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How Edge Computing Helps Deliver Reliable Automated Pressure Testing

System integrator Engenuity uses Opto 22’s groov EPIC for integrated data and control in the oil and gas industries.

By Josh Eastburn, Director of Technical Marketing, Opto 22

Engenuity Inc. provides control automation and data integration solutions with a primary focus on advanced technologies for the oil and gas industry. Through their work in this industry, they have identified specific deficiencies in validation pressure testing of blowout preventers (BOPs) and well control equipment. These tests are often executed manually and can cost operators millions of dollars annually.

In collaboration with customers like Shell International Exploration and Production Company, Engenuity developed a set of fully automated test execution and reporting products. Their high-reliability solution uses Opto 22’s groov EPIC (edge programmable industrial controller) to integrate critical functions like process control, text and email notification, and process history storage and replication.

System design
Using Engenuity’s BOPX testing software, system operators can map out valve arrays and their associated pressure limits, then automatically execute and report on a variety of test scenarios. Engenuity’s EZ Valve retrofittable actuator integrates manual gate, low torque, and plug valves into this automated system, actuating up to 70 valves through as many as 30 test sequences. Engenuity’s EZ Vision leak detection sensors add acoustic analysis to the system to help pinpoint the location of leaks.

While Engenuity has added many features to the BOPX system over the years, Ted Royer, a controls engineer with Engenuity, stresses that “all the test software is on the EPIC. BOPX is just an interface now.”
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It’s primary role in test execution is to send configuration data to the groov EPIC edge controller over a Modbus/TCP connection using the EPIC’s configurable firewall to protect critical control data. One of the controller’s two network ports is configured as a read-only interface joined to an untrusted network named the Manufacturing Demilitarized Zone (DMZ). The other network port is joined to a separate, trusted network, named the Manufacturing Zone, where all I/O and control communication takes place. The EPIC prevents routing traffic between its two ports, so there is no risk of untrusted connections tampering with configuration, execution, or process history data on the trusted network.

Process control and history
With configuration data securely transmitted, the edge controller begins executing test scenarios. Automated valve manifolds and EZ Valve and EZ Vision connections are integrated directly into the EPIC’s local I/O modules or into additional EPICs used as remote I/O.

As test execution proceeds, the primary controller monitors the process. “We have a really well-developed alarm system we’ve developed over decades,” Royer adds. “It runs in the controller, not the HMI, so it’s available to other systems,” including external mail and messaging services, which the control program contacts to generate notifications for a range of conditions.

The primary controller also stores process data to an internal MariaDB server, a popular and proven open-source database management system. MariaDB is available in a cryptographically signed package from Opto 22’s Linux repository. Using the free secure shell (SSH) license for groov EPIC, Engenuity can download and install this and many other applications for execution directly on their edge controller. Signed applications prevent the introduction of malware posing as legitimate software.

To transfer data from the control engine to the database, Engenuity uses Node-Red, an open-source IoT engine originally designed by IBM, which is pre-installed and integrated into groov EPIC’s management layer. It provides thousands of functions for connecting and processing data from different sources, including devices, databases, and web services. Engenuity configures Node-Red to monitor I/O, process variables, and events, then transmit these data points to the internal MariaDB server.

Data integrity and availability
Because testing data is used to validate the safety and efficacy of the user’s system, customers need frequent access to process
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history and often require additional protections to ensure data integrity.

“Typically, on an oil rig, customers just have a Wi-Fi connection to the equipment, which isn’t super reliable,” Royer explains. “Sometimes they want to pull massive amounts of records, even entire jobs, into an Excel spreadsheet. It doesn’t have to be real-time, though, so we will set up another controller here in the office that serves as a replica for the one that’s in the field.”

Instead of burdening the primary EPIC with large data requests, customers connect to the replica controller, which periodically requests updates from the primary MariaDB server. “We have plenty of bandwidth here [in the office],” adds Royer, “so it gives them the best of both worlds.”

To facilitate secure data exchange, Engenuity joins the replica controller to the off-shore Manufacturing Zone network over a point-to-point VPN connection. Engenuity then grants customers read-only credentials to this private network. Engenuity houses multiple replica controllers in their offices, each of which connects to the outside through a separate, dedicated VPN appli-

With Engenuity’s BOPX testing software, users can map out valve arrays and identify validation pressure limits for each component in the system.
How Edge Computing Helps Deliver Reliable Automated Pressure Testing

“...It’s simple and as bulletproof as we could make it,” says Royer.

If a customer wants to distribute process data beyond a single site, Engenuity takes advantage of the embedded Ignition Edge platform on groov EPIC. Designed by Inductive Automation, the platform’s modular architecture allows Engenuity to install a range of components, including functions to send OPC tag data directly to cloud services like AWS, Azure, Google Cloud, or IBM Cloud. Once there, customers can access testing data around the world.

