Driven by innovations developed for the Internet of Things and general computing, many industrial automation niches are experiencing signs of disruption. The question is: Is the industrial automation industry closer to a tipping point towards broad disruption when it comes to system architectures, software, and edge computing devices? This edition of my Automation & Controls Trends Report lays out what I see shaping automation and driving change into 2021. In it, I identify my Top 10 trends, and provide links to related articles.

This is my 5th annual trends report and the usual caveat applies: I will never truly know with certainly what the future will hold. Yet, I’ve spent many years talking to a wide range of users, suppliers and industry consultants, and attending many industry conferences and related events. As always, I invite everyone to share their own thoughts, criticisms, and perspectives during this exciting time for automation. I look forward to talking with you through LinkedIn or via email at wlydon@automation.com.
**Digitalization Driving Manufacturing to New Heights**

As we enter the new decade, innovative manufacturing and process companies worldwide are automating and digitizing with the aim to be more competitive. By leveraging disruptive innovations and technological developments, these manufacturers are positioning themselves to become industry leaders—creating new markets and increasing market share—while those who lag behind risk their own competitive positions. I have repeated many times the importance of learning from lessons of the past, since new transformative technology and methods need to be adopted by manufacturers to remain viable, competitive and profitable.

**External Technology Drives Industrial Change**

External technology developments, including open software, IoT, consumer electronics, and communications are combining with new architectural thinking. The accelerated rate of adoption and application of this combination have become a significant change agent for industrial automation.

Over the years, industrial automation industry advancements primarily have been driven by the application of new technology developed outside of the industry. That is still true today. Ethernet, PCs, Windows software, server virtualization, WiFi, Wireless Personal Area Network 802.15.4 (ISA100, WirelessHART, ZigBee), and cloud computing have all developed outside the automation industry and yet have had a profound impact in it.

Reliability, quality and availability of technologies need to be proven before they are adopted in mission-critical applications, such as in industrial controls and automation. In 2020-2021, new technology is advancing at a much higher rate and reliability is significantly higher, making many of these new solutions suitable for industrial automation applications. The application of new technology for consumer electronics (i.e. smartphones; personal fitness trackers), mobile (i.e. truck tracking; driver assist) and medical devices has demanded all of high quality, reliability, availability, and durability and this has been shortening the time that new technology has needed in order to become suitable for industrial control and automation applications.

“Management is doing things right; leadership is doing the right things.”

-Peter Drucker
Yet, the influx of new technology continues to create a tension between the status quo and change in the industry. In the past, for example, traditional automation suppliers initially fought against the use of Microsoft Windows and Ethernet networks but eventually adopted these technologies.

These technologies have enabled a rapid digitalization for many organizations in the manufacturing industry. Driven by a clear trend of integrating industrial automation into the entire business information and computer architecture, this integrated and digitized environment is enabling enhanced competitiveness. Technology is finally providing the means for manufacturing companies to achieve highly efficient, synchronized production as a holistic enterprise rather than a collection of functional silos and this is driving the integration of automation, IT, and OT. The accelerated digital revolution of manufacturing and process business has seen many organizational functions being digitized and integrated including:

- Accounting
- Supply chain
- Human resources
- Procurement
- Customer services
- Business intelligence
- Distribution management

Manufacturing and production companies are realizing digitalization requires structure, organizational changes, and integration of information technology (IT), operations technology (OT) and automation technology.

Related Articles

- Industry 4.0: Intelligent and flexible production
- Is IT/OT Convergence Becoming Misguided Thinking?
- Industry 4.0: Should you bet on it?
- Internet of Things - Industrial automation industry exploring and implementing IoT
- Epicor Strategy Empowers Digitalization for Small & Medium Manufacturers
- Is it time for a new automation architecture?
- IoT Impact on Industrial Automation
- The IoT Impact on Business Models: What Should Manufacturers Do First?
- Disruptive innovations
- Forces Driving Innovation in Industrial Automation
The impact of open manufacturing initiatives continues to be a worldwide affair. These initiatives continue to grow as industry recognizes the need to modernize and the Industry 4.0 movement (called “Industrie 4.0” in Germany, its country of origin) continues to accelerate. This has defined a pattern for all industrial automation organizations to use in order to achieve the goal of holistic and adaptive automation system architectures. Sustained competitiveness and flexibility to the dynamic technological growth, can only be accomplished by leveraging these advanced technologies, using automation as a center to enable a successful transition. As covered in previous reports, Germany’s Industrie 4.0 initiative ignited worldwide cooperative efforts in other countries, including China, Japan and India.

Inside the Asian Manufacturing Push
Asian economies have been very active in taking advantage of these new initiatives. This is a familiar pattern characterized by Japan’s post-World War II record period of economic growth in significant market share gains in several markets including automotive, television, and electronics. Each of the efforts in China, India and Japan mentioned here continue to gain in momentum. (Country Information comes from the World Economic Forum Report - Readiness for the Future of Production Report 2018.)

