for every type of signal is the same, automation system designers need only know an approximate I/O count at the design-freeze milestone. Designers can then order standard—not custom—I/O module bases and enclosures, knowing that they have full flexibility to alter the mix of I/O types at any point in the project. Further, since control system hardware components are now standard issue, the factory acceptance test (FAT) of control system hardware is a thing of the past.

Second, because each channel can take on any signal type and be digitally marshalled to any controller, the need for physical marshalling—and all those cabinets and terminations, too—disappears completely (Figure 3). In addition to lowering costs and speeding execution, this has the added benefit of significantly reducing overall system footprint, which can be critically important in an application such as an off-shore oil rig where floor-space and even allowable weight are at a premium. Instrument installation techs save time, too, because they can simply land their wire pairs on the most convenient pair of I/O terminations and move on to the next.
In the end, single-channel, configurable I/O does much to sever the serial design dependencies that plague the execution of automation projects. Hardware and software aspects of automation system design can proceed in parallel, compressing schedules and reducing risk. But ABB goes a step further, delivering software tools and new execution workflows to ensure that these streamlined, parallel engineering processes meet up in a fully tested, fully functional automation solution.

**PHYSICAL MARSHALLING ELIMINATED**

Figure 3: (Left) For those instruments that rely on analog/multi-core cabling, Control readers indicate more than 70% already take advantage of configurable I/O modules in their organizations’ project work. Before (above) and after (below). A key advantage of I/O modules that can be configured on a single-channel basis is the elimination of marshalling cabinets and all the physical space, expense and labor they represent.
NO NODES...
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Most of the conversation related to the Industrial Internet of Things (IIoT) has been about factory automation, but the ExxonMobil vision for Next Generation Open Automation System (NGOAS) and Open System Architecture (OSA) is bringing these same concepts to process automation. The good news is that thanks to the enterprise, we have open systems at the top—the cloud and associated storage/data transfer mechanisms—and at the bottom, the analog and digital networks are also well defined. The work that remains is the all-important middle, which just happens to be where all the proprietary systems, technology and information reside. This is what the NGOAS project hopes to separate from its hardware dependence.

The ExxonMobil team now has U.S. Patent 20160065656A1, “Method and System for Modular Interoperable Distributed Control,” which specifies in general terms their proposed system of the future. It describes a system with several elements, the key one being the Distributed Control Node (DCN) to interface the middle layer with the field layer.

The patent does not differentiate between the two types of DCNs defined in the document: the software or application DCN I call the application control node (ACN), and the hardware node that interfaces to the field devices I’ll call the device control node (DCN). Think of the DCN as similar to a combination single-loop controller/gateway with configurable I/O (analog, fieldbus, wireless), IPv6-addressable and suitable for mounting in Zone 2 (Class I, Div. 2, Group C/D)—in
The public reason that ExxonMobil is pushing NGOAS is because they want to be untethered from the hardware.

other words, an intelligent, single-signal I/O card that can be mounted anywhere.

The ACN, on the other hand, is similar to the Virtual Field Device in the Foundation fieldbus world, and can reside in any device with memory and microprocessor, from the DCN itself (thus enabling control in the field) to a redundant server on the control network. This effectively brings the cloud nearer to the edge, since the DCN is the fence on the edge of the control system and the devices themselves are the edge. Therefore, once the signal has been processed by the DCN, it’s simply another piece of data, likely in the form of an object or metatag that needs to be managed.

The patent indicates the desire to incorporate applications developed using anything from one of the IEC 61131-3 languages to imported code from products such as LabView, Matlab or GNU Octave, thus allowing anyone with knowledge of these widely deployed systems to work in the environment in which they’re most comfortable.

The public reason that ExxonMobil is pushing NGOAS is because they want to be untethered from the hardware, in part, so they can take advantage of the latest processors and migrate on demand without having to replace an entire system. A big concern they have is what happens if they pick the wrong existing standard, which is why all the discussions go through Open Group. One requirement for wide adoption is that the results be published as standards. But standards require release of patents, which means that in order to succeed, (with apologies to the inventors), the ExxonMobil patent is more of a whitepaper or vision document that, because it is a patent, will be accessible and read.

One last thing I’m confident about is that SCADA-like technology will play a role in NGOAS and IIoT because IoT is really super-sized SCADA connecting lots of things to each other in real time. So I’m pleased that ISA is about to kick off the S112 committee, which will develop a new set of SCADA standards.

Yes, ExxonMobil has a good idea here, and many of the elements are available. However, the trick will be making it work and keeping it working because when it or something like it does happen, the IIoT will be “on or near the edge.”
The Open Process Automation initiative presents predictable challenges in I/O systems

OPA is not a standards-developing body, which means they will either have to adopt existing standards or work with another standards-developing organization such as ISA, FM, or UL to create any required documents.

by Ian Verhappen

The Open Process Automation Forum (OPA) and the team led by end-user companies ExxonMobil, Chevron, Shell and BASF to develop the next generation control system have stated from the start that the solution will be based on open standards. Unfortunately, OPA is not a standards-developing body, which means they will either have to adopt existing standards or work with another standards-developing organization such as ISA, FM, or UL to create any required documents.

