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Industrial Ethernet Automation Networking & IIoT

Special Report

OPC UA Solutions Update

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GET CONNECTED…

AI to next level in manufacturing

The potential impact of Artificial intelligence in manufacturing has become a hot topic and the focus of this issue of the Industrial Ethernet Book.

Research conducted by *MIT Technology Review Insights* found ambitions for AI development has been stronger in manufacturing than in most other sectors.

In the report *Taking AI to the next level in manufacturing*, they stated that "manufacturers rightly view AI as integral to the creation of the hyper-automated intelligent factory. They see AI's utility in enhancing product and process innovation, reducing cycle time, wringing ever more efficiency from operations and assets, improving maintenance, and strengthening security, while reducing carbon emissions. Some manufacturers that have invested to develop AI capabilities are still striving to achieve their objectives."

"Few technological advances have generated as much excitement as AI. In particular, generative AI seems to have taken business discourse to a fever pitch. Many manufacturing leaders express optimism: Research conducted by MIT Technology Review Insights found ambitions for AI development to be stronger in manufacturing than in most other sectors," the report stated.

The following are the study's key findings:

• Talent, skills, and data are the main constraints on AI scaling. In both engineering and design and factory operations, manufacturers cite a deficit of talent and skills as their toughest challenge in scaling AI use cases.

• The biggest players do the most spending, and have the highest expectations. In engineering and design, 58% of executives expect their organizations to increase AI spending by more than 10% during the next two years.

• Scaling can stall without the right data foundations. Respondents are clear that AI use-case development is hampered by inadequate data quality (57%), weak data integration (54%), and weak governance (47%).

• Fragmentation must be addressed for AI to scale. Most manufacturers find some modernization of data architecture, infrastructure, and processes is needed to support AI, along with other technology and business priorities.

Check out the full report on the web. ***Click here to download the report >***

Also check out our coverage of AI in manufacturing starting on page 6.

Al Presher

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Industrial Ethernet Book

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OPC UA certification program and digital product passports

OPC Foundation announced at the end of 2024 two key developments: a certification program for OPC UA FX controllers and combining forces to support the upcoming Digital Product Passports (DPP).

SOURCE: ISTOCKPHOTO

Certification Program for OPC UA FX Controllers

OPC UA Compliance Test Tool (UACTT) verifies Compliance of OPC UA FX controllers for Controller-to-Controller (C2C) communication

The OPC Foundation, a global organization dedicated to building industrial interoperability to exchange standardized information from the sensor to the cloud, announced the addition of OPC UA FX (Field eXchange) capabilities to its certification program. This marks a significant milestone in supporting manufacturers, system integrators, and end-users in deploying fully interoperable and standardized automation systems for Controller-to-Controller (C2C) communication that enhance connectivity, streamline processes, and reduce the cost of integration.

With this the OPC UA Certification Program provides a formal testing and certification process for controllers that implement the OPC UA FX specification series (OPC 10000-80, OPC 10000-81, OPC 10000-82, OPC 10000-83 and OPC 10000-84). The program is based on the OPC UA Compliance Test Tool (UACTT) that has been extended to include now more than 350 test scripts for testing the OPC UA FX functionality in addition to the existing test capabilities for OPC UA and for the Companion Specifications.

Through this validation program, participating vendors can certify their controllers as compliant with the OPC UA FX standards, providing confidence to end-users that their devices will operate seamlessly with other OPC UA FX-compliant systems. The validation process includes rigorous testing procedures to ensure that controllers meet the OPC Foundation's strict requirements for performance, reliability, and interoperability.

Alexander Allmendinger, Test Lab Manager of the European Certification Test Lab, explained "Vendors using the UACTT during their development process can confidently prepare their OPC UA FX controllers for certification by the OPC Foundation's test laboratories. After that, they can bring their products to market, ensuring smooth integration and high customer satisfaction regarding interoperability."

Stefan Hoppe, President and CEO of the OPC Foundation, emphasized the importance of this important milestone: "Adding OPC UA FX Controller testing to our Certification Program is a landmark development for the OPC Foundation and the industry as a whole. By certifying controllers that meet the OPC UA FX standards, we are setting a new benchmark for interoperability and enabling a more connected, integrated, and efficient automation landscape for horizontal communication on the shopfloor. This program is a testament to our commitment to open standards that empower end-users and strengthen the global industrial automation ecosystem."

Joint forces for Digital Product Passport (DPP)

Major standardization associations and initiatives partner to create the best of breed system architecture to support the upcoming Digital Product Passport (DPP) by combining the best aspects of the Asset Administration Shell and OPC UA.

The Clean Energy and Smart Manufacturing Innovation Institute (CESMII), the Labs Network Industrie 4.0 (LNI 4.0), the Digital Twin Consortium, the ECLASS e.V., the Industrial Digital Twin Association (IDTA), the OPC Foundation (OPCF), the VDMA and the ZVEI have joined forces to create a best of breed system architecture to support the upcoming Digital Product Passport (DPP) by combining the best aspects of the Asset Administration Shell, OPC UA and other related technologies.

By making use of CESMII's Smart Manufacturing Profiles, which are modelled with OPC UA, and integrating them with the semantics of the Asset Administration Shell and ECLASS, the rich and existing ecosystem of OPC UA modelling tools can be leveraged to build DPPs. To access the resulting DPPs, the existing REST interfaces of both OPC UA and the Asset Administration Shell can be used. An integration with international dataspaces is also possible.

"I am glad we managed to build consensus with so many of the leading Industry 4.0 consortia and institutes to create this better-together architecture", said Erich Barnstedt, Senior Director & Architect Industrial Standards, Corporate Standards Group at Microsoft Corporation. "With this approach, companies can use their existing investment in OPC UA technology and use it to easily build Digital Product Passports for their industry, while making them available in their supply chain via standardized interfaces, data models, data formats and semantics. I believe this will give the DPP technology the necessary adoption boost it will need to meet the 2027 deadline set by the European Commission."

"The Plattform Industrie 4.0 has been promoting the interoperability of the Asset Admin Shell, OPC UA and related technologies in their Reference Architecture for Industrie 4.0 (RAMI4.0) for over a decade", said Thomas Hahn, coordinating the International Manufacturing-X activities worldwide, Siemens Fellow. "Therefore, we are delighted that key stakeholders and industry consortia have come together to build this joint architecture including results from the DPP4.0 initiative (https://dpp40.eu/) to accelerate and to support the adoption of the Digital Product Passport (DPP). We are confident that this will drive cost of deployment and operations for the DPP down and enable the use of DPP technology also for small- and medium-sized manufacturers on a worldwide basis."

News report by ***OPC Foundation****.*

Artificial intelligence in smart manufacturing

AI technology is helping to empower automation and control engineers by automating routine tasks, improving system efficiency, and enabling smarter decision-making. This allows engineers to focus on innovation and higher-value activities, ultimately driving better outcomes for manufacturing operations

SOURCE: ISTOCKPHOTO

"AI technologies and megatrends are set to reshape manufacturing, driving Digital Transformation by creating smarter, connected, and more autonomous systems. By 2025 and beyond, AI-powered analytics will leverage IoT and edge computing to process real-time data, enabling predictive maintenance, optimized production, and streamlined supply chains." -- John Marchiando, Industrial IoT Manufacturing Lead - Americas, Cisco.

ARTIFICIAL INTELLIGENCE SOLUTIONS ARE poised to make an impact in manufacturing by providing tools for AI-enabled digital transformation including machine learning, advanced analytics, cloud operating models and use of neural networks.

For this special report on AI in manufacturing, IEB reached out to industry experts to get their perspective on the technologies that are impacting smart manufacturing operations.

Industry leaders have responded with their take on the latest trends and how AI will create agile, efficient, and sustainable manufacturing ecosystems. It will enable industries to address challenges like rising consumer expectations, supply chain complexities, and environmental concerns, ultimately driving innovation and competitiveness.

AI-driven analytics spur digital transformation

Reducing downtime, increasing efficiency and enhancing decision-making.

According to John Marchiando, Industrial IoT Manufacturing Lead - Americas, and David Gutshall, Senior Manufacturing Sales Leader at Cisco, AI is poised to impact manufacturing operations using AI-powered analytics and edge computing.

"AI technologies and megatrends are set to reshape manufacturing, driving Digital Transformation by creating smarter, connected, and more autonomous systems. By 2025 and beyond, AI-powered analytics will leverage IoT and edge computing to process real-time data, enabling predictive maintenance, optimized production, and streamlined supply chains. These capabilities will reduce downtime, increase efficiency, and enhance decision-making," Marchiando told the Industrial Ethernet Book recently.

"Advanced robotics and autonomous systems will enable greater flexibility in manufacturing, allowing rapid adaptation to product variations and fluctuating demand. AI-driven automation will support customization at-scale, while maintaining efficiency and precision," Marchiando said. "Digital twins, combined with AI and real-time data, will revolutionize process simulation, allowing manufacturers to optimize workflows, test innovations, and accelerate time-to-market without disrupting operations."

He added that sustainability will become a central focus, with AI improving energy efficiency, waste reduction, and resource

Realize the promise of AI more quickly with advanced technology solutions that address networking, security and operational challenges.

utilization. Manufacturers will adopt AI-enabled tools to meet environmental regulations and achieve sustainability goals while enhancing cost-efficiency.

AI-driven megatrends

Gutshall added that emerging megatrends such as 5G and the slow-to-develop industrial metaverse will further enhance connectivity, enabling seamless communication across devices and systems while supporting immersive, remote collaboration. These technologies will empower manufacturers to operate with unprecedented agility and resilience, even amid global disruptions.

"AI and related megatrends will create agile, efficient, and sustainable manufacturing ecosystems," Gutshall said. "They will enable industries to address challenges like rising consumer expectations, supply chain complexities, and environmental concerns, ultimately driving innovation and competitiveness in the era of Industry 4.0 and beyond.

While typical applications provide static, rule-based capabilities, AI offers more dynamic, data-driven, and potentially solutions that are self-improving. It turns your manufacturing systems into intelligent, adaptive ecosystems that can respond to challenges and opportunities far more effectively than in the past. The results are greater efficiency, improved quality, reduced costs, and a significant competitive advantage for those implementing this technology.

AI in manufacturing

Marchiando and Gutshall said that AI solutions in smart manufacturing offer distinct advantages, enhancing efficiency, precision, and adaptability.

AI's predictive maintenance, analyzing sensor data to forecast failures and reduce downtime, is a notable application. Machine learning optimizes processes, improving energy efficiency and reducing waste. AI-driven computer vision enhances quality control with improved defect detection and real-time feedback.

Advanced AI models forecast demand and manage inventory, optimizing levels and adapting to market trends. AI-powered robots adapt to task variations and support human collaboration, unlike rigid pre-programmed robots.

AI enables quick reconfiguration for new products, facilitating mass customization. Digital twins simulate and optimize systems in real-time, surpassing static simulation models.

Supply chain optimization, with AI's logistics optimization and disruption adaptation, enhances efficiency and costs. AI also aids workers with existing augmented reality (AR) tools and adaptive training, boosting productivity and reducing errors.

IoT integration, processing real-time data at the edge, enables faster and smarter decision-making.

Overall, AI transforms manufacturing with smarter, autonomous systems that enhance productivity, reduce costs, and adapt to complex demands.

They added that AI impacts manufacturing by enhancing efficiency, quality, and flexibility. Notable examples include:

- *Predictive Maintenance:* AI sensors predict equipment failures, minimizing downtime and costs.
- *Quality Control*: AI-driven vision systems detect defects and analyze quality, ensuring consistency.
- *Process Optimization:* AI adjusts production parameters to minimize waste and optimize performance.
- *Supply Chain Management:* AI optimizes inventory, demand, and logistics, improving efficiency.
- *Worker Assistance:* AI monitors work environments and supports operators, boosting productivity.
- *Flexible Manufacturing:* AI enables agile systems to meet personalized product demands, allowing for adaptability.

AI has the potential to revolutionize industries by enhancing efficiency, productivity, and adaptability. It can assist in optimizing processes, identifying ways to reduce waste, and lowers operational costs while ensuring consistent quality and minimizing defects. AI-driven automation enables faster production cycles and customization at-scale, supporting greater ability in meeting market demands. Predictive capabilities reduce downtime and enhance resilience by anticipating equipment failures and supply chain disruptions.

AI also fosters innovation through advanced simulations, data-driven R&D, and rapid prototyping, accelerating breakthroughs in product design and processes. By augmenting human capabilities, AI shifts workforce focus to high-value tasks, driving upskilling and transforming roles. AI also supports sustainability goals by reducing resource consumption and emissions, helping companies meet regulatory requirements. These advancements provide a significant competitive advantage, reshaping industry dynamics and preparing businesses for a more sustainable, future-ready landscape.

AI solutions

"AI solutions help to empower automation and control engineers by automating routine tasks, improving system efficiency, and enabling smarter decision-making. This allows engineers to focus on innovation and higher-value activities, ultimately driving better outcomes for manufacturing operations," Marchiando said.

Some examples of these implementations are in areas like complex data management, where the growing volume of IoT and sensor data can be overwhelming. AI can assist engineers in processing this data in real time and then delivering actionable insights to simplify decision making.

"Engineers often struggle with identifying and diagnosing system faults quickly, especially in complex systems. AI-powered

SOURCE: ISTOCKPHOTO

"We are already seeing AI-powered systems enabling predictive maintenance, optimizing production workflows, and automating quality control and defect detection on the shop floor. AI-driven insights from connected devices and processes allow manufacturers to make faster, more informed decisions to boost efficiency, quality, and sustainability," Dr. Matthias Loskyll, Senior Director Software, Virtual Control and Industrial AI, Siemens AG.

analytics can detect anomalies, pinpoint root causes, and suggest corrective actions, reducing downtime and troubleshooting time," Gutshall added.

Another example is around scalability and adaptability. Engineers can face difficulties reconfiguring systems for new products or workflows. AI enables flexible automation, learning and adapting to the new conditions without extensive reprogramming.

"AI can assist automation and controls engineers to improve sustainability by managing energy consumption. AI can help analyze usage patterns and recommend optimizations to processes to reduce waste and cost," Marchiando said.

"Modern systems have numerous interconnected variables, making manual control and optimization difficult. AI excels at managing complex, nonlinear relationships, helping engineers maintain optimal performance across the entire system," he added.

AI-enabled digital transformation

Manufacturing companies to increasingly leverage AI capabilities.

Dr. Matthias Loskyll, Senior Director Software, Virtual Control and Industrial AI at Siemens sees AI as playing a key role in the continuing development of customized, flexible production systems.

"As a global leader in industrial automation and digitalization, we at Siemens see AI and generative AI technologies playing a pivotal role in accelerating the digital transformation of manufacturing. Key megatrends like the rise of the Internet of Things, the growing importance of data analytics, and the increasing demand for customized, flexible production will drive manufacturers to increasingly leverage AI capabilities," Loskyll said.

He added that reaping AI's benefits in industry is complex due to stringent standards, critical reliability requirements, and a shortage of skilled experts. It must meet the rigorous requirements and standards of the most demanding industrial environments. AI in industry has to be industrial-grade. Siemens is committed to making industrial-grade AI accessible without the need for specialized AI expertise, enabling companies to drive transformation effectively.

"We are already seeing AI-powered systems enabling predictive maintenance, optimizing production workflows, and automating quality control and defect detection on the shop floor. AI-driven insights from connected devices and processes allow manufacturers to make faster, more informed decisions to boost efficiency, quality, and sustainability. Additionally, AI will enable more personalized, on-demand production to meet evolving consumer preferences. In production, we're already harnessing the advantages of AI, and its future potential promises to revolutionize efficiency, precision, and innovation on an unprecedented scale," Loskyll said.