Made in China 2025. Released in 2015, Made in China 2025 is the government’s ten-year plan to update China’s manufacturing base by rapidly developing ten high-tech industries, with the goal of transforming China into a “manufacturing superpower.” Goals include developing electric cars and other new energy vehicles, next-generation information technology (IT), telecommunications, advanced robotics, artificial intelligence, agricultural technology, aerospace engineering, new synthetic materials, advanced electrical equipment, biomedicine, high-end rail, and high-tech maritime engineering. Chinese policymakers drew inspiration from the German government’s Industry 4.0 development plan. The overall goal is to reduce China’s dependence on foreign technology and promote Chinese high-tech manufacturers in the global marketplace. China 2025 has set specific targets: By 2025, China aims to achieve
70 percent self-sufficiency in high-tech industries, and by 2049—the hundredth anniversary of the People’s Republic of China—it seeks a dominant position in global markets.

**Make in India.** Make in India covers 25 sectors of the Indian economy and was launched by the Government of India in order to encourage companies to manufacture their products in India with dedicated investments into the country’s manufacturing industry. The ‘Make in India’ initiative has been providing support for both small and large companies to develop advanced manufacturing capabilities and invest in technology upgrades. There is also a focus on infrastructure modernization, as part of this effort, including smart cities. In addition to creating jobs, these initiatives are appealing to a new generation of workers with different values and skills.

**Japan Society 5.0.** Boldly identified as “Society 5.0,” Japan describes its initiative as a purposeful effort to create a new social contract and economic model, which fully incorporates the technological innovations of the fourth industrial revolution. It envisions embedding these innovations into every corner of its aging society. Underpinning this effort is a mandate for sustainability, bound tightly to the new United Nations global goals, the SDGs. Japan wants to create, in its own words, a “super-smart” society, and one that will serve as a road map for the rest of the world. With Society 5.0, the Japanese government and companies are working together to put developments in technology, especially in AI and automation, at the service of improving human society and evolving civilization as a whole.

**Related Articles**

- Can Manufacturers Compete When Trapped in Existing Automation Architectures?
- Expecting one-year ROI on automation systems is short sighted
- OPC UA: The United Nations of Automation
- PLCoopen and OPC Foundation release new edition of PLCopen OPC-UA Client for IEC 61131-3
- OPC UA REDEFINES Automation Architectures
- Powering Industry 4.0 & Industrial IoT
- Stimulus for New Automation Architecture
Continued Evolution for Process Automation

The Process Automation industry has been heavily impacted by the influx of new technologies and, as we enter the next decade, several organizations are providing roadmaps in order to help process automation companies enable the best practices to leverage these technologies and drive competitiveness and productivity forward.

INDUSTRY 4.0 FOR PROCESS – MODULAR PRODUCTION

One effort focusing on the application of Industry 4.0 concepts in order to improve process automation, is being driven by NAMUR, ZVEI, VDI, VDMA, and ProcessNet. The “Module Type Package” (MTP) is a key concept for standardized non-proprietary description of modules for process automation. The Process INDUSTRIE 4.0: The Age of Modular Production Overview white paper defines a common language for the nomenclature modules.

The structure of modular plants described is, in many ways, a recasting of ISA88 and ISA95 - with automation using plug-and-produce models that are vendor-independent descriptions of the information needed to integrate modules. For this, the data generated during the engineering of a module are provided by the module manufacturer, in an XML-file called a Module Type Package (MTP). The MTP includes many attributes including alarm management, safety & security, process control, HMI, and maintenance diagnostics.

This modular production initiative, started in addition to the Industry 4.0 for Process effort, addresses common complaints users have, where vendors deliver various pieces of equipment that do not directly and intelligently communicate with control, automation, asset management, and business systems.

The Industry 4.0 for Process effort describes smart-networked sensors as a foundational part of the Industry 4.0 process architecture. These sensors will communicate with controls, and automation systems and simultaneously and directly with business systems. This effort, the application of Industry 4.0 concepts to improve process automation, is being driven by NAMUR and VDI/VDE in collaboration with several prominent leaders in the industry, including:

The Industry 4.0 for Process effort describes smart-networked sensors as a foundational part of the Industry 4.0 process architecture.
ABB, BASF, Bayer Technology Services, Bilfinger Maintenance, Endress+Hauser, Evonik, Festo, Krohne, Lanxess, Siemens, and Fraunhofer ICT. The concepts are expressed in NAMUR's Process Sensor 4.0 Roadmap, which describes smart-networked sensors as a foundational part of the Industry 4.0 process architecture.

**RAMI 4.0 Reference Architectural Model**
The RAMI 4.0 Reference Architectural Model provides companies a framework for developing future products and business models. RAMI 4.0 is designed as a three-dimensional map showing these companies how to approach the deployment of Industry 4.0 in a structured manner. A major goal of RAMI 4.0 is to make sure that all participants involved in Industry 4.0 discussions and activities have a common framework with which to understand each other. The RAMI 4.0 framework is intended to enable standards to be identified to determine whether there is any need for additions and amendments. This model is complemented by the Industry 4.0 components. Both results are described in DIN SPEC 91345 (Reference Architecture Model Industrie 4.0). DIN represents German interests within the International Organization for Standardization (ISO). Today, roughly 85 percent of all national standard projects are European or international in origin.

Putting the RAMI 4.0 model in perspective, in the glossary of the VDI/VDE-GMA 7.21 Industrie 4.0 technical committee, a reference model is defined as a model that can be generally applied and can be used to derive specific models. There are many examples of this in the field of technology. The most well-known is the seven-layer ISO/OSI model, which is used as a reference model for network protocols. The advantage of using such models is a shared understanding of the function of every layer/element and the defined interfaces between the layers.