Normally, one of the first steps in the standards development process is to create use cases describing the problem to be solved. Though ExxonMobil has likely created this document or one like it, perhaps called something else, I could not find it on the OPA website. But I suspect that the pending patent discussed in “Pushing IIoT near the edge” summarizes what such a document would identify, and led to the Open Systems Architecture vision with its three new elements: the Real Time Advanced Computing (RTAC) operations platform, Real Time service bus, and Distributed Control Node (DCN), which are mapped to the ISA-95 four-layer model.

In addition to the four-layer model, the group also needs to create documents related to the seven layers of the OSI layer model. Many groups now think the OSI model should be eight layers, adding a “user layer” where the functionality of, for example, EDDL is defined. However, because almost all field-level networks are relatively simple (little or no
One decision that will have to be made...is whether the device will be based on software-configurable I/O (Schneider/Foxboro, Honeywell, Yokogawa) or a hardware snap-in module solution (Emerson, ABB, Wago).

transfer of data across multiple networks), the eight layers are compressed into four or five layers. This simplification of layers may not be possible in this architecture, in which case network management could become a significant challenge as existing DCS systems do not have a single solution, while Ethernet with TCP/UDP and IP only define the lower layers of the OSI model.

The part of the system that is potentially closest to having standards in place is the Device Control Node (DCN), for which I believe:

- FDI will likely be selected for field device communications as more than 90% of process devices are already DD-based (HART, Foundation, Profibus PA), and FDI also includes OPC “hooks.”
- The DCN will most likely not be intrinsically safe (IS) but probably will be non-arcing (nA)/non-incendive (NI), suitable for installation in Zone 2/Div. 2, since that covers the majority of hydrocarbon and oil & gas facilities driving the OPA effort. If IS is required, additional circuitry will be added to those signals, just as is done with fieldbus barrier power supplies.
- One decision that will have to be made and which the DCS suppliers will be campaigning is whether the device will be based on software-configurable I/O (Schneider/Foxboro, Honeywell, Yokogawa) or a hardware snap-in module solution (Emerson, ABB, Wago).
- Because existing I/O cards are based on multiples of four signals, the DCN will also be based on this multiplier.

Reliable power still remains an issue for any field-mounted device, though with the increasing use of distributed data gathering, several options for fully redundant UPS suitable for Zone 2/Div. 2 installation are commercially available. Unfortunately, these power supply systems do not have a standardized way with low overhead (other than a common trouble alarm contact) to communicate with the DCN to share their status with the balance of the control system. A contact normally indicates a failure, rather than a predictive message that can be used to initiate a maintenance activity. If we stay with the EDDL/FDI concept and fieldbus terminology, I would
not be surprised to see development of a new transducer block to link to a digital input (DI) function block for this purpose.

A possible impediment to acceptance of FDI is the potential lack of input from industries such as pharmaceutical and others that may not use EDDL to the same extent as the process industry, but if the DCN contains enough intelligence or the specifications are well enough defined, it will have the flexibility to also serve as a protocol gateway.

I suspect several of the standards identified as being required will be better understood once the first prototype(s) are tested at year end. And I will not be surprised if OPA find these are the same areas that the ISA-112 SCADA standard development group, just getting underway, identifies as part of its work. Surprisingly, though personally invited, the end user companies listed above and chairing the various OPA working groups and subcommittees have not yet identified participants to this standard.

OPA has a vision for the future to migrate legacy systems to a more open, largely software-based future, however, because of this history, they will be constrained by needing to be able to move from today’s platform to the future with minimal disruption to existing field infrastructure and retraining of staff—a not insignificant challenge which, if not addressed, will be the biggest gap to success.
Imagine being able to wire, test and commission your control system while the plant is running, then complete the swingover at the press of a button.

During a traditional control system migration, you must move wires from the old system to the new. Therefore, at some point plants typically have to either shut down completely, or shut down individual systems and migrate one point or loop at a time, a complex and risky process.

The Tempus solution uses a specialized temporary tool that makes it possible to wire from one control system to another, without disrupting the signals. During the migration, both control systems see the same information, which allows online commissioning, testing, and swingover.

“The Tempus hardware allows us to migrate the physical wiring between control system platforms by replicating the original I/O signals to both systems, so there’s no need to shut down,” says David Findlay, P.Tech. (Eng.), automation lead and partner, CIMA+. “It’s a tool we use in the Tempus process, which is part of our control system migration services.”