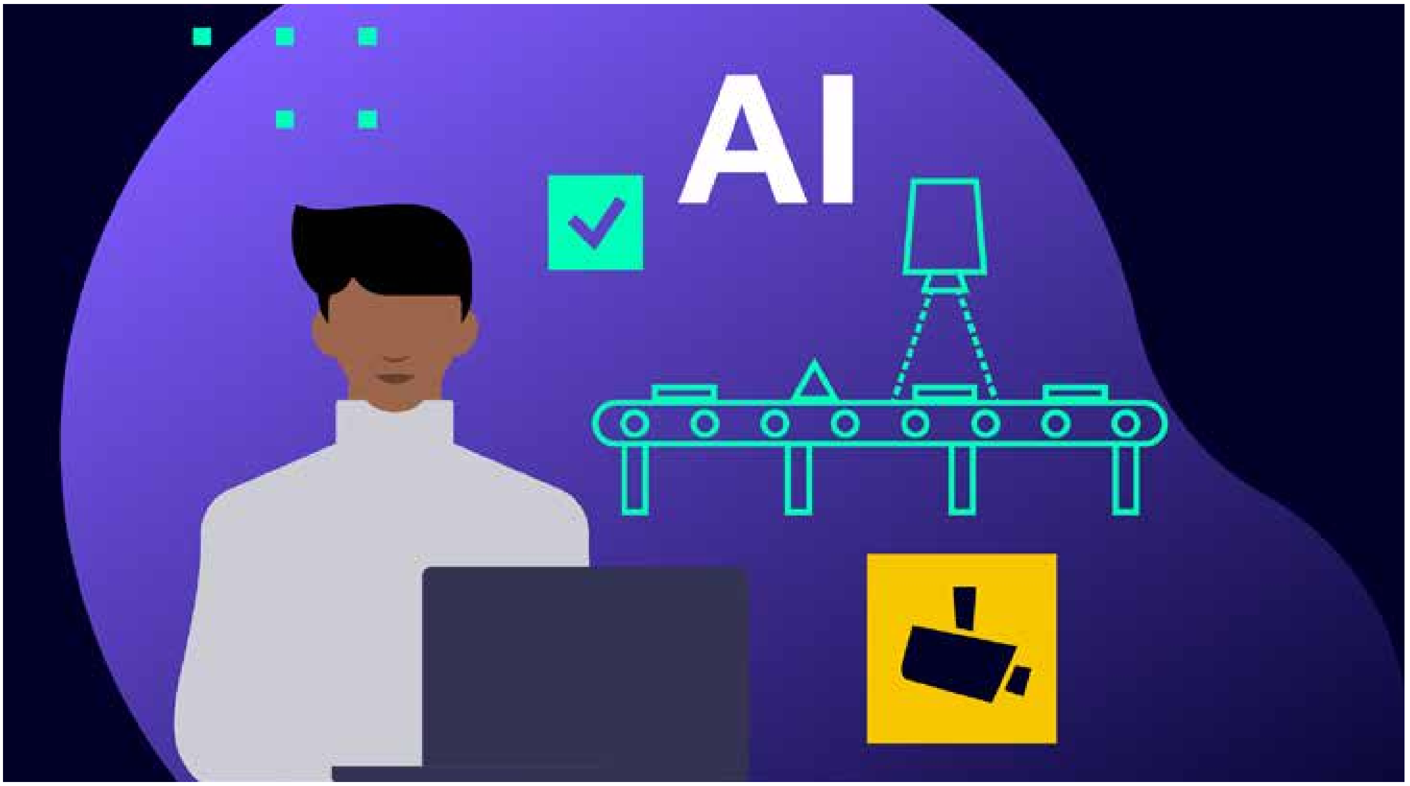
Benefits of AI solutions

Compared to typical automation and analytics applications in use today, Loskyll said that AI-powered systems offer far greater capabilities to sense, analyze, and optimize manufacturing processes in real-time. For example, AI-enabled machine vision can detect defects and anomalies with superhuman accuracy, going beyond the limitations of traditional rule-based quality inspection.

Similarly, predictive maintenance AI models can forecast equipment failures before they occur, allowing for proactive maintenance to minimize unplanned downtime. AI also enables the dynamic optimization of production parameters, supply chains, and logistics to continuously improve efficiency, quality, and throughput. Importantly, the self-learning nature of AI means these systems continually enhance their own performance over time, adapting to changing conditions on the factory floor. This level of adaptive intelligence simply cannot be achieved with conventional software applications.

Impacting the production lifecycle

AI-powered systems are delivering significant benefits across the production lifecycle. In quality control, AI-enabled machine vision can detect defects with speed and accuracy, far exceeding human inspection capabilities. This allows manufacturers to catch issues earlier, reduce waste, and improve overall product quality. For example, in the automotive industry, manufacturers must avoid scratches, dents, poor welds, and faulty electronic



Siemens' Inspekto – ready-to-use visual inspection.

components.

The system learns the "good" parts and then detects the anomalies and defects, even if they are not predefined. Siemens' Inspekto is an automated, easy-to-use visual inspection solution that uses AI but doesn't require AI or vision expertise to set up and use. It delivers a versatile, easy-to-deploy inspection solution that adapts to changes in the production line and requires no machine vision expertise. It also requires only a small amount of production data of only twenty good samples, which makes it an easy entry point for companies who want to use AI-based machine vision for their quality inspection needs.

"Data-driven condition monitoring of an entire plant or multiple sites is challenging, and manual analysis is too complicated and time-consuming. AI systems can provide maintenance workers with the equivalent of an experienced expert, continuously analyzing all the data from machines, such as temperature, vibration, torque, and speed," Loskyll said.

"As a result, AI can detect anomalies, alert human workers, and provide actionable insights based on past events. In addition to facilitating data analysis, AI can also provide early warning signs of when equipment is likely to fail and recommend specific actions to prevent those failures."

He added that these algorithms are continuously trained with new data and insights, so they get better over time. Siemens' Senseye Predictive Maintenance is an AI-based solution that automatically generates machine and maintenance behavior models to direct attention and expertise where it's needed most. It integrates with any asset, system or data source, using data that has been already collected or newly installed sensors, and provides generative AI capabilities that make predictive maintenance more conversational and intuitive.

Adaptive process control

One key challenge is the need for more robust, adaptive process control. Traditional control systems rely on rigid, rule-based algorithms that can struggle to account for the variability and complexity of real-world manufacturing environments. In contrast, AI-driven control systems can learn from sensor data, adapt their parameters in real-time, and optimize production outputs based on dynamic conditions. This allows for tighter process control, improved quality, and greater flexibility.

Another major challenge is the difficulty of predicting equipment failures and anomalies. Unplanned downtime remains a major source of lost productivity and revenue for manufacturers. AI-powered predictive maintenance solutions can analyze sensor data patterns to forecast issues before they occur, enabling proactive maintenance and maximizing asset uptime.

"Automation and control engineers also face the ongoing struggle to extract meaningful insights from the vast amounts of data generated across production systems," Loskyll said. "AI-based analytics can uncover hidden correlations, identify optimization opportunities, and generate predictive models that would be virtually impossible for human analysts to detect."

AI-powered automation

Advances in quality control and supply chain optimization.

According to Dr. Christoph Kelzenberg, Chief Digital Office, Director Digital Innovations & Director Operational Excellence at Phoenix Contact, AI will help integrate IoT communications with Big Data analytics into AI-powered automation.

"AI will play a critical role in shaping and enabling digital transformation in manufacturing through 2025 and beyond. AI will drive advances in quality control and supply chain optimization. The integration of AI with IoT and big data analytics will enable real time monitoring and decision making, leading to increased efficiency and reduced downtime," Kelzenberg said.

"In addition, AI-powered automation will improve production processes and enable greater flexibility and adaptability. These technologies will also facilitate the development of smart factories, where networked systems and machines can communicate and collaborate seamlessly," he said.

Technology benefits

Kelzenberg said that AI solutions offer a wide range of benefits for smart manufacturing

SOURCE: ISTOCKPHOTO

"AI will play a critical role in shaping and enabling digital transformation in manufacturing through 2025 and beyond. AI will drive advances in quality control and supply chain optimization. The integration of AI with IoT and big data analytics will enable real time monitoring and decision making, leading to increased efficiency and reduced downtime," Dr. Christoph Kelzenberg, Chief Digital Office, Director Digital Innovations & Director Operational Excellence at Phoenix Contact.

that go beyond what is possible with typical applications today. AI can improve quality control by identifying defects and anomalies in real time, resulting in higher product quality and less waste. In addition, AI-powered supply chain optimization can streamline operations, shorten lead times and improve inventory management.

"AI solutions are being used across the manufacturing industry in a variety of ways. For example, AI-driven robots and automation systems are used for tasks such as assembly, welding and solder to improve precision and efficiency," Kelzenberg said. "AI-driven predictive maintenance systems monitor the condition of equipment and predict failures before they occur, minimizing downtime. The positive effects of these developments are higher productivity, lower operating costs and improved product quality. AI solutions make it possible to innovate and develop new products faster i.e. the design and creation of circuit diagrams."

Application challenges

Kelzenberg added that one of the most important challenges is the need for data analysis and decision-making in real time. AI can process large amounts of data quickly and accurately and deliver actionable insights.

Another challenge is maintaining plant reliability and minimizing downtime. In addition, AI can optimize control systems, improve efficiency and reduce energy consumption. These solutions make it possible to focus on more strategic tasks and drive continuous improvement.

Leveraging data in manufacturing

An all-purpose AI can solve a wide range of production problems.

Steve Mustard, an independent automation consultant and subject-matter expert for the International Society of Automation (ISA), said that while we are still not able to realize the possibilities of artificial general intelligence, an all-purpose AI that can solve wide ranges of disparate problems, AI is already having a major impact in manufacturing.

"The use of generative AI to generalize information and make predictions is a major use case. Deep learning can be applied to automated inspection systems, analyzing images, video, and other sources of data to identify patterns that predict manufacturing issues or equipment failure," Mustard said. "The internet of things (IoT) and smart sensors provide vast amounts of data that AI systems analyze to optimize and control processes in real time."

Impact of AI

Mustard said that AI solutions allow manufacturers to analyze very large data sets and identify patterns and relationships that were previously invisible to existing methods. AI solutions can also provide more repeatable and consistent results and only tend to improve as more data is analyzed.

Generative AI enables manufacturers to mine vast quantities of standards, policies and procedures to improve requirements development, compliance assessment and standard operating procedure production.

Deep learning can be used in image, video and speech recognition, data visualization and trend analysis in automated inspection systems, predictive maintenance and quality control.

Industry applications

"Autonomous and flexible robots, including collaborative robots (cobots) are incorporating AI-based vision-language-action models, enabling them to more closely mimic human capabilities in perception, understanding, and response to their operating environment," Mustard said.

AI is also being used in digital twins to create real-time system simulations that can be compared to real-world systems for control, diagnostics and prediction, significantly enhancing operational efficiency, reducing risks, and supporting smarter, more proactive decisions.

He added that some of the ongoing challenges that automation and control engineers face that AI can address include:

Decision making: with complex environments, large volumes of data and many interdependencies, AI can support engineers with better and more reliable, repeatable, analysis.

Efficient use of time: AI can help engineers shift their focus to more higher value tasks by supporting the processing of large amounts of data, for instance validating standards, policies, procedures and producing compliance reports.

Detecting cybersecurity threats: cybersecurity is a major risk that automation and control engineers must manage. Having the ability to analyze network traffic and end point activity and identify potential threats early is a major benefit.

The power of neural networks

AI technology will enable new era of digital transformation in manufacturing.

Steve Fales, Director of Marketing at ODVA said that Artificial Intelligence (AI), machine learning, and deep learning are often used interchangeably in high level business discussions. The distinctions are important though to better understand how neural networks will enable a new era of digital transformation in manufacturing.

"At the highest level, AI is the process of automating complicated tasks that normally require the intellectual capability of a person. The first subset of AI is machine learning, which is the idea that machines can learn beyond their original programming. Previously, rules and data were used with programming to create answers," Fales told the Industrial Ethernet Book recently.

"Now it is possible to use data and answers with machine learning to create rules to predict answers from data. The next subset of AI and machine learning is deep learning, which is simply adding multiple layers of transformation between the original input and the final output. Deep learning is what is allowing powerful neural network models to solve highly complex problems in industrial automation today," Fales said.

Leveraging "deep learning"

Fales said that one of the biggest hurdles to leveraging deep learning in plants is labelled data. The internet has enabled large language models to access huge quantities of books, questions and answers, and text conversations as well as labelled pictures of things such as people, animals, and food. However, there doesn't currently exist a free storehouse of manufactured products being labelled with various errors.

This means that manufacturers will have to create their own graphic libraries with metadata describing the product, any errors, and other pertinent information. To help overcome the comparatively low number of data points, deep learning training techniques can be used such as splitting the same smaller data set into multiple partitions. This can allow the same data to be organized into different ways to mimic being a larger data set by using different slices of the same data for outcome validation and different slices for model training per the Data Folding Example.

Deep learning models are open source and available for use by anyone with expertise in both data modeling and" system design," Fales said. "The challenge is that model selection is both an art and a science that requires extensive mathematics, programming, and data modeling expertise. To solve that problem, leaders in industrial automation are creating software tools that enable controls engineers to upload datasets, add labels, and identify the problem to be solved."

He said that the backend of the software then leverages the proper deep learning techniques to create a local, custom model that can provide an ongoing application solution. An example of this is Rockwell Automation's FactoryTalk LogixAI that allows users to leverage their existing EtherNet/IP control data for problem solving such as predictive maintenance. A significant advantage of using private AI solutions is that proprietary data is then blocked from being incorporated into a larger public model for others to be able to access.

AI in general can seem to be too complicated since many different deep learning models, layers, and weights are used, or even lacking in meaning with over usage of the latest buzzword. What's important to understand is that deep learning is simply pattern recognition leveraging existing mathematical principles such as matrices for images, linear regression, and other functions to achieve the best fit to the data. Deep learning breaks large problems such as identifying whether an automotive body weld is defective into much smaller problems such as whether properly done weld rings, excess material, and/or gaps lacking material are identified. Another common example is facial recognition where the problem gets broken down into hundreds or thousands of data points such as distance between eyes, eye shape, eye color, eyelash angle, nose length, etc.

Basic neural network models work by transforming the original data set into much simpler and more homogenous data that can allow the mathematical functions to search for best fit curves. Neural networks use multiple transformation layers with weights applied to each layer. The next step is to make predictions that are compared to the actual data. The difference between the predictions and the actual data nets a loss score. The weights can then be changed via an optimizer to improve the loss score in an iterative process. It's important not to optimize the model too much though or the model will start to become too dependent on the training data. Overfitting a model to the training data makes it too specific and not as generally useful for predicting outcomes with new data.

AI in manufacturing

"AI is being used today in applications such as recognizing whether workers are wearing appropriate Personal Protective Equipment (PPE) for the hazards in each environment. Workers not wearing a hard hat, safety glasses,

SOURCE: ODVA

Programming Paradigm.

Machine Learning Model.

Data Folding Example.

SOURCE: ISTOCKPHOTO

"AI provides the opportunity to continue to reshore manufacturing due to the ability to automate lower value add tasks and enable higher worker productivity. While "dark factories" that don't need lights due to complete automation aren't likely to become commonplace anytime soon, AI will help to solve more problems than previously possible to reduce defects and increase total output," Steve Fales, Director of Marketing at ODVA.

reflective vests, respirators, etc. can be identified and flagged automatically to prevent an accident before it happens. Additionally, AI can automatically identify defects such as improperly manufactured cable connectors to improve quality and increase throughput," Fales said. "AI can even operate highly complex machinery that takes years of training for a human operator. To increase productivity, people need force multipliers to help them to be able to do more with less. AI can enable factory workers to be safer, more productive, and to focus more intellectually engaging higher value add tasks. AI will supercharge the capability of workers in 2020s and 2030s in the same way that personal computers did in the 1990s and 2000s."

Fales said that, to best take advantage of AI going forward, it's more important than ever to adhere to the fundamentals of proper network design and to rely on data models. The creation of separate zones of controllers, switches, and devices is a well-known security technique that is also valuable when leveraging AI at the edge since it will help to minimize network propagation and ensure traffic stays within the limits of bandwidth. Data models that include semantic and scale information, so that control data can be easily ingested by AI tools, are also a hugely valuable investment. Examples of this include OPC UA for discrete automation and PA-DIM for process automation that can both be taken advantage of by industrial Ethernet networks such as EtherNet/IP.

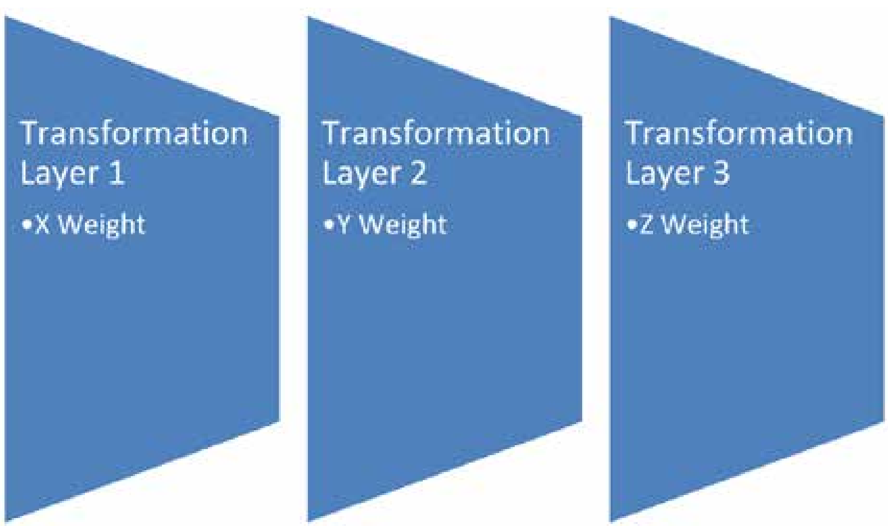
Engineering challenges

AI provides the opportunity to continue to reshore manufacturing due to the ability to automate lower value add tasks and enable higher worker productivity. While "dark factories" that don't need lights due to complete automation aren't likely to become commonplace anytime soon, AI will help to solve more problems than previously possible to reduce defects and increase total output.