**The Open Group, the Open Process Automation Forum**
The Open Group's Open Process Automation Forum (OPAF), formally launched November of 2016, continues to advance since it published the first standard in a series. OPAF is focused on developing a multivendor standards-based, open, secure, and interoperable process control architecture. The Open Group has a track record of success in this area with the FACE standard. This standard has led to the deployment of higher function software designed to lower lifecycle cost. The defense avionics industry is one prime example of one who has transitioned from a proprietary solution to fully open systems architecture.
The industry of the last decade witnessed the beginnings of a massive shift towards digitalization strategies. Organizations looking to harness this momentum into the next decade need to know that efficient and effective digitalization is only possible with multivendor open solutions, which enable efficient and frictionless integration. The computer industry has been on this path for many years and it has been accelerated, by the Internet of Things and a wide range of open source standards. The competitiveness of a manufacturing or process company depends on staff understanding this shift and applying the right technologies to increase profits and efficiency.

Categorizing Manufacturing Success
Automated analysts and vendors frequently categorize manufacturing users, grouping them as innovators, early adopters, late majority and laggards for their adoption of new automation technology. Users today have become significantly more sophisticated, technologically, and with greater cooperation with IT people are starting to do the categorizing themselves. The critical question manufacturing and process company should be asking: Which automation vendors are innovators and early adopters and which are late majority and laggards?

This categorization should be an important consideration for those in industrial automation, because it determines if their automation systems will continue to be effective and, more importantly keep their manufacturing and production operations competitive. The computer industry has proven, many times over, that no single vendor can provide as strong a solution as an ecosystem of suppliers, empowered by open architectures. Traditional suppliers make an argument that they are the gatekeeper protecting you from unreliable solutions, but this is tricky business since it is self-serving. The middle ground has been to create gated third-party programs to “protect users”. I believe that incumbent automation suppliers’ major value is in their development of the key elements of systems for overall industrial production that are unique including application software, training, and solid customer service. If they cannot compete on those dimensions, they need to look for different business.
History has proven the impact of technology, and these advances and the related new architectures are changing the directions of today’s industry. The computer industry is the biggest proof. Their transition resulted in a significant larger selection of lower cost hardware and advanced software that didn’t require programming and increased the number of applications possible (think spreadsheets). This expanded the industry dramatically and manufacturers should not hesitate to follow their example.

Birth of the Digital Twin
One of the digitalization solutions that is already seeing use by some manufacturers is the Digital Twin. The continued growth and refinement of software has made it easier for manufacturing and production people to create digital twins with intuitive software and semantics, self-describing edge sensors, devices, and controllers. By doing so the Digital Twin has become one of the most powerful concepts of today’s Industry 4.0, as it couples virtual plant and process models with physical operations for greater productivity and efficiency, as well as training opportunities. Digital Twins provide a virtual model of the ideal manufacturing operations and processes that are benchmarking actual production metrics in real time. The broadest implementations include all the factors that affect efficiency and profitability of production: machines, processes, labor, incoming material quality, order flow, and economic factors. Implementing Digital Twin concepts is quickly becoming fundamental for organizations achieve real-time integrated manufacturing.

Related Articles

The Digital Twin – Enabling Realtime Closed Loop Manufacturing Optimization

Digitalization – What is an automation professional’s role?

Manufacturing automation—a vital competitive weapon

Disruptive Technologies Make or Break Your Business

Can Manufacturers Compete When Trapped in Existing Automation Architectures?

Automation Controllers & Word Processors – Embrace the Technological Shift or Die

Inside Dell’s Ongoing Quest for Digitalization Acceleration

DelSAP Leonardo Enterprise Wide IT/OT Integration
Amongst the many new technologies that are impacting the manufacturing industry today, I am convinced that collaborative robots are the highest impact automation development, which can improve manufacturing and which are particularly effective for small and medium manufacturing enterprises. Accelerating the application of collaborative type of robots is the integration of vision systems with artificial intelligence, and this integration is enabling a range of new applications.

Collaborative robots are a new breed of lightweight and inexpensive robots, with safety features which enable people to work cooperatively with these devices in a production environment. Collaborative robots can sense humans and other obstacles and respond by automatically stopping so that they cause no harm or destruction. With these robots, protective fences and cages are not required and therefore they can many times be enabled flexibility and lower implementation costs. These robots are particularly attractive investments for small to medium sized companies, as the typical cost is less than $40,000 and their simplified programming means they can be deployed without hiring specialized engineers.

This breed of robots is following a similar pattern that ignited the personal computer revolution - providing a product with less power than larger offerings, but with added value for a broader number of users. The rate of robot adoption is accelerating throughout the world, particularly in China, which has become the largest purchaser of robots in the world.

The International Federation of Robotics report, World Robotics 2019 Industrial Robots, noted that in 2018, global robot installations increased by 6% to 422,271 units, the operational stock of robots was computed at 2,439,543 units (+15%).
Computing processes are continuing to be more integrated with each other and with the Cloud as we enter the next decade. Enterprise systems have been continuing to absorb plant floor computing, through efforts to achieve real Time synchronization and accelerate the continued integration of Information Technology (IT) and Operational Technology (OT) groups. This trend has been facilitating changes in organizational structures, and the creation, in many cases, of integrated IT/OT groups.