**Why edge control?**

For Engenuity’s customers, the cost of downtime may be $15,000-$20,000 per hour, so BOPX must execute quickly and reliably to deliver value. Engenuity decided to standardize on EPICs over traditional PLCs because the integrated automation lowered the cost of operation and maintenance while helping them deliver a more competitive solution.

Depending on an installation’s size and operations, Engenuity’s BOPX testing system can save 10-20 hours for each full test with a fully integrated system. With high uptime and automated testing, Engenuity’s customers can reduce on-site staff and have adapted more easily to remote operations.

“There are so many advantages to having a full control system that can tell you what’s wrong,” says Royer. “I’ll get a text [from...
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the control system] in the middle of the night, and I’m already logged in by the time [the customer] calls me. I can tell them exactly where the problem is, and usually, it’s something simple.”

Royer also points out that, with traditional PLCs, Engenuity’s solution would require ongoing support from IT; but with edge controllers, they are able to manage the entire solution themselves.

“[Users] don’t have space for racks of servers. These [IT rooms] are non-classified areas in the middle of hazardous areas. They are designed to be half full and [typically] they are overfull. So now you are going to replace that with stuff that can go outside in a NEMA 4 box...[Our EPIC’s] got nine servers on it and we haven’t even taken up one foot of space! If you want another one, it’s only another $1500.”

With edge control, Engenuity eliminates complex multiproduct integration requirements and delivers seamless operation and instant data access. Jeff Hilpert, president at Engenuity, adds, “The integration of data and control on a single backplane has been key to dramatically lowering cost, improving uptime, accessing data, and expanding utilization.”

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The world continues to move forward in its search for quality energy alternatives. As these sources of energy advance, companies are looking to gain a foothold in renewable energy generation, storage, and microgrid management. They seek advancement in technology that will not only provide for their specific needs, but also maintain a balance of cost effectiveness and competitiveness in the industry.

As a leader in global distribution of power products, CE+T America designs, manufactures, and markets a wide range of backup power systems for commercial and industrial customers with specific design requirements. They manufacture smart power converters used in data centers, backup power applications, renewable energy integration (photovoltaic and energy storage), microgrid, and electric vehicle charging infrastructures. CE+T America also offers monitoring and control solutions for all of its power converters. Headquartered in Belgium and established in 1936, they started operations in the United States some time ago, but only recently opened the CE+T Power facility in Austin, Texas, in 2019.

3-phase power management system
In early 2020, CE+T America was developing its Maestro Power Management System (PMS). This PMS would manage their Stabiliti power converters that paired with photovoltaic (PV) and energy storage, delivering considerable energy cost savings.
CONTINUED

Alternative Energy Power Management

3-phase system would target high-energy users where solar cannot, by itself, provide the necessary power due to peak demand, time-of-day or seasonal energy costs. CE+T America wanted to make sure all power flows were controlled in real time, prioritizing PV over battery use when possible, combining PV and battery when necessary to offset energy costs, as well as charging batteries from PV or grid to further optimize savings. CE+T’s Maestro PMS microgrids (off-grid systems) would also utilize this PV-first algorithm, minimizing battery use while the sun is shining and making load support the priority while also extending the life of the batteries.

To make this happen, CE+T America needed PLCs, main and uninterruptible power supplies, and Ethernet switches. “First, we were looking for an affordable, feature-rich programmable logic controller (PLC) to be used in control applications like the one required for this power management system,” said Govind Mittal, director of grid edge software for CE+T America. Overseeing development and being the product owner for the power management system, Mittal also wanted to make sure the products he would be using would come with high-end technical support in case he needed help troubleshooting any issues within the PMS.

After a lengthy online search, Mittal came across a few businesses that caught his eye. One of those was Wago, a Germany-based industrial automation company with its North American headquarters located in Wisconsin. Mittal placed a call to Jeff Wittorf, Wago’s regional sales manager, to find out what offerings Wago could provide.

“Govind told me about his immediate needs. That same day I provided some feature
options and had product samples sent to CE+T the following week,” Wittorf said.

Development support
Competing to provide CE+T America with the best that Wago could offer, Wittorf enlisted the help of colleagues such as Chris Dunlap, Wago’s North American energy industry manager. Dunlap was able to provide expert energy industry advice while comparing Wago’s value versus the competition. Kurt Braun, applications engineer and IIoT market specialist for Wago, provided technical resources, giving CE+T America visualization features as well as excellent examples with Modbus libraries to meet their requirements. He was also a great resource for any questions regarding Maestro’s application design to fit within the Wago system. Finally, David Bae, Wago applications engineer, provided a continuation of knowledgeable support—particularly when it came to utilizing Modbus communication through Wago’s e!Cockpit software, firmware updates, and web visualization. Wago also provided CT+E a PLC with a Linux operating system, allowing the company to program the PLC using IEC 61131-3 languages while also allowing for open-source coding within Docker containers.