If you've visited a plant recently, you're already aware of the importance of safety given the preparatory safety videos, usage of PPE, and limited areas that guests can access. Total Recordable Incident Rate (TRIR) is a US Occupational Safety and Health Administration metric that is a key factor in determining whether to do business with another organization. AI can help to automate dangerous tasks and to therefore lower TRIR scores and reduce potential liability.

$$\frac{\textit{Total \# of Incidents} \times 200{,}000}{\textit{Total \# of Hours Worked in Year}} = \textit{TRIR}$$

"One of the challenges of AI that is starting to come to the forefront is its impact on sustainability. AI uses more energy than a traditional Google search engine search by approximately a factor of ten, according to Google generative AI," Fales said. "While optimization of AI will hopefully narrow that gap soon, the usage of more sustainable energy sources such as nuclear, solar, and wind can help to mitigate those concerns. It's also important to make appropriate decisions of onboard, edge, or cloud AI based on cybersecurity threat assessments and business needs. While the benefits of AI clearly outweigh the downsides, it's important to understand the pros and the cons to appropriately deploy this new technology in the correct applications."



SOURCE: ODVA

Neural Network Transformation Layers,

Al Presher, Editor, ***Industrial Ethernet Book***

AI in manufacturing: 2024 Industrial Networking Report

The Cisco 2024 State of Industrial Networking Report for Manufacturing reveals how manufacturing firms worldwide are designing and deploying their operational technologies to improve cybersecurity, quality and efficiency. One of the conclusions of the report is that firms are investing in an AI-ready foundation.

The 2024 Cisco State of Industrial Networking report stated that “the manufacturing sector is embracing new technologies to bolster its infrastructure resilience and reliability." Here are the report's major conclusions:

- The #1 investment priority for manufacturing firms today is AI-enabled devices
- Adoption of AI is the #2 strategy (after upskilling employees) for mitigating internal obstacles to growth
- Over half (51%) expect AI deployment to improve network management across both IT and OT

According to the report, “AI (48%) is the emerging technology that in the future is expected to have most impact on OT, followed by cybersecurity solutions (31%)”. Here is that the report says about AI:

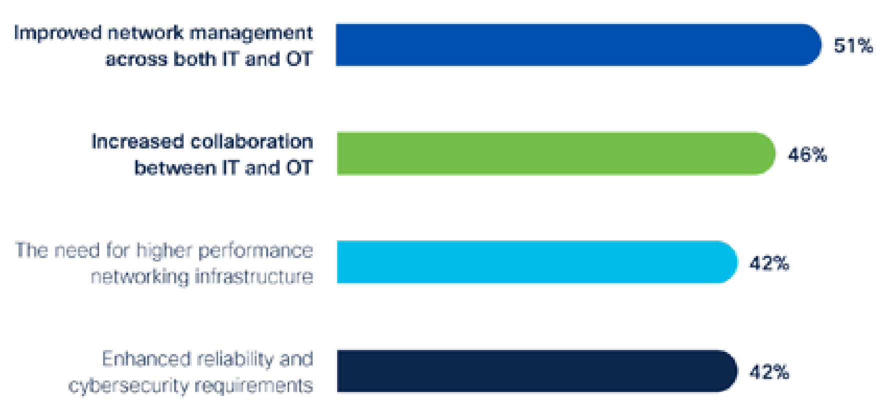
Firms bolster AI and cybersecurity capabilities:
The top investment priorities for manufacturing firms today are AI-enabled devices (31%) and cybersecurity solutions (30%).

AI and cybersecurity top investment priorities
Cybersecurity (43%) and AI (41%) top the charts of planned investments for the next one to two years. There is a significant difference of 31 percentage points between the number of LATAM firms who say AI is a top spending priority (65%) and those in North America who say the same (34%).

AI expected to improve network management
Over half (51%) of respondents to the survey are looking forward to AI improving network management across both IT and OT in their organizations. A further 46% anticipate it leading to better collaboration across IT and OT functions within companies.

AI and cybersecurity top future investment priorities

AI expected to improve network management



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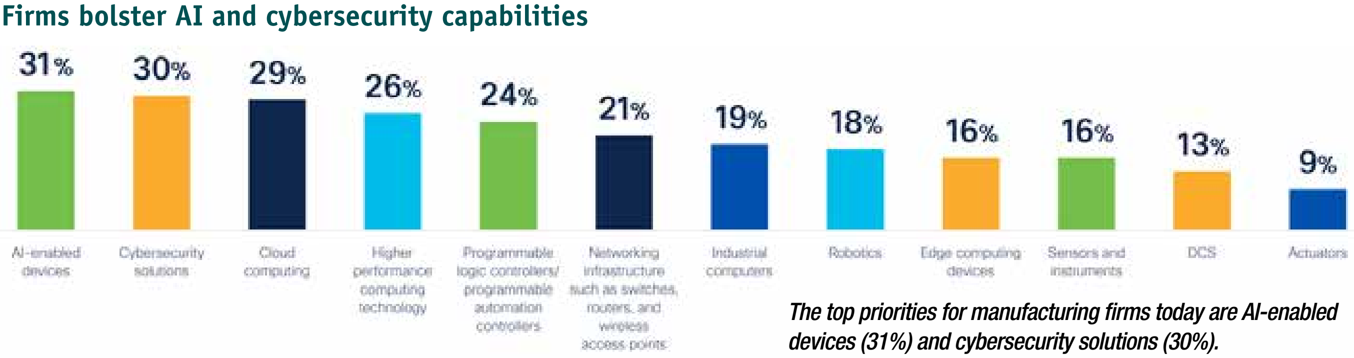
Firms bolster AI and cybersecurity capabilities



The top priorities for manufacturing firms today are AI-enabled devices (31%) and cybersecurity solutions (30%).

TSN-empowered AI in automation

Users can implement automation applications more easily and cost-effectively with new AI tools. The rapid development of these AI tools, combined with a significant acceleration of hardware capabilities and integrated Ethernet interfaces, is opening up both new applications and segments.

SOURCE: POPTIKA@SHUTTERSTOCK.COM

Numerous applications can be implemented by using AI in automation. Many of these examples cannot be realized without convergent TSN networks and time synchronization or are otherwise significantly more complicated and expensive to implement.

ARTIFICIAL INTELLIGENCE (AI) HAS THE potential to also be a game changer in automation. What role could Time-Sensitive Networks (TSN) play in making it easier and more cost-effective to leverage the possibilities of AI applications? What requirements does AI place on the networks of the future? What new applications and solutions can be implemented by TSN? And what does the path to this look like?

Detailed information about TSN is already widely available. This article will therefore look at application examples with an AI focus that can benefit from TSN. The focus here is not on motion control, but on other applications with great benefits for the technology. Some of the examples included should encourage us to explore options beyond the limits of what is currently available.

The rapid development of AI tools, combined with a significant acceleration of hardware capabilities and integrated Ethernet interfaces, is opening up new applications and segments. They generally have the following requirements:

- Large amounts of data have to be transported from the field to the AI system.
- The forwarded data must be provided with highly accurate time stamps so that, for example, a time series data analysis can be carried out by means of comprehensive correlation.
- It must be possible for the result of AI processing to feed back into the field.

These requirements cannot be fully or sufficiently met with conventional industrial Ethernet based on 100 Mbit technology. This is where the possibilities of Time-Sensitive Networking come into play. The following examples are intended to illustrate which applications with an AI focus can be implemented or improved by a convergent TSN network.

Camera-based quality control in the active process

In a production machine or production line, special industrial cameras (GigE Vision) are used to take pictures of the active process or of products. A machine learning mechanism trained on the basis of the good parts detects quality defects and controls the production process accordingly. Current image processing hardware performs such evaluations in a matter of milliseconds. This makes it possible to carry out quality control during the active production process.

Multiple cameras can also be synchronized to take pictures of a workpiece at exactly the same time. This then allows for 3D calculations or time series analyses, for example. It is no longer necessary to

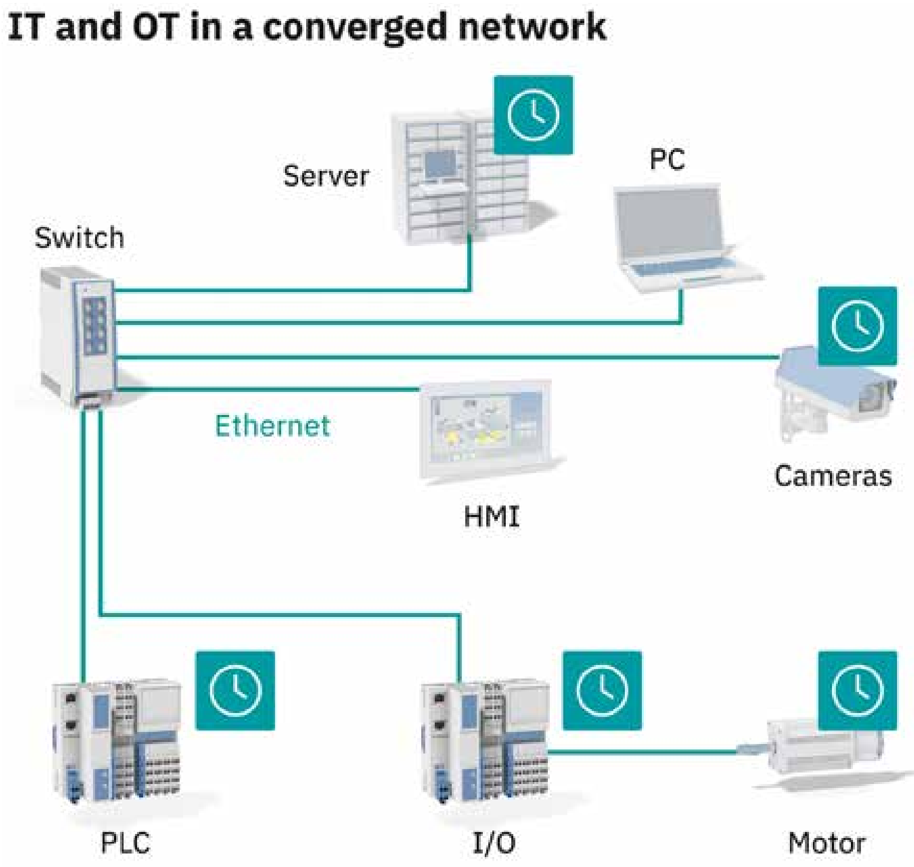


Figure 2: The convergent network for IT and fieldbus as the basis for AI .

separate the camera and control networks. Since the evaluation algorithm runs on external hardware, it can be flexibly adapted to different products and conditions. Industrial vision applications require a lot of bandwidth. Depending on the resolution and refresh rate, the value quickly adds up to several 100 Mbps. In addition, jumbo frames are used in vision applications, which particularly benefit from the TSN mechanism preemption. For this reason, convergent networks are currently the exception rather than the rule in vision applications, but this could change with TSN.

Preventive maintenance of large machines

Use in the field of predictive maintenance is illustrated using the example of large drives. Sensors in or on the motor measure temperature and vibration data. A power measuring device also determines the respective energy requirements of the motor. This trains an AI model for normal operation of the motor based on this data. The exact temporal correlation of energy, temperature, and vibration data is also helpful here.

If several drives are operating in a process, it is also necessary to have a system-wide understanding of time. If any operating

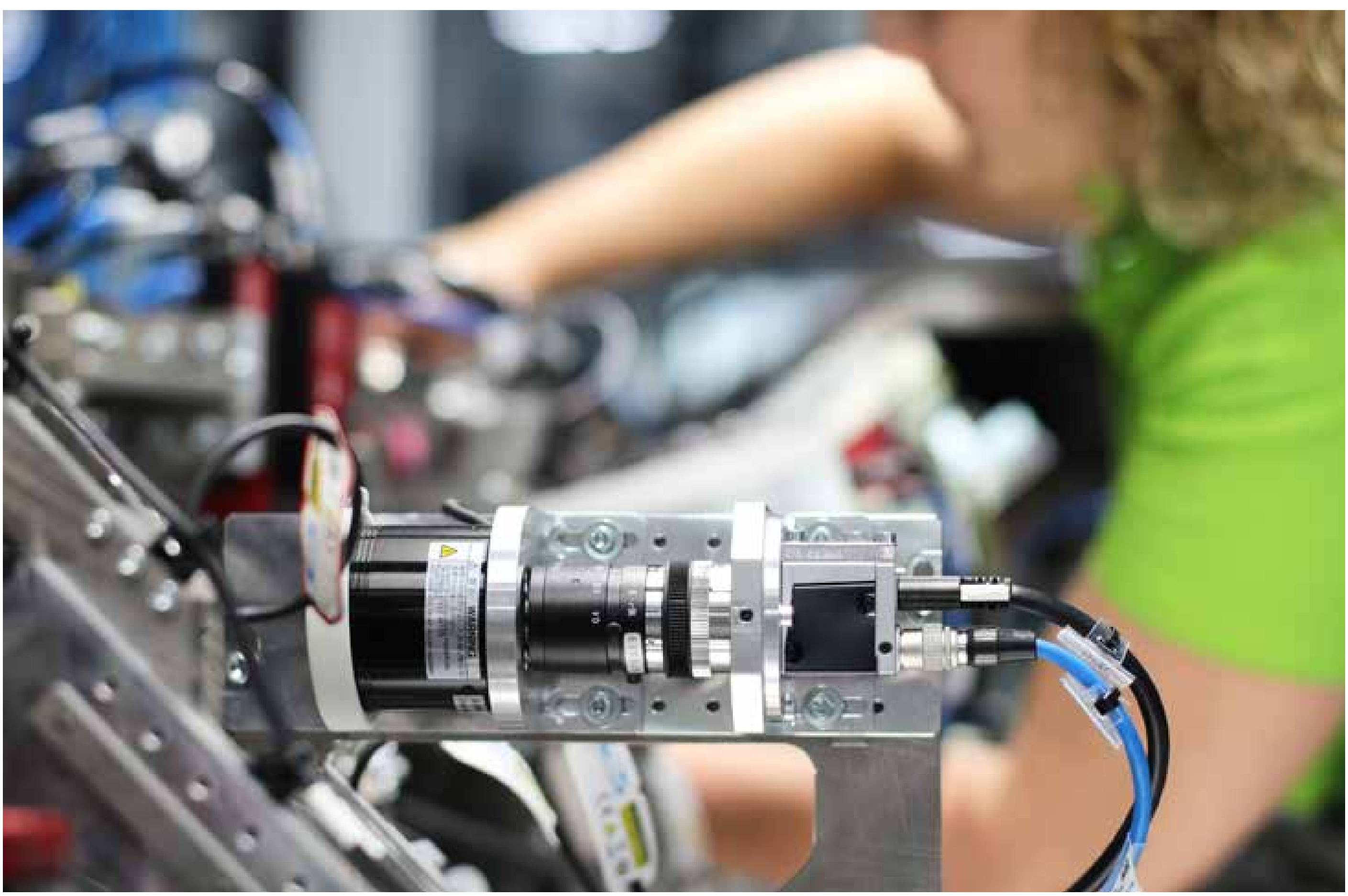


Figure 3: Camera-based quality control in Phoenix Contact production.

SOURCE: HRAMOVNICK@SHUTTERSTOCK.COM

Figure 4: Preventive maintenance of large motors using AI.

parameter deviates from the normal state - for example, due to bearing damage, other wear, or problems in the process - the operator can respond ahead of failure during the next scheduled maintenance, or the process can be controlled differently. The small amount of effort required to train the model is more than offset by the benefits of predictive maintenance.

Synchronized feed-in of renewable energy

The energy transition is creating a new and largely unknown problem. Power stations for primary energy sources such as coal, gas, and nuclear power operate generators with large rotating masses.

The kinetic energy stored in these masses helps the power grid cope with load fluctuations and provides the reference frequency for alternative generators, such as wind turbines or solar parks. With more and more conventional power stations being replaced by alternative generators, this grid-supporting effect is lost.

For example, it is not readily possible to ramp up a wind farm without an external grid in stand-alone operation. One solution to this problem is the highly accurate synchronization of all generators and their electronic feed-in converters with a corresponding setpoint definition. This can be done by TSN over the network that is already required for operating data. Installing two separate networks in a wind farm covering several square kilometers would be a major cost factor.