Business systems can now process real-time transaction to be more responsive in all functions, including Manufacturing Execution Systems (MES) functions. This is being driven by lean manufacturing efforts, which work to optimize entire process including supply chain, production, delivery, genealogy, and customer service. Enterprise systems (ERP, etc.) have become real-time transaction processing and are driving down to the edge, which is resulting in the displacement of traditional HMI and other middleware.

Innovative industrial automation vendors are already providing automation controllers designed to leverage the business network, and directly communicate with enterprise business systems. This communication uses Web services and other IoT transport mechanisms to facilitate the integration and synchronization of the entire manufacturing enterprise including machine and process sensor inputs and outputs. There are notable industry standards being leveraged to accomplish this including: OPC UA, MQTT, AMQP, and B2MML.

Controllers Give Way to Edge Computers
These advances in computing are fundamentally transforming plant control processes. Reliable edge embedded computer hardware platforms are starting to be deployed as automation, PLC, and process controllers that can host a wide range of other applications including analytics, predictive maintenance, machine & process historian, information servers, and other computing functions. Since these are mainstream computing platforms, it has been easier to leverage knowledge and technologies—including open source—from the general computing and IoT industry.
This transfer has been accelerating digitalization, enabling multivendor interoperability at all levels of the system architecture. Further, it has simplified integration, expanding the number of options available for applications, and making applications portable without engineering labor across vendor platforms. The growing number of general IoT applications are spawning continuous introduction of more of these devices.

These devices may well disrupt existing PLC and DCS controllers with their high-performance processing and low cost. The new platforms are coming from a range of suppliers including Dell, Advantech, Beckhoff, B&R, NEXCOM, OPTO 22, Hilscher, Harting and Logic Supply. Traditional industrial automation field controllers have typically remained closed proprietary computers, analogous to the long obsolete computer mainframe and minicomputer era. The impact and integration of the powerful new platforms are fundamental to enabling the digitalization of manufacturing systems in order to be competitive.

Embedded computer hardware platforms are displacing PLC and process controllers and will continue to deliver greater functionality.

**Even the Sensors are Edge Computing Devices**
The manufacturing industry is starting to see a growing trend that sensors are starting are becoming edge computing devices, as well. Incorporating embedded computing technologies and leveraging powerful Systems on a Chip (SoC) embedded processors and communications, these sensors can now incorporate control, analytics, industrial networking, and direct communication with enterprise & cloud systems. There are growing number of communication options including IO-Link, Advanced Physical Layer (APL), Single Pair Ethernet (SPE), and wireless including 802.15.4, Wi-Fi, and Bluetooth. A major goal is to achieve plug-and-play automatic configuration to lower installed cost including application engineering, installation, and asset management.

**Related Articles**

- Industry 4.0 for Process Automation – Process Sensors 4.0 Roadmap
- Article IoT Bridging Edge to Cloud Improves Manufacturing – Petasense & OSIsoft attached
- Automation Fair 2018 - Rockwell Automation & PTC Partner for Industrial Digitization Journey
- The New Era of Automation Architectures: What does it mean for users?
- Digital Factory Comes into Focus at Hannover Messe 2018
- SAP Leonardo Enterprise Wide IT/OT Integration
- Stimulus for New Automation Architecture
- EdgeX Foundry IoT, IIoT, and Industry 4.0 unifying architecture
- Open Process Control Architecture Standard’ is the Rallying Cry at ExxonMobil’s Industry Day
- OPC UA REDEFINES AUTOMATION ARCHITECTURES
- How Industry 4.0 and Digitization Improves Manufacturing Responsiveness, Quality and Efficiency
- Bill’s Deep Dive – Opto 22 EPIC System Programmable Edge Controller
- Embedded IEC 61131 is Enabling Industry 4.0 & Industrial Internet of Things
- Hannover Fair 2017 – Integrated Industry Empowers World Competition
- Is your next automation controller an Ethernet switch?
- Is it time for a new automation architecture?
Behind all the integration and application of these technological advancements are the networks that connect them all together. Both wired and wireless networks have been undergoing a significant evolution during the past decade, enabling greater opportunities to those who leverage the advancements in the next one.

The Ethernet Evolution
Ethernet, both wired and wireless, has become the workhorse network of choice throughout manufacturing and production. Ethernet has been used for all forms of communications including data, audio, video, and industrial control networks leveraging shared infrastructure. Speed and performance continue to increase with Gigabit Ethernet (GbE or 1 GigE) and accelerated use of fiber optic networks. With the increase in power, there have naturally been some interesting developments.

Advanced Physical Layer (APL)
The Advanced Physical Layer is based on IEEE 802.3. The IEEE P802.3cg 10 Mb/s Single Pair Ethernet Task Force Working Group is focused on using a single pair cable operating at 10 Mb/s with power delivery. This is envisioned to conform to requirements for use in hazardous locations up to Zone 0, Division 1.2.1 5G Wireless. The focus is on a replacement for legacy point-to-point & point-to-multipoint, which includes 4-20 mA, HART modem, RS-232, RS-485, CAN (Controller Area Network, and FlexRay.