“You can engineer a way on paper to migrate one point at a time, but logistically, the implementation risks are significant,” says Findlay. We saw this on many projects including our own which was the incentive for developing the Tempus product.”
As part of the Tempus process the module duplicates the signals from the field wiring to both the old and new systems. During the migration, operators will see both the old and new HMI graphics allowing a side by side comparison. “At this point you can test the I/O, programming, logic, and graphics,” Findlay says. Once all your inputs are the same and the programming is the same, then your outputs from both systems will be the same allowing the swingover to be seamless. If there are discrepancies in these values, at this stage is where you would troubleshoot instead of in the old traditional style, during startup.

“When all checks are complete, press a button and the new system takes over with all I/O visible on both systems with zero latency. This action is reversible to return control to the old system at any time” Findlay says. “In a traditional migration, once you start pulling wires off the terminal strips, there’s no going back,” Findlay adds.

All conventional types of signals are supported, and each Tempus module handles one signal with many modules working together at the same time. The number of modules utilized at once is a function of how the full control system is separated into sub-systems.

“For example, at a client’s site with Tempus we upgraded several heat exchangers one at a time as separate sub-systems” Findlay says. “You can do a 10,000-loop system in segments, there’s no physical limit to how many modules can be used at any time.”

“Simply put, Tempus is a game changer, downtime equates to lost production and revenue, and a conventional migration could take days, weeks, or even months. Tempus is a risk mitigation process that completely and safely eliminates downtime for migrations by revolutionizing how control systems are replaced”.

For more information, visit www.cima.ca/tempus.
Making the case for hardware standardization

Operations and management are the real customers, and they have little patience for unforeseen foibles of the process control system.

by John Rezabek

Having a searchable database of all human knowledge, events, weather, trivia, reviews and history in our pocket or purse is practically a foregone conclusion. And while we have our fashion choices of iPhone or Android, there’s a degree of indifference to the hardware. “Phone” functionality is almost entirely a function of the carrier’s network. Jazzy frills (like being submersible in champagne) and tribal affinities aside, one could easily argue that for smart phones, hardware no longer matters.

Even before fieldbus aroused sensitivities about differentiation and commoditization, Fisher-Rosemount’s intrepid “Hawk” team of the 1990s was intimating that hardware didn’t matter. And software didn’t matter. Large portions of the DeltaV (as in change in velocity or acceleration) DCS were assembled from other people’s technology and parts. The controllers and I/O bore an uncanny resemblance to MTL 8000 I/O for good reason—MTL manufactured them. The HMI software was from Intellution (now part of GE). And the original “block ware”—the way you configured the system—was largely based on Foundation fieldbus function blocks. The Austin, Texas, team even conceived a hardware-independent way to settle the bill with their customers: selling licenses for “DSTs” (device serial tags? I’m still not sure what those are), which broadly represented one’s I/O consumption. The idea that DCS suppliers would transition from selling hardware to selling services (apps) was the zeitgeist, and DeltaV seemed to be betting on it.
No wonder we’re intimidated when our “app” runs on an agglomeration of Windows boxes and complex, inscrutable, microprocessor-based gadgetry.

Since then, somehow, the market has transformed the “hardware doesn’t matter” origins of DeltaV to a marketing model that seems more focused on proprietary, built-for-purpose hardware, networking and engineering tools. I have the impression that this conversion was driven largely by their very conservative process industry customers, and the well-worn pathways for marketing systems and winning jobs. Perhaps hardware didn’t matter, but end users (and their EPC firms) buy a DCS because they want to “drive the car,” that is, utilize it to control a process—not assemble the car, test the car, tinker with the car, etc. As a community, our expectation is that the DCS functions as an integrated entity with little or no assembly required. And we also expect the supplier to have an army of competent and meticulous individuals, who have flogged and beaten the bugs into the corner and stomped on them, and will spring into action if you happen across any others.

The conservatism that drives this mindset stems in part from the fact that we aren’t the real end user. We serve an enterprise and an operating organization that use the controls and the dashboard of measurements—the deliverable for which we are accountable—to make the useful products that pay the bills. The operators who deal with our choices have to do so for hours at a time, and unlike us, work isn’t their favorite place to be. Operations managers and plant managers have even less patience for unforeseen foibles of the control system. No wonder we’re intimidated when our “app” runs on an agglomeration of Windows boxes and complex, inscrutable, microprocessor-based gadgetry. Hardware may not matter, but accountability does.

The nebulous accountability for open specifications like fieldbus has been a challenge. It’s taken a decade to evolve testing and specifications that leave little grey area for bugs to live. But today, it does work. Any field device with an analog input (AI) block can be deployed on any segment on any system, and deliver a digitally integrated measurement.

Hardware, to a degree, doesn’t matter. This should embolden us for extending standardization to the next level, per the ambitions of ExxonMobil and Lockheed Martin. We’ll need a new model for accountability. And if there’s a future where hardware doesn’t matter and the deliverable is the artfulness of our app, let’s hope for less than a decade of torments.