Root cause analysis of events

Another field of application is the temporal and localized analysis of events that occur during system operation. These are required by insurance companies in the event of a malfunction in order to be able to carry out a root cause evaluation. If this is primarily handled in the controller at present, this may no longer be sufficient in the future, because not all of the relevant data, such as the above-mentioned data from the motor, is available in the PLC.

Due to the time synchronization, TSN makes it possible to record events with highly accurate time stamps of less than 1 ms in the devices themselves.

The convergent network also ensures the simultaneous transmission of events to an analyzing unit, which does not have to be the controller (and may not be if a controller itself is the root cause). AI makes it easy to search through the vast amounts of messages for anomalies. The high accuracy of the time stamps supports this. In addition to a root cause evaluation, hidden problems are also found and rectified during operation.

Implementation is already possible

In addition to the examples shown above, there are numerous other applications that can be implemented by using AI in automation. Many of these examples cannot be realized without convergent TSN networks and time synchronization or are otherwise significantly more complicated and expensive to implement. In these applications, TSN mechanisms can play to their strengths in the network compared to specialized real-time bus systems.

Perhaps the greatest benefit of TSN lies in these applications rather than in replacing current special bus systems for motion control. Another piece of good news is that it is already possible to implement the applications described. The switches from Phoenix Contact currently support functions such as Quality of Service (QoS), Precision Time Protocol (PTP), and preemption. The GigE Vision standard also specifies the use of PTP. AI combined with TSN will therefore enable a new generation of automation applications, and their development is probably just beginning.

Advantages of TSN at a glance

Time-Sensitive Networks are not a single

Figure 5: Applications for TSN in the generation of renewable energy.

standard. Rather, TSN can be compared to a tool box containing several tools, each of which serves a specific purpose:

Quality of Service (QoS in accordance with IEEE 802.1Q) enables the use of a common network for time-critical process data and large amounts of data, such as camera images. A bandwidth of 1 Gbps or more is essential here.

Precision Time Protocol (PTP in accordance with 802.1AS) provides time synchronization with under 1 µs accuracy, even in larger network topologies. The widely used Network Time Protocol (NTP) is not capable of this, but it can be used together with PTP in the same network.

Preemption (802.3Qbu, 802.3) solves the problem of interference between time-critical real-time data and non-time-critical data, such as jumbo frames from camera systems. This means that real-time transmission is not delayed by large, non-critical telegrams.

Synchronous communication based on PTP allows the transmitters to be synchronized in order to reduce jitter. The function is not always necessary in many applications that currently work with PROFINET RT, for example.

Special QoS mechanisms allow the existing device landscape to be seamlessly integrated into TSN networks. This enables gradual implementation in applications that will yield the greatest benefit.

All of these tools and the way they interact form the convergent network, in which IT data and critical process data as well as highly accurate time synchronization coexist. This significantly reduces the costs and complexity compared to special networks for these disciplines.

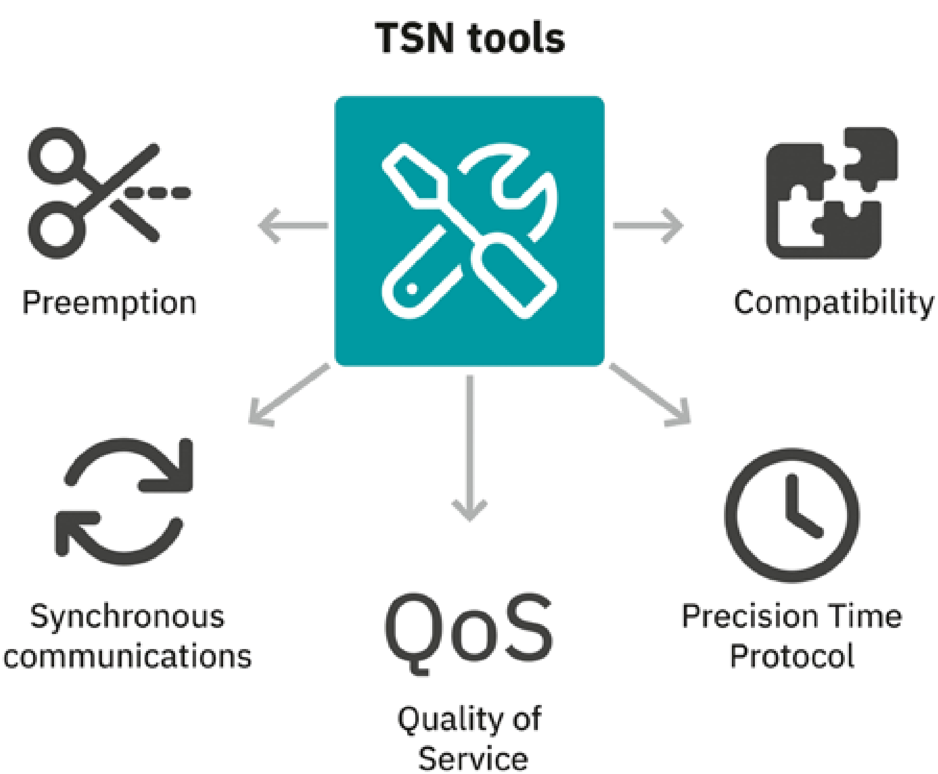


Figure 6: The TSN tool box.

Gunnar Lessmann, Master Specialist Profinet and TSN, PLCnext Technology, ***Phoenix Contact Electronics GmbH.***

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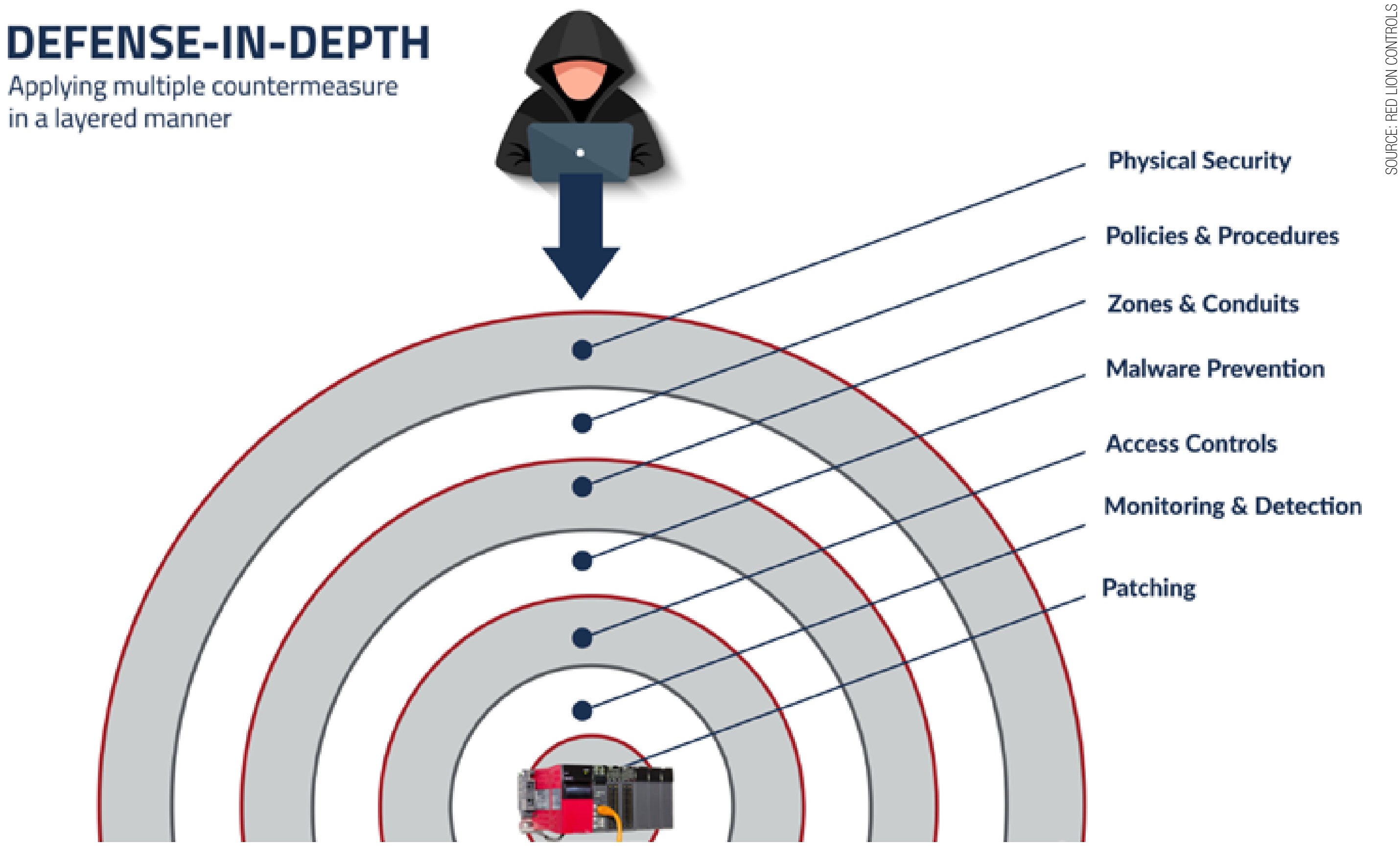
To harness the power of AI, tackle the first mile

Out of the box solutions move data easily and securely from operations to IT. IT specialists don't always grasp the needs and challenges of their counterparts in OT. To align their needs and objectives with IT, they need surer footing to navigate today's cybersecurity requirements and quality solutions to bring to the table.



Defense-in-depth strategies apply countermeasures in layers from physical security, to policies and procedures, zones and conduits, malware prevention, access controls, monitoring and detection, plus network patches.

STATE REGULATIONS REQUIRED A MAJOR PULP The trade journals are abuzz with talk of Artificial Intelligence (AI) for industrial applications. AI platforms help tie together, analyze, and contextualize data from every corner of an enterprise. They give organizations a big picture view of how their business is performing. They drive value by empowering people in various parts of the organization to make decisions benefiting the business.

That buzz is heard in factory control rooms, head offices, and boardrooms, too. Industrial enterprises are busy figuring out what problems they can solve with AI to add value. The sales office wants new efficiencies for handling orders, shipping, and purchasing. Facilities management wants AI to improve plant safety and product quality. Accounting wants to reduce costs and eliminate waste. Line operators want to optimize forecast maintenance to ensure maximum uptime.

Before AI, these process improvements were hard to identify. Decision-makers had to sift through heaps of data manually or compare outcomes across a range of programs to find efficiencies and places to optimize. Now, modern AI systems can collect and analyze data quickly – even on the fly. They're designed to deliver powerful results quickly. As such, they can be easy investments to make and justify. Information Technology (IT) departments are right to be enthusiastic about their potential.

There's just one problem. To leverage the full benefit of AI, you need the proper foundation. You need data from every part of your operation, including foundational systems. That includes data from your factory floor, your remote stations, your legacy equipment. You need data from the all-important first mile of your industrial process.

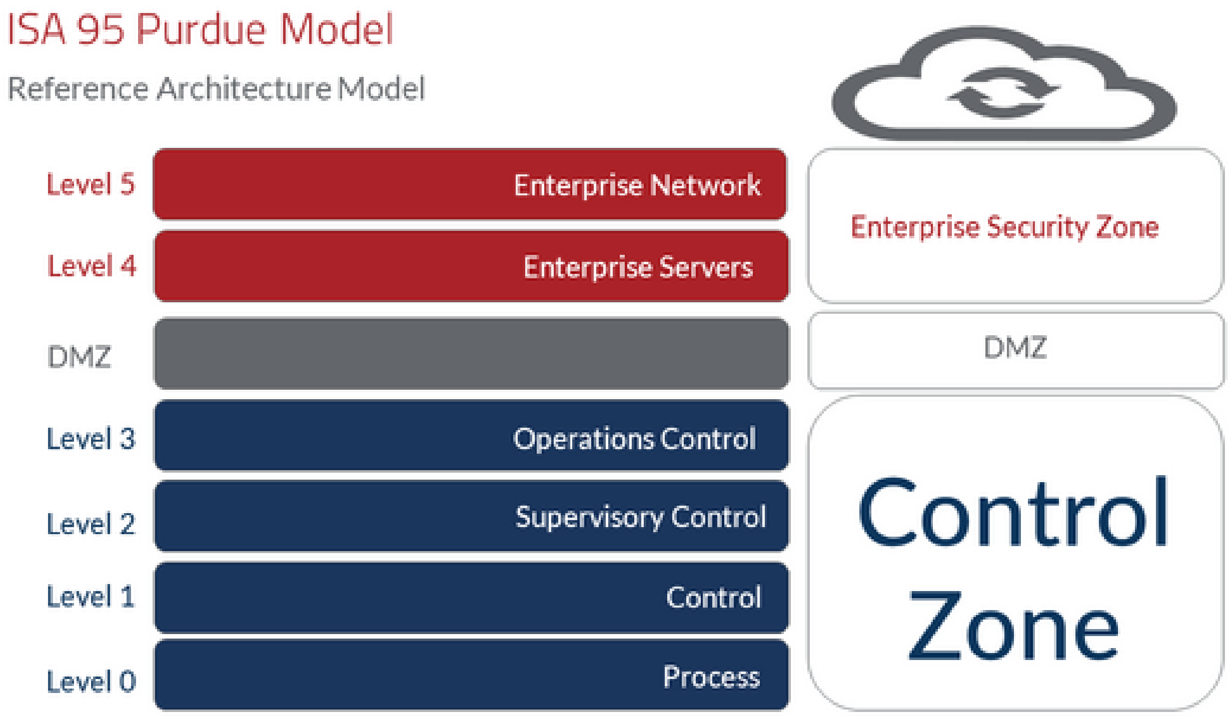
Crossing the foundational first mile

For many organizations, these applications and control systems have been in operation for a long time – 10, 15, 25 years or more. Acquiring data from these systems can be a challenge.

In principle, it's not the age of the equipment. Even modern facilities have a first mile that needs crossing. To illustrate, consider the six-layer Purdue Model, an established blueprint for building secure industrial control systems.

The architecture is divided into six layers: a lower "Control Zone" which comprises the most critical OT functions, and an upper "Enterprise Security Zone, which consists of two layers for IT functions. The two areas are separated by a protective barrier, called the Demilitarized Zone (DMZ).

The first mile covers Levels 0-2 This is where an organization measures its flow of



SOURCE: RED LION CONTROLS

Purdue Model diagram.

oil or gas, the amount and pressure of water going through pipes, or the number of widgets passing by a counter.

Process systems, such as motors and sensors, are at Level 0. Control systems, such as Programmable Logic Controllers (PLCs), are at Level 1. Human supervisory systems enter the system at Level 2, such as the SCADA systems that operators and decision-makers use. Level 3 is for operations control systems. These systems gather data from the levels underneath and sent it through the DMZ to the IT layers above.

AI capabilities lie in the DMZ, on Level 4, which comprises databases and servers, and Level 5, for networking and cloud connectivity. The AI application might be on a server managed by the IT department (DMZ or Level 4), with its own data models and machine learning algorithms. Or it could be in the cloud, with data models drawing information from other systems through the organizations. Processes at the Enterprise levels perform top-level analysis to connect the dots across the organization. They're plugged into accounts payable, accounts receivable, and order processing, to contextualize the data and make decisions that benefit the organization.

Securing the first mile – right out of the box

Whether you're running antiquated machines or brand-new equipment, data from below needs to move to enterprise levels above. But it needs to move securely, reliably, and with high data integrity.

As an example, let's say a plant has a widget production line with a rate counter that's been running smoothly for 15 years. The production line communicates with the rate counter through an Input/Output (I/O) device using Modbus TCP/IP. Now the plant wants to push this count data upstream for use in leading-edge AI applications, but the Modbus communication protocol doesn't meet modern security standards. Data sent over a network via Modbus runs the risk of being changed or compromised. At the same time, the organization has no desire to change its current application.

By plugging in an intelligent automation platform to connect the plant to their data, the plant can shield its existing application without changing the existing setup.

The first mile: your deepest defense

SOURCE: RED LION CONTROLS

The FlexEdge® Intelligent Edge Automation Platform, powered by Crimson® is designed to connect organizations to their data. It makes first mile processing as simple and secure as possible.

The ISA/IEC 62443 standards for OT cybersecurity, which reference the Purdue Model, are crucial for industrial organizations. A key principle of the standard series is the Defense-in-Depth strategy (see below), which layers security approaches on top of each other.

Cyberattacks can come from multiple directions – malicious software, an on-site hacker with a personal laptop, or a sophisticated infiltration attempt by a nation state. Adopting a layered strategy is the best way to protect industrial applications against would-be attackers – starting with the deepest layer.