Key characteristics of the APL include short reach and up to 1 km distance, on a single pair of wiring, that can survive fault conditions and harsh automotive and industrial environments. There is work being done to define the requirements and develop the necessary technology meet requirements for use in hazardous locations up to Zone 0, Division 1.2.1 5G.

The FieldComm Group, ODVA and PI (Profibus & Profinet International) are working together to promote developments for Industrial Ethernet to expand use
of EtherNet/IP™, HART-IP™ and PROFINET™ into hazardous locations in the process industry leveraging the work currently underway in the IEEE 802.3cg Task Force.

There is a great deal of discussion and (in some quarters) excitement about the prospect of Time-Sensitive Networking (TSN), that some believe will become the single unifying deterministic network shared by all applications throughout the computer industry. Since TSN is a totally-managed shared network architecture, all network traffic - including all industrial protocols in the plant - would need to conform and be compliant with the TSN set of standards; in order to achieve deterministic and reliable communications. Based on interviews and discussions I’ve had with people involved in the IEEE committees, they report the entire standard will be completed in a few years.

Creating a practical multi-vendor TSN architecture has challenges and adds new layers of complexity for industrial ethernet networking. Network timing has been tightly coupled to network configuration and management. One network like this, in my experience, was the Allen-Bradley and The ControlNet network. This was a tightly timed scheduled and managed network dedicated to industrial control and monitoring, with those tight-scheduled communications yielding high determinism. While complex, the scope of the issue was dedicated to industrial automation applications, with one set of software and controllers from a single vendor, Allen-Bradley. In contrast, TSN is seen as a common multivendor shared network for multimode communication for general computing, VOIP, professional audio, video, file transfer, industrial automation, building automation, and any other data communication.

In order to take advantage of TSN time scheduling, it would seem that control programming software and controller firmware will have to be redesigned to accommodate the definition of I/O point and variable timing specifications.

Since the goal is to support multiple industrial network protocols along with data multimedia applications this will require an industry-wide shared network manager and API standard to which all vendors need to conform. Yet, when asking multiple people about standardization in this area, it is clear that there is no open defined standard and certainly no identified certification group on the horizon.
Before the entire standard is completed in a few years, there are likely to be offerings by industrial automation suppliers, but I suggest buyers beware it’s those solutions could become “white elephants”.

The Rise of 5G Wireless and What it Means for Industrial Automation

Wireless networks, in particular, are advancing in ways which are driving many possibilities for industrial automation. The idea of wireless industrial automation has long been an elusive goal on the wish list of many users. But it might not be as elusive soon, as 5G is starting to make this goal a reality. Companies are already starting to deploy private 5G networks within plants and are seeing increases in performance, determinism, low latency, and reliability. One example of this was a demonstration at the 2018 Hannover Messe, where Beckhoff and Huawei demonstrated high-speed and deterministic coordinated motion over 5G wireless communications. With the power of 5G, it will likely not be the last example.

5G is the fifth generation of cellular mobile communications, targeted to succeed the 4G (LTE/WiMax), 3G (UMTS) and 2G (GSM) systems. 5G performance targets high data rate, reduced latency, energy saving, cost reduction, higher system capacity, and massive device connectivity. The International Telecommunication Union (ITU) IMT-2020 specification demands speeds up to 20 gigabits per second. The first phase of 5G specifications in Release-15 will be completed by March 2019 to accommodate the early commercial deployment. The second phase in Release-16 is due to be completed by March 2020 for submission to the International Telecommunication Union (ITU) as a candidate of IMT-2020 technology.

There are three major benefits of 5G networks, according to IEEE:

• High Data Rates (1-20 Gbit/s)
• Low Latency (1 ms)
• Larger Network Capacity & Scalability

Another example of use is Daimler’s Mercedes-Benz Cars division’s effort towards establishment of a local 5G network to support automobile production processes at its “Factory 56” in Sindelfingen Germany. SNS Telecom & IT estimates that as much as 30% of investments approximately $2.5 Billion will be directed towards the build-out of private 5G networks, which will become preferred wireless connectivity medium to support ongoing Industry 4.0 revolution for the automation and digitization of factories, warehouses, ports and other industrial premises, in addition to serving other applications.

Corning and Verizon have installed 5G Ultra-Wideband service in Corning’s fiber optic cable manufacturing facility in
Hickory, NC. Corning will use Verizon’s 5G technology to test how 5G can enhance functions, such as factory automation and quality assurance, in one of the largest fiber optic cable manufacturing facilities in the world. The companies are also working together to co-innovate 5G-enabled solutions that can potentially revolutionize the way goods and services are produced. 5G’s low latency, fast speeds and high bandwidth can improve the manufacturing process, enhancing capabilities like machine learning, augmented reality and virtual reality (AR/VR). Engineers from Verizon and Corning will explore how the factory of the future can use 5G to speed data collection, allow machines to communicate with each other in near real time, and wirelessly track and inspect inventory using 5G-connected cameras. They’ll also test how 5G can improve the function of autonomous guided vehicles (AGVs) by helping them move more efficiently around the factory floor.