“Pricing and feature set was the main driver, but what really made the difference was the exceptional sales and technical support,” Mittal said. “Without this, I would have gone a different direction.” Wittorf agrees with Mittal’s assessment of Wago’s support. “Our difference maker is our people,” he said. “Our sales and industry management teams genuinely care about helping our customers.” Turnaround was very quick and the Maestro Power Management System was finished and ready for use in June 2020. Today, Wago continues to support CE+T America customer inquiries regarding the system and is looking into deploying the program remotely, connecting it to Wago controllers. Wittorf says that he stays in constant contact with CE+T America to ensure its needs are being met both for today and tomorrow.

Mittal is excited for future endeavors, saying, “The Maestro is in action today and we are expecting many deployments to customers later this year. We are using and will continue to utilize Wago products in our power management systems.” For more information regarding CE+T America, please visit www.cet-power.com/en. To find out more about Wago, go to www.wago.us.
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A Deep Dive into Time-Sensitive Networking

Learn how Time-Sensitive Networking brings determinism to Ethernet—from time synchronization and prioritization to preemption and boundary ports.

By Michael Bowne, Executive Director, PI North America

Current industrial trends like Industry 4.0 and Industrial Internet of Things (IIoT) lead to more communication in ever-growing converged networks. Such networks require flexibility and scalability to support everything from small devices to machine and production line control devices as well as big data server systems. They also need to ensure bounded latency for time critical real-time communication. Time-Sensitive Networking (TSN) is defined by IEEE, the Ethernet standardization organization. It is intended to cover all these requirements to enable the simultaneous use of deterministic and non-deterministic communication in converged networks.

Before the features of TSN can be detailed, it should first be clarified that TSN is not a protocol. Instead, TSN is a generic term for a set of features collectively enabling standardized deterministic Ethernet. Without such features, standard Ethernet is not real-time capable. Note: the TSN features described below were chosen based on the IEC/IEEE 60802 Joint Profile for Industrial Automation.

**Time synchronization and prioritization**

Two long-established principles in Ethernet underpin TSN features: time synchronization and prioritization. First, TSN works best if the internal clock of each sender and receiver is synchronized to the other clocks on a network. Second, the data flowing through a network from a sender to a receiver is called a stream and is assigned a priority. IEC/IEEE 60802 specifies four priority classes. For our purposes, let’s simplify these to just three classes: high, low, and best-effort. If we
A Deep Dive into Time-Sensitive Networking

take vehicles on a roadway as an analogy, prioritization would be akin to the HOV lanes on a highway.

Apart from senders and receivers, the other key piece of hardware in any network is the Ethernet switch, or in TSN parlance, a bridge. The features of a bridge can also be explained using the analogy of roads and vehicles. Bridges are best thought of as traffic circles. Vehicles enter the rotary (bridge), traverse the circle as necessary, and exit at the appropriate roadway. Similarly, Ethernet frames arrive at a bridge and are directed to the correct port without congestion loss. This prevention of congestion loss at bridges is one of the critical pieces of TSN.

**Scheduling and time aware shaper**

Think of senders like a factory at the end of a shift. All the workers want to drive off at the exact same time. To avoid congestion loss (and maintain bounded latency) at the bridge, senders schedule the order in which they transmit their frames based on priority.

Once arriving at the bridge, prioritization alone is not the only method to determine which vehicles get to exit at their desired point. Internally, bridges can set up queues of similar priority frames. Algorithms would then determine the next frame per queue to be sent. This would imply the possibility that queues with lower priorities never get sent. Instead, priority queues are replaced by a repetitive cycle of time slots to ensure frames of all
A Deep Dive into Time-Sensitive Networking

Priorities can be sent. This is known as a time aware shaper (TAS) and is analogous to a city bus timetable. Every time slot starts with high-priority frames.

Next in line are low-priority frames. Finally, the remaining time in the slot is filled with best-effort frames that do not rely on time awareness. In this way, all priorities get transmitted while maintaining determinism for high-priority traffic.

Preemption

At the end of each time slot, the TAS creates a short time window called a guard band. Its purpose is to ensure that the transmission of best-effort frames do not spill over into, and therefore delay, high-priority frames in the next slot. Often, best-effort frames are relatively large. In this case, the guard band must be as large as the transmission time for the potentially largest frame.