IT departments have been applying these cybersecurity principles for years at the enterprise level. However, IT often has a different view on legacy technology than OT. IT routinely swaps out laptops and PCs every three to five years. For IT, cybersecurity updates often come embedded within that new hardware.

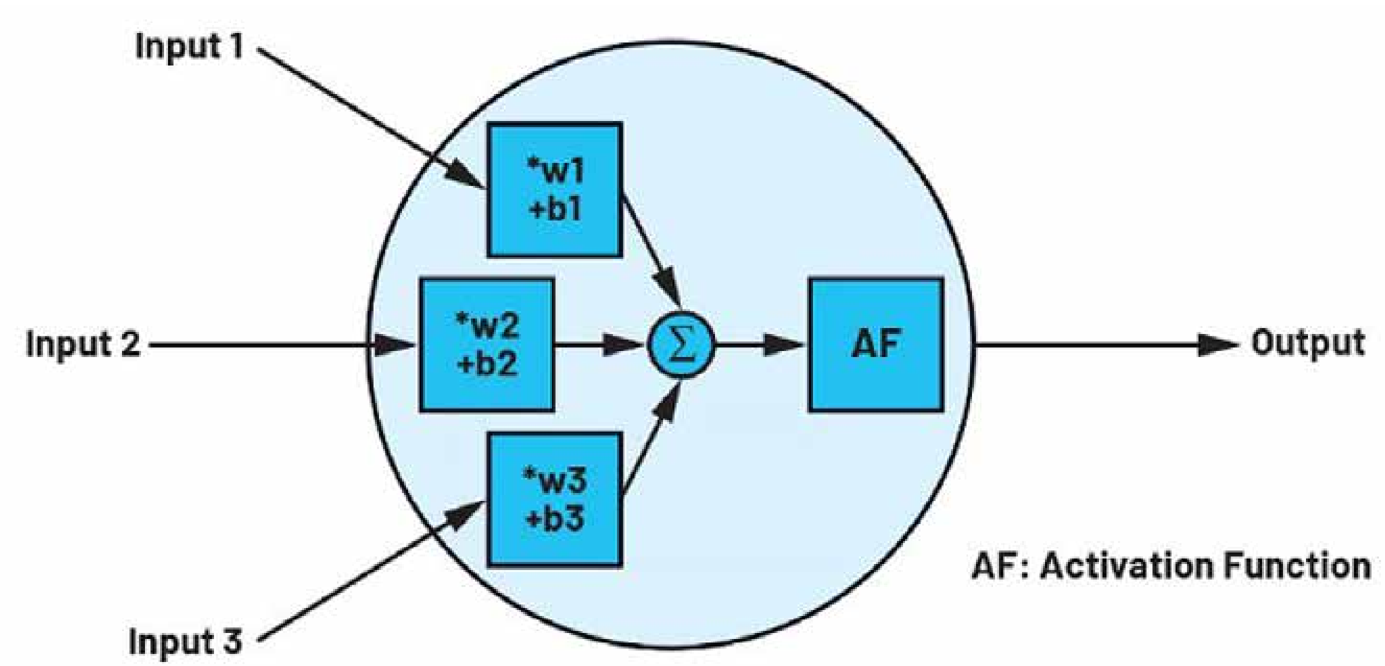
As a result, IT specialists don't always grasp the needs and challenges of their counterparts in OT, who have valid reasons for keeping reliable applications around for a long time. To align their needs and objectives with IT, they need surer footing to navigate today's cybersecurity requirements and quality solutions to bring to the table. By developing a deeper understanding of these principles, OT operators and control engineers can align their systems with everything AI has to offer without putting their organizations at risk.

Barry Turner, Technical Business Development Manager, ***Red Lion Controls.***

Learn More

Convolutional neural networks: machine learning—Part 1

The main application areas for Convolutional Neural Networks (CNN) are pattern recognition and classification of objects contained in input data. This first part of a three part series in this issue explore how CNNs are a type of artificial neural network used in deep learning.



SOURCE: ANALOG DEVICES

Figure 1. A neuron with three inputs and one output.

THE WORLD OF ARTIFICIAL INTELLIGENCE (AI) is rapidly evolving, and AI is increasingly enabling applications that were previously unattainable or very difficult to implement. This series of articles explains convolutional neural networks (CNNs) and their significance in machine learning within AI systems. CNNs are powerful tools for extracting features from complex data.

This includes, for example, complex pattern recognition in audio signals or images. This article discusses the advantages of CNNs vs. classic linear programming. A subsequent article, "Training Convolutional Neural Networks: What Is Machine Learning?—Part 2" will discuss how CNN models are trained. Part 3 will examine a specific use case to test the model using a dedicated AI microcontroller.

Convolutional neural networks

Neural networks are systems, or structures of neurons, that enable AI to better understand data, allowing it to solve complex problems. While there are numerous network types, this series of articles will solely focus on convolutional neural networks (CNNs).

The main application areas for CNNs are pattern recognition and classification of objects contained in input data. CNNs are a type of artificial neural network used in deep learning. Such networks are composed of an input layer, several convolutional layers, and an output layer. The convolutional layers are the most important components, as they use a unique set of weights and filters that allow the network to extract features from the input data.

Data can come in many different forms, such as images, audio, and text. This feature extraction process enables the CNN to identify patterns in the data. By extracting features from data, CNNs enable engineers to create more effective and efficient applications. To better understand CNNs, we will first discuss classic linear programming.

Linear program execution in classic control engineering

In control engineering, the task lies in reading data from one or more sensors, processing it, responding to it according to rules, and displaying or forwarding the results. For example, a temperature regulator measures temperature every second through a microcontroller unit (MCU) that reads the data from the temperature sensor. The values derived from the sensor serve as input data for the closed-loop control system and are compared with the setpoint temperature in a loop. This is an example of a linear execution, run by the MCU. This technique delivers conclusive outcomes based on a set of preprogrammed and actual values. In contrast, probabilities play a role in the operation of AI systems.

Complex pattern and signal processing

There are also numerous applications that work with input data that first must be interpreted by a pattern recognition system. Pattern recognition can be applied to different data structures. In our examples, we restrict ourselves to one- and two-dimensional data structures. Some examples are as follows: audio signals, electrocardiograms (ECGs), photoplethysmographs (PPGs), vibrations for one-dimensional data and images, thermal images, and waterfall charts for two-dimensional data.

In pattern recognition used for the cases mentioned, conversion of the application in classic code for the MCU is extremely difficult. An example is the recognition of an object (for example, a cat) in an image. In this case, it

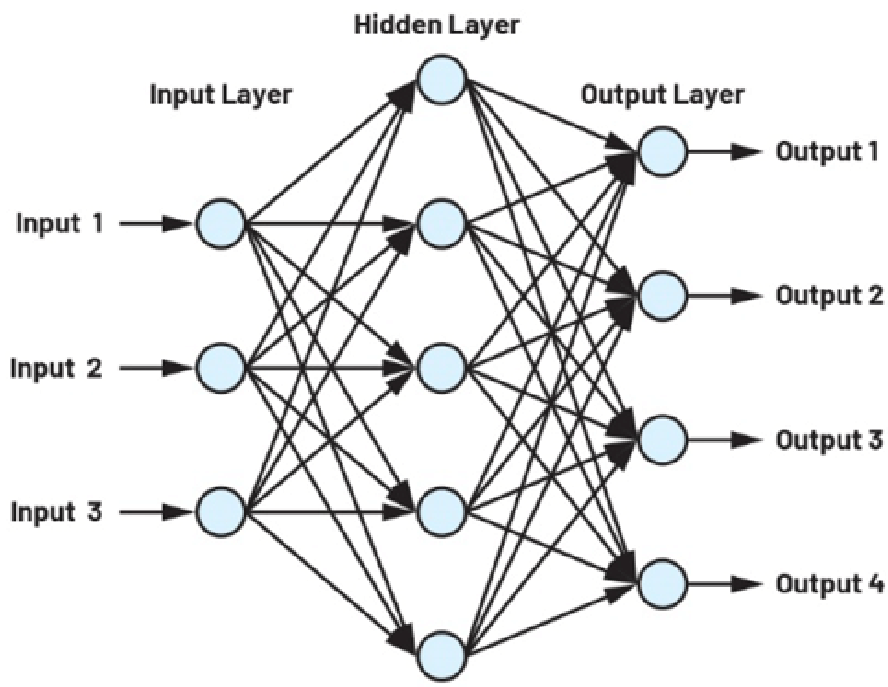


Figure 2. A small neural network.

doesn't make a difference if the image to be analyzed is from an earlier recording or one just read by a camera sensor. The analysis software performs a rules-based search for patterns that can be attributed to those of a cat: the typical pointed ears, the triangular nose, or the whiskers.

If these features can be recognized in the image, the software reports a cat find. Some questions arise here: What would the pattern recognition system do if the cat is only shown from the back? What would happen if it didn't have any whiskers or lost its legs in an accident? Despite the unlikelihood of these exceptions, the pattern recognition code would have to check a large number of additional rules covering all possible anomalies. Even in our simple example, the rules set by the software would quickly become extensive.

How machine learning replaces classic rules

The idea behind AI is to mimic human learning on a small scale. Instead of formulating a large number of if-then rules, we model a universal pattern recognition machine. The key difference between the two approaches is that AI, in contrast to a set of rules, does not deliver a clear result.

Instead of reporting "I recognized a cat in the image," machine learning yields the result "There is a 97.5% probability that the image shows a cat. It could also be a leopard (2.1%) or a tiger (0.4%)." This means that the developer of such an application must decide at the end of the pattern recognition process. A decision threshold is used for this.

Another difference is that a pattern recognition machine is not equipped with fixed rules. Instead, it is trained. In this learning process, a neural network is shown a large number of cat images. In the end, this network is capable of independently recognizing whether there is a cat in an image or not. The crucial point is that future recognition is not restricted to already known training images. This neural network needs to be mapped into an MCU.

What does a pattern recognition machine look like on the inside?

A network of neurons in AI resembles its biological counterpart in the human brain. A neuron has several inputs and just one output. Basically, such a neuron is nothing other than a linear transformation of the inputs—multiplication of the inputs by numbers (weights, w) and addition of a constant (bias, b)—followed by a fixed nonlinear function that is also known as an activation function.

This activation function, as the only nonlinear component of the network, serves to define the value range in which an artificial neuron fires. The function of a neuron can be described mathematically as:

$$Out=f(w*x+b) \qquad (1)$$

where f = the activation function, w = weight, x = input data, and b = bias. The data can occur as individual scalars, vectors, or in matrix form. Figure 1 shows a neuron with three inputs and a ReLU[2] activation function. Neurons in a network are always arranged in layers.

As mentioned, CNNs are used for pattern recognition and classification of objects contained in input data. CNNs are divided into various sections: one input layer, several hidden layers, and one output layer. A small network with three inputs, one hidden layer with five neurons, and one output layer with four outputs can be seen in Figure 2. All neuron outputs are connected to all inputs in the next layer. The network shown in Figure 2 is not able to process meaningful tasks and is used here for demonstration purposes only. Even in this small network, there are 32 biases and 32 weights in the equation used to describe the network.

A CIFAR neural network is a type of CNN that is widely used in image recognition tasks. It consists of two main types of layers: convolutional layers and pooling layers, which are both utilized to great effect in the training of neural networks. The convolutional layer uses a mathematical operation called convolution to identify patterns within an array of pixel values. Convolution occurs in hidden layers, as can be seen in Figure 3. This process is repeated multiple times until the desired level of accuracy is achieved. Note that the output value from a convolution operation is always especially high if the two input values to be compared (image and filter, in this case) are similar. This is called a filter matrix, which is also known as a filter kernel or just a filter. The results are then passed into the pooling layer, which generates a feature map—a representation of the input data that identifies important features. This is considered to be another filter matrix. After training—in the operational state of the network—these feature maps are compared with the input data. Because the feature maps hold object class-specific characteristics that are compared with the input images, the output of the neurons will only trigger if the contents are alike. By combining these two approaches, the CIFAR network can be used to recognize and classify various objects in an image with high accuracy.

CIFAR-10 is one specific dataset commonly used for training CIFAR neural networks. It consists of 60,000 32 × 32 color images broken up into 10 classes that were collected from various sources like web pages, newsgroups, and personal imagery collections. Each class has 6000 images divided equally between training, testing, and validation sets, making it an ideal set for testing new computer vision architectures and other machine learning models.

The main difference between convolutional neural networks and other types of networks is the way in which they process data. Through filtering, the input data are successively examined for their properties. As the number of convolutional layers connected in series increases, so does the level of detail that can be recognized. The process starts with simple object properties, such as edges or points, after the first convolution and goes

SOURCE: ANALOG DEVICES

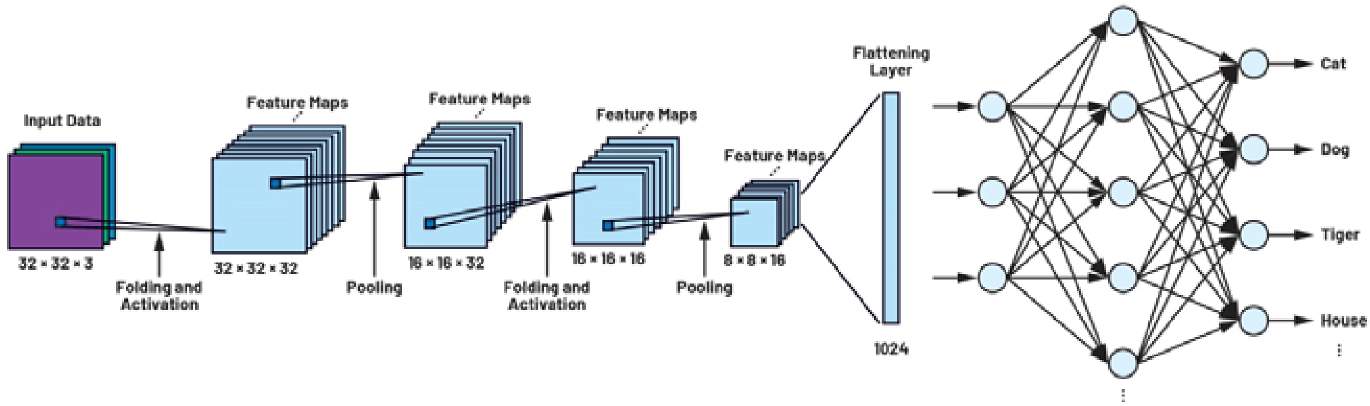


Figure 3. A model of the CIFAR network trained with the CIFAR-10 data set.

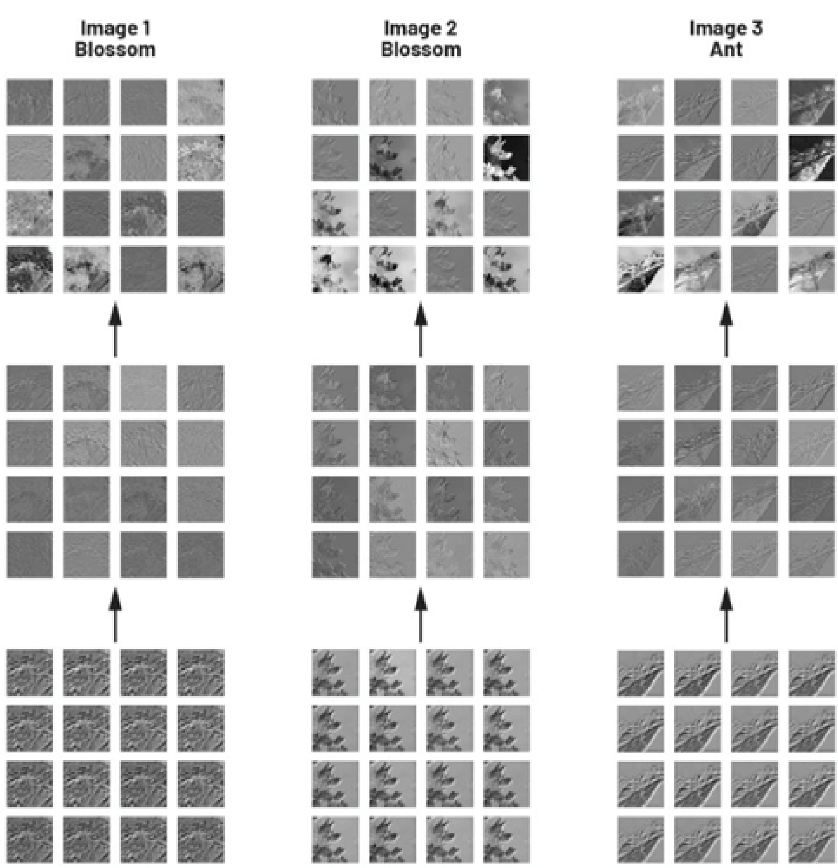
on to detailed structures, such as corners, circles, rectangles, etc., after the second convolution. After the third convolution, features represent complex patterns that resemble parts of objects in images and that usually are unique to the given object class. In our initial example, these are the whiskers or ears of a cat. Visualization of the feature maps—which can be seen in Figure 4—is not necessary for the application itself, but it helps in the understanding of the convolution.