Supporting the Growth of 5G
There are many who are working to support the growth of 5G wireless in industrial organizations. The 5G Alliance for Connected Industries and Automation (5G-ACIA) serves as the central and global forum for addressing, discussing, and evaluating relevant technical, regulatory, and business aspects with respect to 5G for the industrial domain. The 5G Alliance notes that one of the main differences between 5G and previous generations of cellular networks lies in 5G’s strong focus on machine-type communication and the Internet of Things (IoT). The capabilities of 5G thus extend far beyond mobile broadband with ever increasing data rates. In particular, 5G supports communication with reliability and very low latencies, while also facilitating massive IoT connectivity. The organization comments that manufacturing, in particular, may see 5G having a disruptive impact as related building blocks, such as wireless connectivity, edge computing or network slicing, find their way into future smart factories. The organization has published the 5G-ACIA White Paper, 5G for Connected Industries and Automation providing an overview of 5G’s basic potential for connected industries, in particular the manufacturing and process industries, and outline relevant use cases, requirements, and other information.

Related Articles
Inside the Rise of 5G Industrial Automation Networking
Digital Factory Comes into Focus at Hannover Messe 2018
Industrial 5G: The future is now
TSN (Time Sensitive Networking): Lack of timing mechanism remains an elephant in the room
802.3CG OVERVIEW 10 MB/S SINGLE PAIR ETHERNET
There is an increasing recognition that an integrated cybersecurity approach is required for an entire manufacturing and production company. Many manufacturing companies are realizing with the integration of IT, OT, automation and other functions that designating one leader responsible for all cybersecurity for the company is most effective. This leadership is empowered to deploy a holistic cybersecurity strategy for the entire manufacturing or production enterprise including supply chain and customers. This is accomplished by orchestrating coordinated activities of a number of functional areas in a company, including IT, OT, and automation. The Chief Information Security Officer (CISO) is most likely to take on this responsibility, recognizing that cybersecurity in IT is significantly more mature than in OT, and someone with IT security experience understands how to methodically build the cybersecurity program across the organization using a risk-based approach.

**Embedded Cybersecurity at the Edge**

Though edge computers are delivering greater opportunities for production and efficiency, they are also enabling greater vulnerabilities to outside influences. The software industry has been trending towards using cyber security practices and solutions to provide protection at the fundamental root entry points for intruders, utilizing powerful Systems on a Chip (SoC) embedded in edge devices. As these devices now include industrial controllers, process controllers, smart instrumentation, and other devices, the cybersecurity attack surface continues to grow larger. Internet of Things (IoT) applications, including consumer, municipal, industrial, connected vehicles, connected health, smart farming, and smart supply chain also put themselves at risk of intrusion.

In problem solving, it is always important to identify root causes and any entry point into a system is a root level cause. Systems on a Chip (SoC) and other highly integrated solutions are driving control, monitoring and analytics to the edge providing functions that in the past were done in a PLC or DCS controller. The introduction of Cyber Secure Systems on a Chip (SoC) is an architectural improvement designed to address the broad scope of cybersecurity challenges. The key building blocks include cybersecurity functions and features embedded...
in Systems on a Chip (SoC) incorporating microprocessors, communications, cyber encryption, cloud security services, secure update services, and other functions.

**Joining Together to Meet Cyber Threats**

These efforts are in the early stages of development by vendors and standards groups without common standards at this point. These efforts are leaving users with a simple question: Should we hold off on new purchases of industrial controllers, process controllers, smart instrumentation, and other devices until these new secure SoC and methods are integrated into those devices?

The goal is to incorporate this new breed of cyber security processors in IoT devices to implement more cybersecure systems including industrial and process automation components including PLCs, controllers, sensors, actuators, motor controls, and other intelligent devices.

Because the cybersecurity of Level 0,1 devices is not being addressed elsewhere, the ISA99, Industrial Automation and Control Systems Security committee has established a new task group to identify if Level 0,1 devices are adequately addressed in the existing IEC 62443 series of standards, particularly IEC 62443-4-2.

Some of the more prominent cybersecurity initiatives include these four:

**Microsoft Azure Sphere**

Microsoft is making an unexpected push into the chip business. Announcing “Azure Sphere,” Microsoft has combined chip design, a cloud security service, and a Linux kernel with the goal of better securing billions of IoT devices around the world. In 2016, Microsoft announced that it had co-designed a FPGA (Field Programmable Gate Array), in order to enhance the intelligence of its cloud servers. This was the first instance of a Microsoft designed chip. Expanding on this genesis, Microsoft’s representatives at the 2018 Hannover Messe described how the Azure Sphere includes a microcontroller (MCU) design which the company is licensing, royalty-free. Other features include:

- The Microsoft hardware security module Pluton Security Subsystem creates a hardware root of trust, stores private keys, and executes complex cryptographic operations to create secure devices.
- A new crossover MCU combines the a Cortex-A processor with the Cortex-M class processor.
- Built-in network connectivity provides secured, online experiences and ensures devices are up to date.

The first Azure Sphere chip is the MediaTek MT3620 which incorporates Arm Cortex-A7, which Microsoft shared as the result of years of close collaboration and testing between MediaTek and Microsoft. Other early partners include ARM, who worked closely for the integration of Cortex-A application processors into Azure Sphere MCUs.

In October of 2019, Qualcomm Technologies announced at its 5G Summit in Barcelona, Spain that it is developing the first cellular chip optimized and certified for Microsoft’s Azure Sphere Internet of Things (IoT) operating system. Qualcomm Technologies’ new Azure Sphere-certified chipset for IoT will include hardware-level security, come preconfigured with the Azure Sphere, and will automatically connect to Azure Sphere security cloud services.