The TAS is inefficient with its bandwidth in this way. Instead, time-aware bridges can calculate the transmission time of these large best-effort frames and then decide whether they can complete their transmission by the end of the slot or not. If not, these frames are split into fragments, transmitted separately, and recombined at the next bridge. This procedure is called preemption. It minimizes the size of the guard band, eliminates latency and congestion loss, and maximizes timeslot utilization (i.e., best-effort traffic throughput).
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**TSN boundaries**

In converged networks, it is likely that a TSN domain will be connected to non-TSN capable devices, or even another TSN domain. Ports on bridges connected to devices outside the TSN domain are known as boundary ports. To protect network resources inside the domain, boundary ports invoke a function known as the ingress rate limiter.

If we return to the vehicles on a roadway analogy, the ingress rate limiter works like a highway onramp traffic light. The light regulates the access of vehicles to the motorway based on the traffic density on the highway.

These TSN boundaries are smarter than your typical traffic light, however. They can individually assign priorities, effectively allowing vehicles to join the HOV lanes directly. In technical terms, this is the remapping of priorities and VLAN assignments.

**Network management engine**

If all of this sounds terribly complex, that's because it is! Even Ethernet today, if you were intimately aware of its inner workings, is quite complex. And yet, Ethernet is incredibly easy to use. The same applies to these complex TSN features. The software that enables and handles these mechanisms, according to IEC/IEEE 60802, is the TSN Domain Management Entity (TDME). Within Profinet, we call this the Network Management Engine (NME). The NME takes care of all calculations, planning, configuration, and resource allocation to make the administration of a TSN network easy—if not invisible to a user.

You may be asking yourself: Why do all of this? Don't some features like these already exist in certain industrial Ethernet protocols (e.g., Profinet)?

The answer is yes, but we're not in it for the features, we're in...
A Deep Dive into Time-Sensitive Networking

it for the benefits they yield. For example, because of IEEE standardization, a wide variety of hardware is available thanks to off-the-shelf TSN-capable Ethernet chips. This is beneficial to automation component vendors as it lowers costs and drives competition among technology providers.

For end-users, the benefits are clear: Converged networks based on TSN enable plug-and-produce manufacturing. New machine and network concepts are now made possible by this technology.

This illustration depicts the operation of the Network Management Engine, handling the configuration of a TSN network.
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How Cyber-Physical Systems Extend Mechatronic Capabilities

As exemplified by the Festo Motion Terminal, the use of cyber-physical systems is extending the capabilities of automated devices—even pneumatic ones—in preparation for Industry 4.0.

By Philipp Wahl, Product Marketing Manager, Festo

Smart cyber-physical systems (CPSs) are completely new and are set to increase production and make it much more flexible by enabling autonomous production with self-regulating systems. As such, they are also set to change traditional processes in the value chain by simplifying them—this is what we call digital simplicity.

An example of the kind of smart CPS I’m referring to is the Festo Motion Terminal, which is being used to future-proof new plants for machine and system builders as well as for operators. With its digital pneumatics, the Festo Motion Terminal combines maximum standardization with a very high level of flexibility. It is also enabling Festo to propel pneumatics into the age of Industry 4.0. The technology behind the Festo Motion Terminal unites the benefits of traditional pneumatics with those of controlled and complex electrical motion. Despite the simplicity, it integrates more functionalities than conventional technology.

Intelligent automation

The trend in automation towards networked, decentralized, and intelligent systems with optimum function integration is unstoppable because technical and economic requirements are constantly on the increase. The demand for additional features, such as the interpretation of environmental information, is also on the rise in the age of Industry 4.0. New communication opportunities, including the ability of components to communicate with each other, are opening up completely new areas of activity. This not only allows for more specific preventive maintenance, but also clears the way for autonomous production with self-regulating systems.
How Cyber–Physical Systems Extend Mechatronic Capabilities

Because automation needs to continually be ever faster and more diverse, as well as more flexible and more intelligent, greater availability and flexibility are required along with productivity, energy efficiency, and cost-effective just-in-time production down to batch size of one. However, this is where conventional mechatronic systems reach their limits.

Cyber–physical systems
Digitization will profoundly alter the world of production. For the first time, cyber–physical systems are enabling solutions that combine mechanical systems, electronics, and software. CPSs also prepare systems for Industry 4.0 applications, including pneumatics. Compared with modular mechatronic systems, CPSs offer an impressive combination of maximum standardization and a very high level of flexibility. Since the Festo Motion Terminal uncouples pneumatic functions from the mechanical hardware and makes them available via apps, a wide range of pneumatic motion tasks can be performed with just a single valve type. This offers many measurable benefits along the entire value chain.

The Festo Motion Terminal as a CPS solution enables complex movements like gentle retraction into the end position as well as various speed profiles or positioning tasks that were formerly only possible with servo-pneumatics or electrical automation. It also makes it easy to realize a wide range of functions such as condition monitoring and preventive maintenance while reducing energy consumption. Any higher purchase costs associated with CPSs are quickly compensated for by hugely simplified processes, increased productivity, and process reliability.
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