Even small networks such as CIFAR consist of hundreds of neurons in each layer and many layers connected in series. The number of necessary weights and biases grows rapidly with increasing complexity and size of the network. In the CIFAR-10 example pictured in Figure 3, there are already 200,000 parameters that require a determined set of values during the training process. The feature maps can be further processed by pooling layers that reduce the number of parameters that need to be trained while still preserving important information.

As mentioned, after every convolution in a CNN, pooling, often also referred to in literature as subsampling, often occurs. This serves to reduce the dimensions of the data. If you look at the feature maps in Figure 4, you notice that large regions contain little to no meaningful information. This is because the objects do not make up the entire image, but only a small part of it. The remaining part of the image is not used in this feature map and is hence not relevant for the classification. In a pooling layer, both the pooling type (maximum or average) and the window matrix size are specified. The window matrix is moved in a stepwise manner across the input data during the pooling process. In maximum pooling, for example, the largest data value in the window is taken. All other values are discarded. In this way, the data is continuously reduced in number, and in the end, it forms, together with the convolutions, the unique properties of the respective object class.

However, the result of these convolution and pooling groups is a large number of two-dimensional matrices. To achieve our actual goal of classification, we convert the two-dimensional data to a long one-dimensional vector. The conversion is done in a so-called flattening layer, which is followed by one or two fully connected layers. The neurons in the last two layer types are similar to the structure shown in Figure 2. The last layer of our neural network has exactly as many outputs as there are classes to be distinguished. In addition, in the last layer, the data are also normalized to yield a probability distribution (97.5% cat, 2.1% leopard, 0.4% tiger, etc.).

This concludes the modeling of our neural network. However, the weights and contents of the kernel and filter matrices are still unknown and must be determined through network training in order for the model to work. This will be explained in the subsequent article, "Training Convolutional Neural Networks: What Is Machine Learning?—Part 2." Part 3 will explain the hardware implementation for the neural network we have discussed (for cat recognition, as an example). For this, we will use the MAX78000 artificial intelligence microcontroller with a hardware-based CNN accelerator developed by Analog Devices.



SOURCE: ANALOG DEVICES

Figure 4. Feature maps for a CNN.

Ole Dreessen, Staff Engineer - Field Application, ***Analog Devices.***

Learn More

Convolutional neural networks: the training process—Part 2

This three part series of articles explains convolutional neural networks (CNNs) and their significance in machine learning within AI systems. CNNs are powerful tools for extracting features from complex data. Part 2 puts the focus on the training process for neural networks.

SOURCE: ISTOCKPHOTO

The world of artificial intelligence (AI) is rapidly evolving, and AI is increasingly enabling applications that were previously unattainable or very difficult to implement.

THIS IS PART 2 IN A SERIES OF ARTICLES focusing on the properties and applications of convolutional neural networks (CNNs), which are mainly used for pattern recognition and the classification of objects.

In the first article "Introduction to Convolutional Neural Networks: What Is Machine Learning?—Part 1," (starting on page 17) we showed how a classic linear program execution in a microcontroller differs from a CNN and its advantages. We discussed the CIFAR network, with which it is possible to classify objects such as cats, houses, or bicycles in images or to perform simple voice pattern recognition. Part 2 explains how these neural networks can be trained to solve problems.

A subsequent article, Part 3, begins on page 23, with a focus on testing.

The training process for neural networks

The CIFAR network, which is discussed in the first part of the series, is made up of different layers of neurons, as shown in Figure 1. The image data from 32 pixels × 32 pixels are presented to the network and passed through the network layers. The first step in a CNN is to detect and investigate the unique features and structures of the objects to be differentiated. Filter matrices are used for this. Once a neural network such as the CIFAR has been modeled by a designer, these filter matrices are initially still undetermined and the network at this stage is still unable to detect patterns and objects.

To facilitate this, it is first necessary to determine all parameters and elements of the matrices to maximize the accuracy with which objects are detected or to minimize the loss function. This process is known as neural network training. For common applications as described in the first part of this series, the networks are trained once during development and testing. After that, they are ready for use and the parameters no longer need to be adjusted. If the system is classifying familiar objects, no additional training is necessary. Training is only necessary when the system is required to classify completely new objects.

Training data is required to train a network, and later, a similar set of data is used to test the accuracy of the network. In our CIFAR-10 network dataset, for example, the data are the set of images within the ten object classes: airplane, automobile, bird, cat, deer, dog, frog, horse, ship, and truck. However—and this is the most complicated part of the

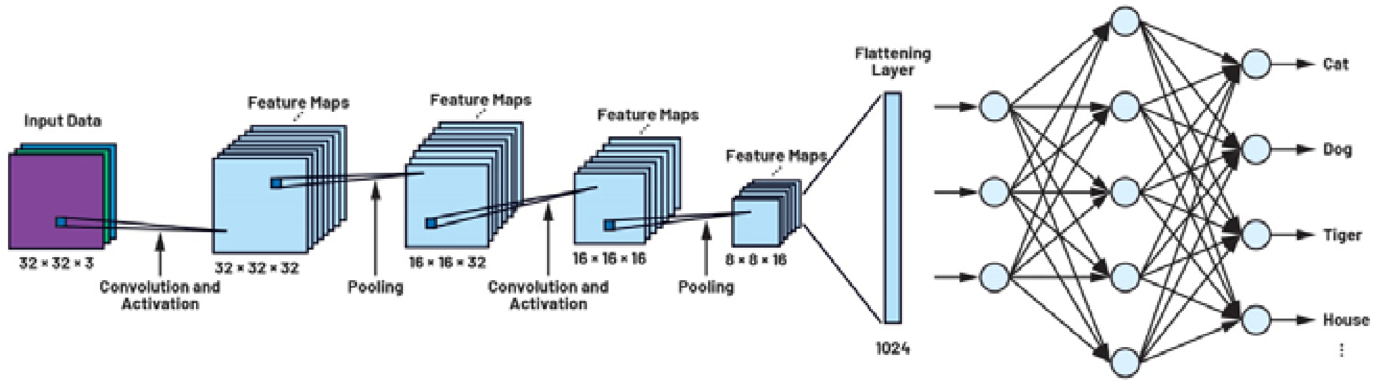


Figure 1. CIFAR CNN architecture.

overall development of an AI application—these images must be named before training a CNN.

The training process, which will be discussed in this article, works according to the principle of backpropagation; the network is shown numerous images in succession and simultaneously conveyed a target value each time. In our example, this value is the associated object class. Each time an image is shown, the filter matrices are optimized so that the target and actual values for the object class match. After this process has been completed, the network can also detect objects in images that it did not see during training.

Overfitting and underfitting

In neural network modeling, questions often arise around how complex a neural network should be—that is, how many layers it should have, or how large its filter matrices should be. There is no easy answer to this question. In connection with this, it is important to discuss network overfitting and underfitting. Overfitting is the result of an overly complex model with too many parameters.

We can determine whether a prediction model fits the training data too poorly or too well by comparing the training data loss with the test data loss. If the loss is low during training and increases excessively when the network is presented with test data that it has never been shown before, this is a strong indication that the network has memorized the training data instead of generalizing the pattern recognition. This mainly happens when the network has too much storage for parameters or too many convolution layers. In this case, the network size should be reduced.

Loss function and training algorithms

Learning is done in two steps. In the first step, the network is shown an image, which is then processed by a network of neurons to generate an output vector. The highest value of the output vector represents the detected object class, like a dog in our example, which in the training case does not yet necessarily have to be correct. This step is referred to as feedforward.

The difference between the target and actual values arising at the output is referred to as the loss and the associated function is the loss function. All elements and parameters of the network are included in the loss function. The goal of the neural network learning process is to define these parameters in such a way that the loss function is minimized. This minimization is achieved through a process

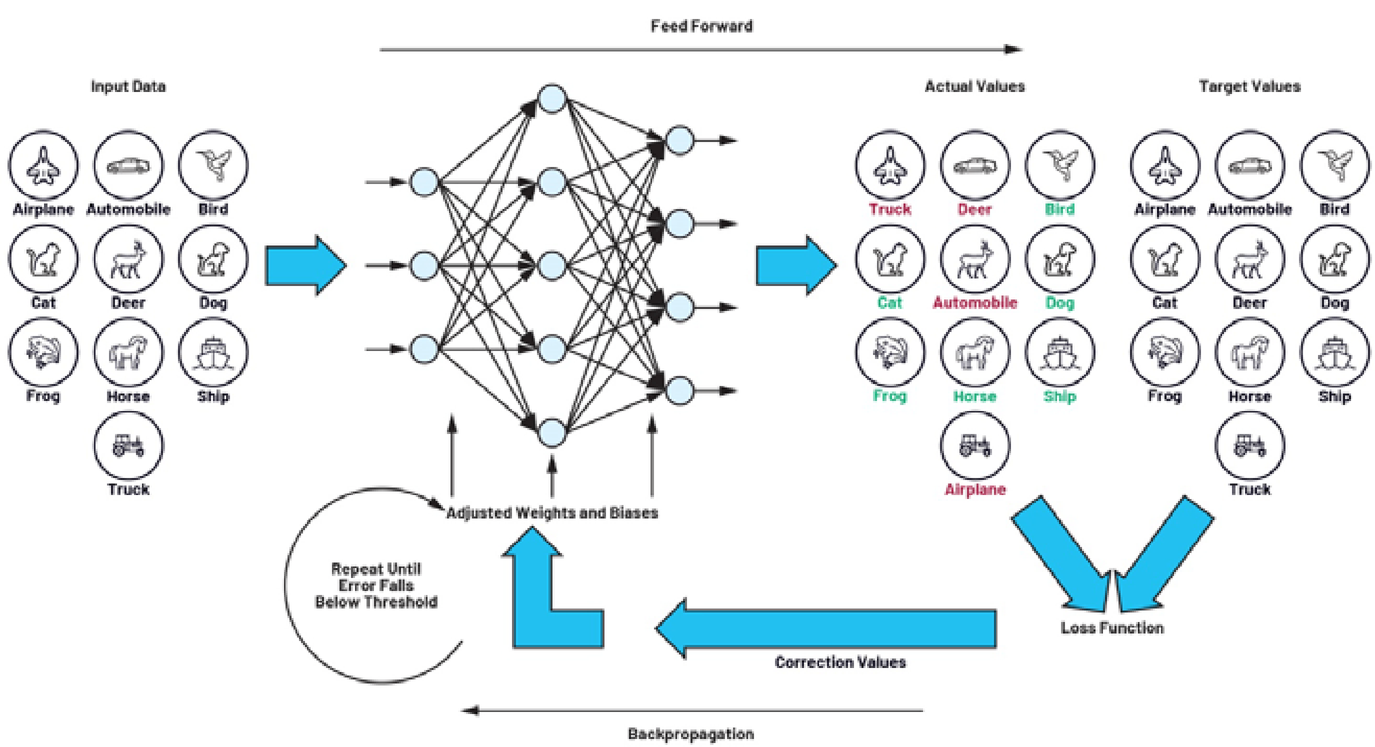


Figure 2. A training loop consisting of feedforward and backpropagation.

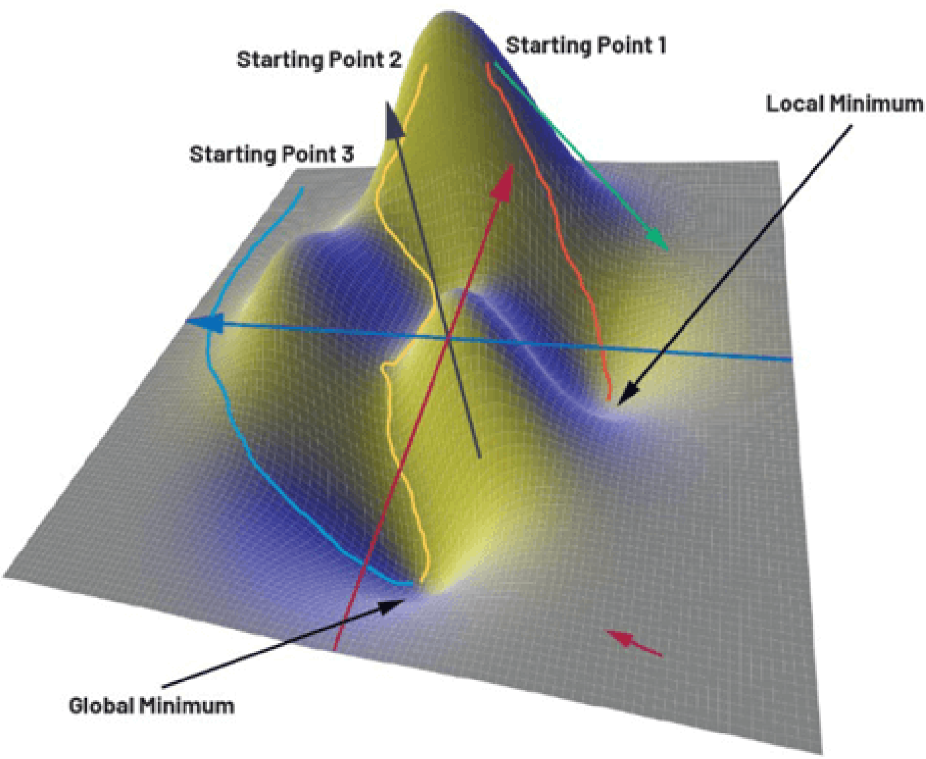


Figure 3. Different paths to the target using the gradient descent method.

in which the deviation arising at the output (loss = target value minus actual value) is fed backward through all components of the network until it reaches the starting layer of the network. This part of the learning process is also known as backpropagation.

A loop that determines the parameters of the filter matrices in a stepwise manner is thus yielded during the training process. This process of feedforward and backpropagation is repeated until the loss value drops below a previously defined value.

Optimization algorithm, gradient, and gradient descent method

To illustrate our training process, Figure 3 shows a loss function consisting of just the two parameters x and y. The z-axis corresponds to the loss. The function itself does not play a role here and is used for illustration purposes only. If we look more closely at the three-dimensional function plot, we can see that the function has a global minimum as well as a local minimum.

A large number of numerical optimization algorithms can be used to determine weights and biases. The simplest one is the gradient descent method. The gradient descent method is based on the idea of finding a path from a randomly chosen starting point in the loss function that leads to the global minimum, in a stepwise process using the gradient. The gradient, as a mathematical operator, describes the progression of a physical quantity. It delivers, at each point of our loss function, a vector—also known as a gradient vector—that points in the direction of the greatest change in the function value.

The magnitude of the vector corresponds to the amount of change. In the function in Figure 3, the gradient vector would point toward the minimum at a point somewhere in the lower right (red arrow). The magnitude would be low due to the flatness of the surface. The situation would be different close to the peak in the further region. Here, the vector (green arrow) points steeply downward and has a large magnitude because the relief is large.

With the gradient descent method, the path that leads into the valley with the steepest descent is iteratively sought—starting from an arbitrarily chosen point. This means that the optimization algorithm calculates the gradient at the starting point and takes a small step in the direction of the steepest descent. At this intermediate point, the gradient is recalculated and the path into the valley is continued. In this way, a path is created from the starting point to a point in the valley. The problem here is that the starting point is not defined in advance but must be chosen at random. In our two-dimensional map, the attentive reader will place the starting point somewhere on the left side of the function plot. This will ensure that the end of the (for example, blue) path is at the global minimum. The other two paths (yellow and orange) are either much longer or end at a local minimum. Because the optimization algorithm must optimize not just two parameters, but hundreds of thousands of parameters, it quickly becomes clear that the choice of the starting point can only be correct by chance. In practice, this approach does not appear to be helpful. This is because, depending on the selected starting point, the path, and thus, the training time may be long, or the target point may not be at the global minimum, in which case the network's accuracy will be reduced.

As a result, numerous optimization algorithms have been developed over the past few years to bypass the two problems described above. Some alternatives include the stochastic gradient descent method, momentum, AdaGrad, RMSProp, and Adam—just to name a few. The algorithm that is used in practice is determined by the developer of the network because each algorithm has specific advantages and disadvantages.

Training data

As discussed, during the training process, we supply the network with images marked with the right object classes such as automobile, ship, etc. For our example, we used an already existing CIFAR-10 dataset. In practice, AI may be applied beyond the recognition of cats, dogs, and automobiles.