**Google CLOUD IoT CORE**

The Google CLOUD IoT CORE is a system designed for the management of connected IoT devices, like sensors, with Google’s cloud. The platform also serves as a pipeline for securely getting data to and from those devices. This effort has been enhanced through Google’s Partner ecosystem, which offer devices and kits that work with the Cloud IoT Core. These partners include: Allwinner Technology, Arm, Intel, Marvell, Microchip, Mongoose OS, NXP, Realtek, Sierra Wireless, and SOTEC. Microchip, specifically, provided a prime example of a Google chip partner delivering Trusted and Secure Authentication with the ATECC608A chip.
Amazon FreeRTOS
Amazon is promoting the Amazon FreeRTOS, an IoT operating system for microcontrollers that are qualified through The Amazon FreeRTOS Qualification Program (Amazon FQP). Amazon FreeRTOS is open source and it extends the FreeRTOS kernel, a real-time operating system for microcontrollers. The Amazon FQP outlines a set of security, functionality and performance requirements that all microcontrollers (along with the associated hardware abstraction layers and drivers) must meet. Open sourced and based on the FreeRTOS kernel, a real-time operating system for microcontrollers, Amazon FreeRTOS has a large ecosystem of existing tools developed for the system. Amazon FreeRTOS includes software libraries designed to help users program commonly needed IoT capabilities into devices, such as the configuration of devices to a local network using common connectivity options like Wi-Fi or Ethernet. Amazon FreeRTOS also includes an over-the-air (OTA) update feature to remotely update devices with feature enhancements or security patches. In order to secure this operating system, the Amazon FreeRTOS comes with libraries to help secure device data and connections, including support for data encryption, key management, and Transport Layer Security (TLS v1.2) which helps devices connect securely to the cloud. Partners today that fully supports Amazon FreeRTOS features and capabilities include Espressif, Microchip, NXP Semiconductors, and STMicroelectronics.

Arm PLATFORM SECURITY ARCHITECTURE (PSA)
ARM has a PLATFORM SECURITY ARCHITECTURE (PSA) that includes Mbed’s Arm TrustZone technology is a System on Chip (SoC) and CPU system-wide approach to security. TrustZone is hardware-based security built into SoCs by semiconductor chip designers who want to provide secure end points and a device root of trust. The family of TrustZone technologies can be integrated into any Arm Cortex-A and the latest Cortex-M23 and Cortex-M33 based systems. The Arm Mbed IoT Device Platform is made up of two sets of products: device software and cloud-based device management services. These products are designed to securely move data from sensor to server. The Arm Mbed IoT Device Platform is a fully integrated device management solution. It provides the operating system, gateway, device management services, and partner ecosystem to speed adoption and deployment of IoT solutions. Further, the Arm Mbed IoT Platform provides connectivity and communication for constrained devices. Partner companies have enabled 6LoWPAN, Bluetooth Low Energy, Thread, LoRa, WiFi, NFC, RFID, Mobile IoT (LPWA), cellular and Ethernet on Mbed. The Mbed IoT platform secures the device itself from untrusted or malicious code, the communications between device and cloud, and the lifecycle of the system itself using uVisor, Mbed TLS, and Mbed Client respectively.

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The enhanced technologies and software offerings are opening up new options for industrial automation as well. Open system options continue to emerge from nontraditional suppliers and standards groups, and this is a trend that I expect will accelerate and enable multivendor interoperability at all levels of the system architecture. Further, this will simplify integration, expand the number of options available for applications, and make applications portable – without engineering labor – across vendor platforms. In contrast, there are still far too many incumbent industrial automation suppliers today with highly gated automation partner programs. Selected based on protective commercial criteria, these third-party partners are technically and legally enabled to work with the vendor’s unique, tightly-bound, closed architectures. Suffice it to say, there are significantly fewer obstacles in open ecosystems.

There are some intriguing Industry 4.0/Smart Manufacturing open source edge platforms emerging, which are leveraging knowledge and technologies from the general computing and IoT industry. In addition to the efforts coming out of specific countries mentioned in trend #2, several multinational organizations and corporations have been driving manufacturing open architecture initiatives. Some of the more prominent examples going into 2021 include the following.

**MTConnect**

The [MTConnect](https://www.mtconnect.org) standard (ANSI/MTC1.4-2018) offers a semantic vocabulary for manufacturing equipment to provide structured, contextualized data with no proprietary format. The MTConnect Institute is a 501(c)(6) not-for-profit standards development organization for the MTConnect standard (ANSI/MTC1.4-20). Its membership is made up of over 400 companies and research organizations in discrete manufacturing including automotive, aerospace, medical, and other industries as well as software developers, system integrators, and research organizations supporting those industries. Membership is free and open to anyone with a stake in MTConnect.
OPC Foundation
The OPC Foundation continues to add OPC UA semantic models and schema from industry organizations to further the global standard for interoperability. OPC UA is becoming an important machine to machine and IT/OT integration mechanism. OPC UA is a framework for industrial interoperability based on data models that provide a syntactical definition of information that can be communicated with virtually any communication methods, including modern industrial protocols, Ethernet, cellular, and wireless. Device and machine manufacturers describe the object-oriented information of their system and also define the access rights with integrated information technology (IT) security.