If a new application must be developed to detect the quality of screws during the manufacturing process, for example, then the network also has to be trained with training data from good and bad screws. Creating such a dataset can be extremely laborious and time-consuming and is often the most expensive step in developing an AI application. Once the dataset has been compiled, it is divided up into training data and test data. The training data are used for training as previously described. The test data are used at the end of the development process to check the functionality of the trained network.

Conclusion

In the first part of this series "Introduction to the World of Artificial Intelligence: What Is Machine Learning?—Part 1," we described a neural network and examined its design and its functions in detail. Now that we have defined all the required weights and biases for the function, we can assume that the network can work properly.

In a subsequent article (part 3), we will test our neural network for recognizing cats by converting it into hardware. For this, we will use the MAX78000 artificial intelligence microcontroller with a hardware-based CNN accelerator developed by Analog Devices.

Ole Dreessen, Staff Engineer - Field Application, ***Analog Devices.***

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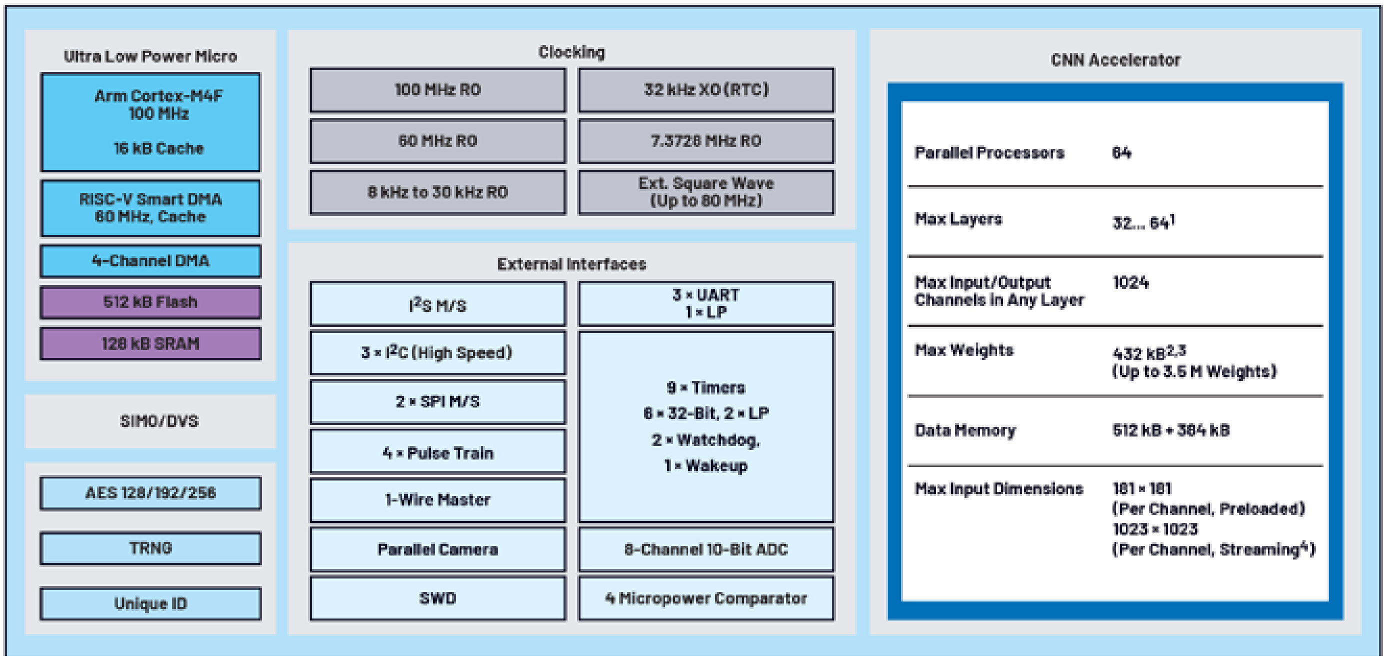
Convolutional neural networks: hardware conversion—Part 3

Previously, AI applications required massive energy consumption. Now, microcontrollers with a dedicated CNN accelerator make it possible to power AI applications from a single battery for extended periods. This breakthrough is making edge-AI accessible and unlocking the potential for exciting edge-AI applications.



SOURCE: ANALOG DEVICES

Figure 1. A MAX78000 block schematics.

IN THIS THREE-PART SERIES, WE HAVE BEEN exploring the properties and applications of convolutional neural networks (CNNs), which are mainly used for pattern recognition and the classification of objects. Part 3 will explain the hardware conversion of a CNN and specifically the benefits of using an artificial intelligence (AI) microcontroller with a hardware-based CNN accelerator—a technology that is enabling AI applications at the edge of the Internet of Things (IoT).

Previous articles in this series are "Introduction to Convolutional Neural Networks: What Is Machine Learning?—Part 1" and "Training Convolutional Neural Networks: What Is Machine Learning?—Part 2."

Introduction

AI applications require massive energy consumption, often in the form of server farms or expensive field programmable gate arrays (FPGAs). The challenge lies in increasing computational power while keeping energy consumption and costs low.

Now, AI applications are seeing a dramatic shift enabled by powerful Intelligent Edge computing. Compared to traditional firmware-based computation, hardware-based convolutional neural network acceleration is now ushering in a new era of computational performance with its impressive speed and power. By enabling sensor nodes to make their own decisions, Intelligent Edge technology dramatically reduces data transmission rates over 5G and Wi-Fi networks. This is powering emerging technologies and unique applications that were not previously possible. For example, smoke/fire detectors in remote locations or environmental data analysis right at the sensor level become reality—all with years of usage on a battery supply. To examine how these capabilities are made possible, this article explores the hardware conversion of a CNN with a dedicated AI microcontroller.

AI microcontroller with ultra low power convolutional neural network accelerator

The MAX78000 is an AI microcontroller with an ultra low power CNN accelerator, an advanced system on chip. It enables neural networks at ultra low power for resource-constrained edge devices or IoT applications. Such applications include object detection and classification, audio processing, sound classification, noise cancellation, facial recognition, time-series data processing for heart rate/health signal analysis, multisensor analysis, and predictive maintenance.

Figure 1 shows a block diagram of the MAX78000, which is powered up to 100 MHz by an Arm® Cortex®-M4F core with a floating-point unit. To give applications sufficient memory resources, this version of the microcontroller comes with 512 kB of flash and 128 kB of SRAM. Multiple external interfaces are included such as I²Cs, SPIs, and UARTs, as well as the I²S—which are important for audio applications. Additionally, there is an integrated 60 MHz RISC-V core. The RISC-V copies data from/to the individual peripheral blocks and the memory (flash and SRAM), making it a smart direct memory access (DMA) engine. The RISC-V core preprocesses the sensor data for the AI accelerator, so the Arm core can be in a deep sleep mode during this time. If necessary, the inference result can trigger the Arm core via an interrupt, and the Arm CPU then performs actions in the main application, passes on sensor data wirelessly, or informs the user.

A hardware accelerator unit for performing inference of convolutional neural networks is a distinct feature of the MAX7800x series

Table 1. CNN Inference Time and Energy per Inference for Three Different Scenarios

Scenario	Inference Speed (MS)	Energy per Inference (µWs)
(1) MAX32630, MNIST network in firmware	574	22887
(2) MAX78000, MNIST network in hardware	1.42	20.7
(3) MAX78000, MNIST network in hardware, optimized for low energy consumption	0.36	1.1

SOURCE: ANALOG DEVICES

of microcontrollers, which sets it apart from the standard microcontroller architecture and peripherals. This hardware accelerator can support complete CNN model architectures along with all the required parameters (weights and biases). The CNN accelerator is equipped with 64 parallel processors and an integrated memory with 442 kB for storing the parameters and 896 kB for the input data.

Because the model and parameters are stored in SRAM memory, they can be adjusted via firmware and the network can be adapted in real time. Depending on whether 1-, 2-, 4-, or 8-bit weights are used in the model, this memory can be sufficient for up to 3.5 million parameters. Because the memory capabilities are an integral part of the accelerator, the parameters do not have to be fetched via the microcontroller bus structure with each consecutive mathematical operation. This activity is costly due to high latencies and high power consumption. The neural network accelerator can support 32 or 64 layers, depending on the pooling function. The programmable image input/output size is up to 1024 × 1024 pixels for each layer.

CNN Hardware conversion: energy consumption and inference speed comparison

CNN inference is a complex calculations task comprising large linear equations in matrix form. Using the power of Arm Cortex-M4F microcontrollers, CNN inference on an embedded system's firmware is possible; however, there are certain drawbacks to consider. With firmware-based inference running on microcontrollers, energy and time are heavily consumed as the commands needed for calculation, along with associated parameter data, need to be retrieved from memory before intermediate results can then be written back.

Table 1 presents a comparison of CNN inference speed and energy consumption utilizing three different solutions. This example model was developed using MNIST, a handwritten digit recognition training set, which classifies digits and letters from visual input data to arrive at an accurate output result. The inference time required by each processor type was measured to determine differences between energy consumption and speed.

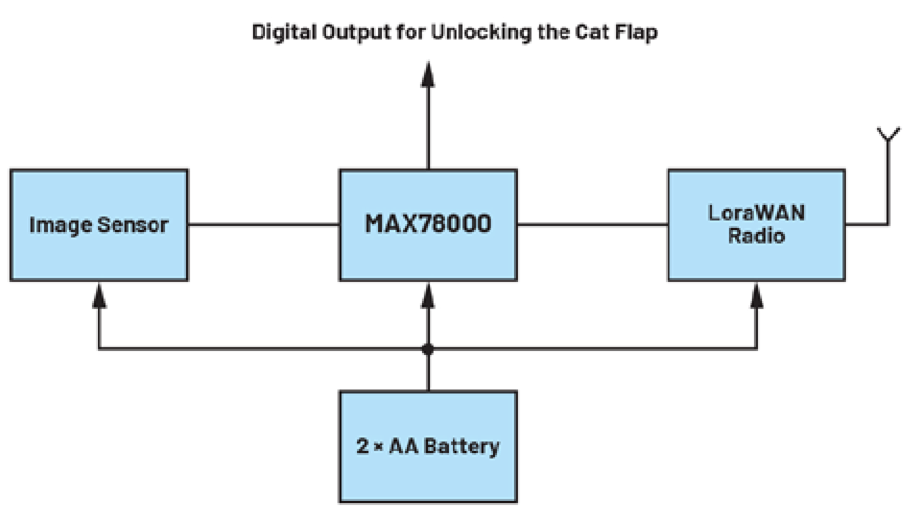
In the first scenario, an Arm Cortex-M4F processor integrated into the MAX32630, which runs at 96 MHz, was used to compute inference. In the second scenario, to process the computations, the MAX78000's hardware-based CNN accelerator was used. The inference speed—that is, the time between the presentation of the visual data at the network input and the output of the result—is lower by a factor of 400 when using a microcontroller with a hardware-based accelerator (MAX78000). Moreover, the required energy per inference is a factor of 1100 lower. In a third comparison, the MNIST network was optimized for minimal energy consumption per inference.

The accuracy of the result drops in this case from 99.6% to 95.6%. However, the network is much faster, requiring just 0.36 ms per inference. The energy consumption is reduced to a mere 1.1 µWs per inference. In applications that use two AA alkaline batteries (a total of 6 Wh of energy), five million inferences are possible (power consumed by the rest of the circuit is omitted).

These data illustrate the power of hardware-accelerated computation. Hardware-accelerated computing is an invaluable tool for applications unable to utilize connectivity or a continuous power supply. The MAX78000 enables edge processing without the demand for large amounts of energy, broadband internet access, or prolonged inference times.

Example use case for the MAX78000 AI microcontroller

The MAX78000 enables a multitude of potential applications, but let's examine the following use case as an example. The requirement is to design a battery-powered camera that detects when a cat is in the field of view of its image sensor and consequently enables access to the house, via a digital output through the cat door.
Figure 2 depicts an example block diagram for such a design. In this case, the RISC-V core switches the image sensor on at regular intervals and the image data is loaded into the CNN powered by the MAX78000. If the probability of a cat recognition is above a previously defined threshold, the cat door is enabled. The system then returns to standby mode.



SOURCE: ANALOG DEVICES

Figure 2. A block diagram of a smart pet door.

Development environments and evaluation kits

The process of developing an AI-on-the-edge application can be divided up into the following phases:

Phase 1: AI–Definition, training, and quantization of the network

Phase 2: Arm firmware–Inclusion of the networks and parameters generated in Phase

SOURCE: ANALOG DEVICES

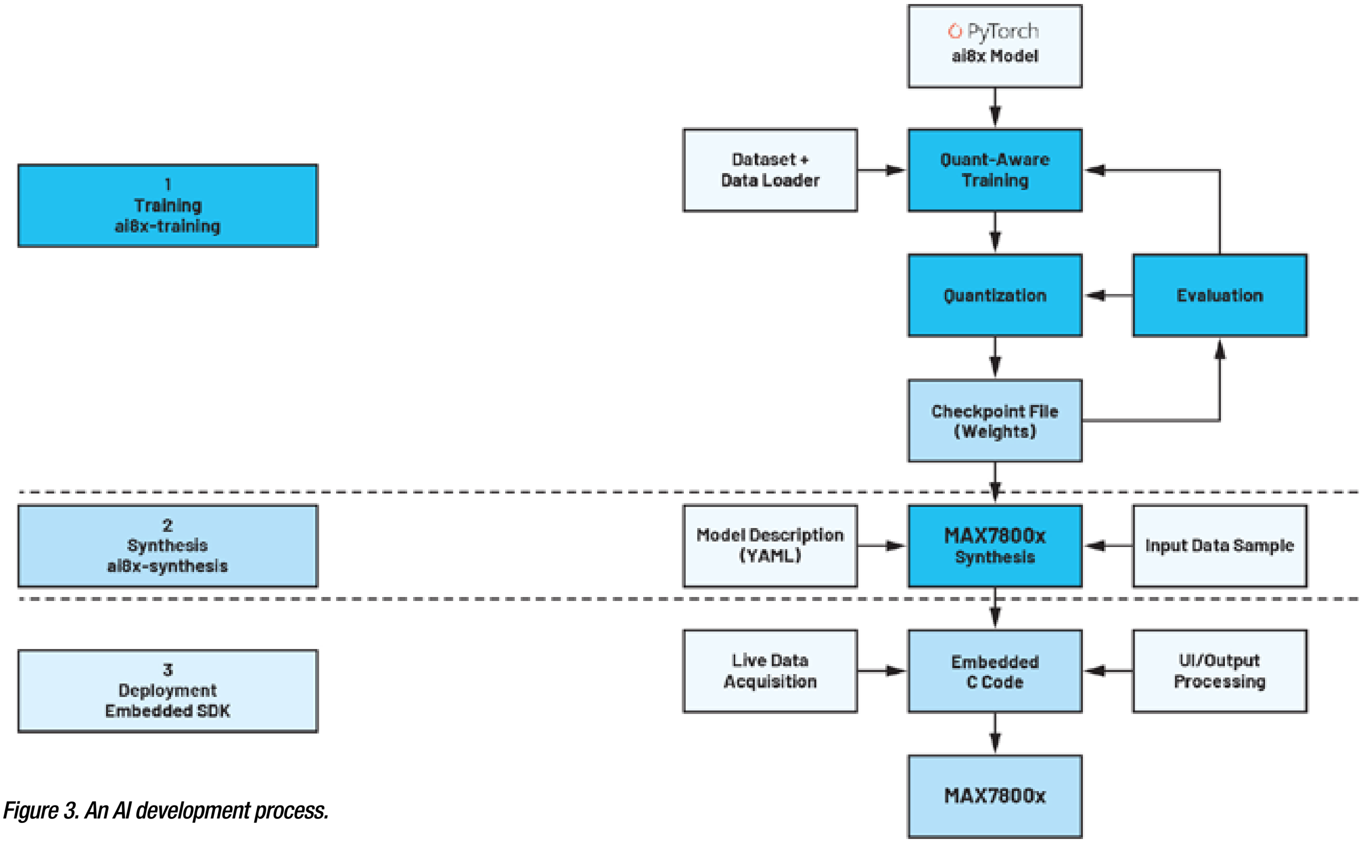


Figure 3. An AI development process.

1 in the C/C++ application and creation and testing of the application firmware

The first part of the development process involves modeling, training, and evaluating the AI models. For this stage, the developer can leverage open-source tools such as PyTorch and TensorFlow. The GitHub repository provides comprehensive resources to help users map out their journey in building and training AI networks using the PyTorch development environment while taking into consideration the hardware specifications of the MAX78000. Included in the repository are a few simple AI networks and applications like facial recognition (Face ID).