Eclipse Foundation
The Eclipse Foundation’s open standards for Industry 4.0 are designed to allow for solutions that are interoperable, modular and vendor independent. The following relevant standards are supported through different open source projects:

- OPC UA - Eclipse Milo is a full implementation of OPC UA.
- MQTT - Eclipse Paho and Eclipse Mosquitto provide a client and broker implementation of the MQTT messaging protocol.
- Production Performance Management Protocol (PPMP) is a payload specification to capture data that is required to do performance analysis of production facilities.
- oneM2M – oneM2M is a service layer standard that defines common service functions that can be shared by applications, gateways, and devices. oneM2M includes defined interworking with standards such as OSGi, DDS, OPC UA, and Modbus so that industrial data can be aggregated and exposed to applications uniformly.
- Eclipse 4diac provides the development tools and the runtime to create control systems for PLCs that is based on IEC 61499. 4diac also integrates OPC UA and MQTT into PLC to ease PLC connectivity.
- IoT Gateway Eclipse Kura provides a portable Java/OSGi edge computing framework for building IoT Gateways that can be deployed into Industry 4.0 solutions. Kura supports a wide variety of fieldbus protocols including OPC UA, Siemens S7, and Modbus. Eclipse Kura also features a modular and visual data flow programming tool called Wires. Wires allows to define data collection and processing pipelines at the edge by simply selecting components from a palette and wiring them together.
- Digital Twin Eclipse Ditto is a framework to create and manage digital twins. Ditto exposes a unified resource-based API that can be used to interact with devices, abstracting from the complexity of different device types and how they are connected. It helps to structure the devices into their distinct aspects of functionality and can optionally enforce data types and data validation based on a formal device meta model, based on Eclipse Vorto.
**EdgeX Foundry**
The Linux Foundation’s EdgeX Foundry is a vendor-neutral, open source project providing a common open framework for Internet of Things (IoT) edge computing and an ecosystem of interoperable components that unifies the marketplace and accelerates enterprise and Industrial IoT. The project is aligned around a common goal: the simplification and standardization of Industrial IoT edge computing, while still allowing the ecosystem to add significant value. EdgeX Foundry leverages cloud-native principles, including microservices and platform-independence, but is architected to meet specific needs of the IoT edge. This includes accommodating both IP- and non-IP based connectivity protocols, security and system management for widely distributed compute nodes, and scaling down to highly-constrained devices.

EdgeX Foundry has gone through rapid refinement as illustrated by the reduction of computer resource requirements from the initial 2.5 GB to 128 MB memory requirement suitable for embedding in sensors and control devices.

**Related Articles**

- [EdgeX Foundry and the Quest for Multivendor Interoperability](#)
- [What is open source & why you should care?](#)
- [EdgeX Foundry IoT, IIoT, and Industry 4.0 unifying architecture](#)
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Era of Empowerment for Automation Professionals

All of these new technologies from outside the traditional automation solutions, as well as the rapid expansion of the tools that can be applied to improve productivity, profitability, and competitiveness of manufacturers, means that the automation professional is going to be more important than ever in the next decade. Manufacturing companies should expect to see significant changes, which will be heavily driven by technology. Automation professionals are critical to successfully selecting and applying these technologies and guiding management to maximize their productivity. This role will continue and expand, as more companies look to make informed productive technological investments and implementation decisions to yield profitable results. The alternative is management making uninformed decisions, and that could be costly in a big way.

Control and Operations Will Get Easier
Software programming gurus have always been an inefficient way for users to create applications and get results. Hence why there will be more applications, that allow control and operations people to configure systems and deploy applications without using a programming language, which will be introduced. This is new to the industry, but hardly new to the world. Decades ago, the spreadsheet was the first big development that allowed users to directly create analysis and applications without requiring a programmer and resulted in dramatically improved productivity. More recently, Facebook has been a great example of people creating webpages without ever programming. More relevantly, PLC Ladder Logic was a significant productivity tool, which allowed people to directly create applications without computer programming. In manufacturing industries, there will be an acceleration of these kinds of easy-use software to create applications without programming, as they leverage IoT and other computer industry developments. At the forefront of these changes will be the integration of real time industrial automation & control, PLM, CAD, and simulation enabling visual design, virtual commissioning, and direct deployment without procedural programming.
The Users are Gaining the Power
There is growing understanding in the user community that industrial automation systems technology is lagging, which is limiting the ability to deliver functionality and value, compared to the computer industry, IoT, and consumer products. Exposure to a wide range of computer and consumer technologies has been driving the exploration of alternative solutions.

The influx of open standards-based hardware and software is shifting implementation of industrial automation system functions to users. A simple example is the application of virtualization in the factory, in order to lower total cost of ownership and improve performance. Users were ahead of industrial automation vendors in deploying this innovation in their operations and in some cases, vendors threatened to void their system warranties. Later, automation vendors embraced virtualization. A more pointed example is the use of Amazon Web Services (AWS) for plant historians.

Very important for the industry, we will see increasing numbers of younger people entering the industry. We have already seen the growth of an interesting and productive phenomenon. The collaboration of experienced industrial automation veterans, with younger professionals that understand the open IoT and computing industry technologies, have led to the creation of highly effective solutions.