Figure 3 shows the typical AI development process in PyTorch. First, the network is modeled. It must be noted that not all MAX7800x microcontrollers have hardware that supports all data manipulations available in the PyTorch environment. For this reason, the file ai8x.py supplied by Analog Devices must first be included in the project.

This file contains the PyTorch modules and operators required for using the MAX78000. Based on this setup, the network can be built and then trained, evaluated, and quantized using the training data. The result of this step is a checkpoint file that contains the input data for the final synthesis process. In this final process step, the network and its parameters are converted to a form that fits into the hardware CNN accelerator. It should be mentioned here that network training can be done with any PC (notebook, server, etc.). However, without CUDA graphics card support, this can take a lot of time—even for small networks, days or even weeks are completely realistic.

In Phase 2 of the development process, the application firmware is created with the mechanism of writing data to the CNN accelerator and reading the results. The files created in the first phase are integrated into the C/C++ project via #include directives. Open-source tools such as Eclipse IDE and the GNU Toolchain are also used for the development environment for the microcontroller. ADI provides a software development kit (Maxim Micros SDK (Windows)) as an installer that already contains all the necessary components and configurations. The software development kit also contains peripheral drivers as well as examples and instructions to ease the process of developing applications.

Once the project has been compiled and linked without any errors, it can be evaluated on the target hardware. ADI has developed two different hardware platforms for this purpose. Figure 4 shows the MAX78000EVKIT, and Figure 5 shows the MAX78000FTHR, which is a somewhat smaller, feather form factor board. Each board comes with a VGA camera and a microphone.

SOURCE: ANALOG DEVICES

Figure 4. A MAX78000 evaluation kit.

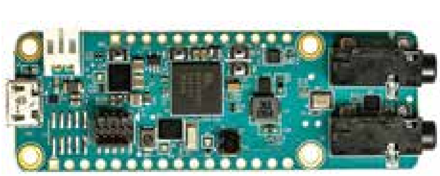


Figure 5. A MAX78000FTHR evaluation kit.

Conclusion

Previously, AI applications required massive energy consumption in the form of server farms or expensive FPGAs. Now, with the MAX78000 family of microcontrollers with a dedicated CNN accelerator, it's possible to power AI applications from a single battery for extended periods.

This breakthrough in energy efficiency and power is making edge-AI more accessible than ever before and unlocking the potential for new and exciting edge-AI applications that were previously impossible.

Ole Dreessen, Staff Engineer - Field Application, ***Analog Devices.***

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Tackling AI processing challenges at the Industrial Edge

The challenges industrial environments face when processing AI data at the edge can include cost and power constraints, as well as limited memory resources. While cloud solutions can accommodate higher costs and power requirements, edge applications often operate within stricter financial and energy limits.

SOURCE: ISTOCKPHOTO

Providing "eyes" around any scene: *Embedded vision in robotics and drones extends perception to more places, often ones difficult for humans to reach easily.*

As Artificial Intelligence (AI) technology shifts from centralized cloud systems to 'the edge,' industrial applications face major hurdles in processing AI data. A key challenge is balancing AI performance with power efficiency, particularly for demanding tasks like Generative AI, where high performance demands often clash with energy constraints. Real-time processing is crucial for industries needing timely data-driven decisions, but doing so with limited resources remains a significant obstacle.

For instance, applications such as autonomous vehicles (drones, cars, industrial robots), where instantaneous decision-making is essential–any delay in data processing could have dire consequences. Additionally, integrating new AI technologies with existing architectures and legacy systems often poses significant technical, cost, and institutional hurdles. Expanding AI applications to edge environments can also increase exposure to cyber threats.

When AI processing relies on continuous cloud communication due to limited edge capabilities, it increases the risk of exposing critical data, highlighting the importance of robust security measures. AI platforms capable of in-system processing without relying on cloud communication are therefore more desirable, offering lower latency and higher levels of safety and security.

Finally, challenges with AI applications at the edge can include cost and power constraints, as well as limited memory resources. While cloud solutions can accommodate higher costs and power requirements, edge applications often operate within stricter financial and energy limits, making lower-cost, energy-efficient AI processing crucial.

Furthermore, the memory capacity at the edge is limited compared to cloud systems, necessitating efficient use of available memory to maintain high performance. Physical space constraints further complicate matters, as edge devices must fit within compact environments such as drones, 5G base stations, manufacturing robots, or aerospace solutions.

Overcoming these challenges

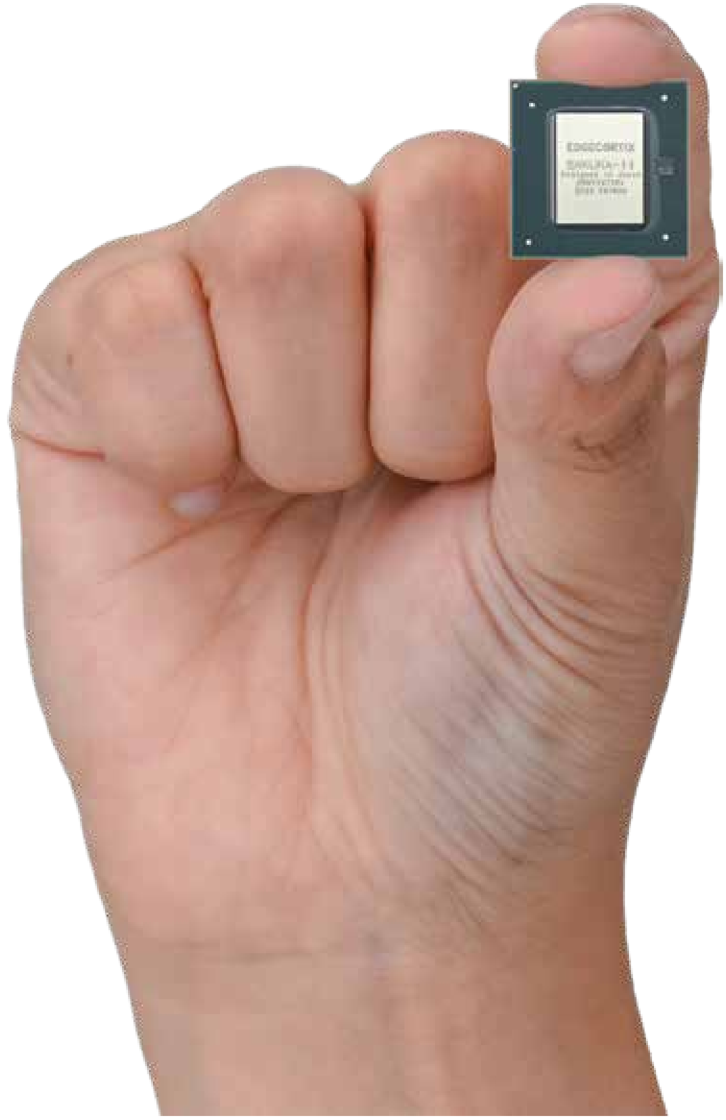
EdgeCortix addresses these challenges with innovative solutions. The company's SAKURA-II AI accelerator platform is designed to deliver near cloud-level AI performance while drastically improving energy efficiency, making it exceptionally suitable for demanding edge workloads. Additionally, the Dynamic Neural Accelerator® (DNA) architecture provides runtime reconfiguration, optimizing data paths for efficiency while providing real-time processing capabilities, which ensures low latency—a key requirement for edge applications.

The MERA Compiler Framework facilitates the deployment of AI models in a framework-agnostic manner, supporting seamless integration with existing systems and diverse processor architectures. EdgeCortix also offers modular AI accelerator solutions, such as PCIe Cards and M.2 Modules, which seamlessly integrate into existing systems to streamline AI deployment timelines.

Real-world applications

Real-world deployment examples illustrate the effectiveness of these solutions. In smart cities, EdgeCortix technology can enhance AI capabilities for traffic management and security monitoring by processing large volumes of data from cameras and sensors in real-time. Additionally, edge AI solutions can improve public safety by enabling high-resolution video analysis in crowded areas and enhance emergency response with accurate recognition of people and objects.

In manufacturing, edge AI solutions can optimize production lines, predict equipment failures, and improve quality control through immediate sensor data analysis, improving overall efficiency and reducing downtime. In the aerospace industry, these solutions can monitor aircraft engine performance and predict component wear, contributing to safety and reliability while lowering maintenance costs.



SOURCE:-EDGE CORTIX

AI has many applications in sorting through volumes of big data coming from manufacturing floors today. At the edge, higher speed, higher resolution sensors including video reveal more about processes and product quality than ever.

SOURCE:-EDGE CORTIX

SAKURA-II is designed for applications requiring fast, real-time Batch=1 AI inferencing with excellent performance in a small footprint.

Overall, as AI continues to proliferate across various industries, the challenges faced by embedded designers transitioning from cloud to edge solutions become increasingly necessary and significantly more complex. Selecting the correct AI hardware solutions platform and provider is crucial in order to overcome these obstacles and successfully implement edge AI products. By evaluating AI accelerators, like EdgeCortix's SAKURA-II, against the key design challenges outlined, engineers can develop energy-efficient and high-performing solutions that meet the demands of modern applications within existing systems.

This shift toward edge AI not only enhances real-time data processing capabilities but also supports the growing need for cost-effective and scalable AI technologies across sectors such as smart cities, manufacturing, telecommunications, aerospace, and others. With the increased demand for Generative AI processing at the edge, it is critical for AI solutions to operate these complex, multi-billion parameter models efficiently with very low power consumption.

SAKURA-II meets these generative AI requirements using DNA architecture, optimizing data paths, and employing parallelized processing for maximum efficiency.

These advancements demonstrate EdgeCortix's ability to tackle the critical challenges of AI data processing at the edge across various business sectors. They also illustrate how EdgeCortix solutions are engineered to provide superior performance and power efficiency for edge AI applications.

Jeffrey H. Grosman, Executive VP of Marketing & US Operations, ***EdgeCortix.***

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Industry experts offer OPC UA solutions update

OPC UA solutions provide platform independence, secure data exchange, and scalability for industrial environments. Key advantages include standardized communication protocols and interoperable data models that simplify system integration. New cloud initiatives enhance the ability to aggregate and analyze data.

SOURCE: ISTOCKPHOTO

The OPC Unified Architecture (UA), released in 2008, is a platform independent service-oriented architecture that integrates all the functionality of the individual OPC Classic specifications into one extensible framework. This multi-layered approach accomplishes the original design specification by achieving goals including functional equivalence, platform independence, secure, extensible and comprehensive information modeling.

OPC UA TECHNOLOGY IS MAKING AN IMPACT in industrial automation applications as machine builders and end users leverage the technology to enable information exchange, achieve interoperability goals and integrate its security capabilities into a wide range of computer and networking technology solutions.

For this special report, the Industrial Ethernet Book reached out companies involved in developing technology solutions utilizing OPC UA technology. Here is what these industry experts had to say about the megatrends shaping the future of OPC UA for industrial networking, its influence on edge and cloud computing architectures and how the technology is advancing Industry 4.0 objectives. The future is bright as technology providers look to seamlessly integrate OPC UA with Ethernet-APL and TSN.

OPC UA security enhancements

Enables information exchange and facilitates applications like Digital Twins, AI and Metaverse.

According to Stefan Hoppe, President and Executive Director of the OPC Foundation, "OPC UA adoption is primarily being driven by the security enhancements that OPC UA brings to interoperable products. Combined with the exchange of standardized information, it provides a ready-to-use technology for information exchange throughout the automation pyramid and facilitates new applications like Digital Twins, AI and Metaverse, etc."

OPC UA update

Hoppe outlined a series of developments that are shaping the direction of OPC UA.

- First of all, multiple security authorities throughout the world have analyzed and confirmed the OPC UA approach for improved encryption and authentication mechanisms that ensure robust protection against cyber threats.
- Secondly, OPC UA's compatibility with IIoT platforms continues to support seamless connectivity, enabling predictive maintenance, remote monitoring, and analytics. This allows integrating OPC UA with edge devices, ensures real-time data processing, and localized control, enabling faster decision-making.
- In factory applications, it is critical to directly connect machines in horizontal architectures with one another. The OPC UA standardized Controller-to-

SOURCE: ISTOCKPHOTO

"Looking forward, we continue to engage industry experts from myriad domains to lend their know-how to the development and global cooperation on new information models. GenAI is helping here, reducing the time spent on this work. Harmonization of all these models will ensure consistency and avoid double standardization." -- Stefan Hoppe, President and Executive Director, OPC Foundation.

Controller (C2C) communication, connecting all major PLC brands, is unique throughout the world, without any competition.

- Cloud scenarios provide centralized, semantic data storage, preserving the context of OPC UA-based information models, wherein data analytics can quickly and easily leverage standardized OPC UA data.
- Network infrastructure, like Ethernet-APL and TSN, are seamlessly integrated into OPC UA technology, thus, broadening additional fields of adoption.

"Looking forward, we continue to engage industry experts from myriad domains to lend their know-how to the development and global cooperation on new information models. GenAI is helping here, reducing the time spent on this work. Harmonization of all these models will ensure consistency and avoid double standardization," Hoppe said.

"With the ecosystem of collaboration growing, likewise, adoption will grow in the future. Observing OPC UA, now embedded in vending machines and even large industrial kitchen equipment, we see OPC UA is growing beyond the core industrial automation market," he added. "With end users frequently spreading the good news about OPC UA, they continue to accelerate adoption throughout their suppliers' offerings."

Technology distinctive

Hoppe said that OPC UA offers key technical advantages including the following:

- *Interoperability:* OPC UA provides platform-independent communication, enabling seamless integration of devices and systems across different vendors.
- *Scalability:* Suitable for even the smallest sensors, up to enterprise systems, OPC UA scales effortlessly in industrial environments.
- *Security:* Built-in encryption, authentication, and access control ensures secure data exchange. Very uniquely, it also covers security configuration, which is omitted by many other technologies.
- *Data Modeling:* Rich, standardized information modeling supports complex data structures and enhances system interoperability.
- *Reliability:* OPC UA ensures high reliability with redundancy and failover mechanisms for continuous operation.
- *Internationality:* OPC UA is an IEC standard with over 1010 members. The OPC Foundation brings to the table all major suppliers from both OT and IT, spanning all continents of the world.

Cloud initiative

He added that the OPC Foundation Cloud Initiative has three primary goals:

- *Standardized interoperability:* Accelerate interoperability of IT and cloud applications using OPC UA, e.g. data analytics using AI, industrial data spaces, digital product passports, industrial metaverse, as well as digital twin applications.
- *Best practices:* Create a cloud reference architecture to provide best practices to further increase standardized data sharing and cloud-optimized profiles for the OPC UA standard.
- *Semantic Data Models in the Cloud:* Preserve and Maintain OPC UA Information Models (Companion Specifications) within the cloud to utilize the context of data inside and across cloud services.

OPC UA certification also ensures compliance with the OPC UA specifications to provide high levels of interoperability and security, boosting user confidence and system reliability. The OPC Foundation Cloud Initiative will establish validation and certification for OPC UA Cloud Interoperability, including a new Protected Identity for OPC UA Cloud eXchange "UACXTM", which makes it easy for end users to order a set of functionalities.

Applications focus

"Applications in factory automation require direct, horizontal communication. We will soon see the first products supporting the new OPC UA FX specifications by the Field Level Communications initiative," Hoppe said. "End-customers are asking for OPC UA over MQTT communication in order to connect their IIoT applications and assets to cloud infrastructure. This is one communication solution common to all cloud suppliers."

Hoppe said that several new OPC UA-based information models are focusing on energy activities, including electrolyzer assets. This market is rapidly growing as we humans strive to reduce the world's CO2 footprint. First-release products are already available.

Analyzing all of the challenges across various domains, Hoppe said that they

SOURCE: ISTOCKPHOTO

"The latest OPC UA systems address key engineering challenges by standardizing communication across devices, eliminating the need for custom interfaces or middleware. " -- Dan White, Director of Technical Marketing for Opto 22.

always see identical requirements for IoT and Enterprise Connectivity. In the end, it's once again the same key factors, like interoperability, based on standardized data, which requires data modeling, a secure reliable connection between OT and IT, and (sometimes underestimated) a scalable solution (supporting diverse IoT ecosystems, from edge devices to enterprise-level systems). While other associations start to define new solutions for Digital Twins, OPC UA is enabling the creation and management of digital twins for improved asset management and process optimization.

Engineering challenges

"We have noticed that an increasingly connected world continues to run into engineering challenges of data complexity, like trying to simplify the handling of complex, multi-source data with robust information modeling and semantic frameworks. The OPC Foundation addresses this with Companion Specifications by expanding domain-specific standards for seamless implementation across industry verticals," Hoppe said.

Additional challenges found within the cybersecurity threat landscape are being quickly solved with built-in encryption, authentication, and access control mechanisms native to OPC UA. The OPC Foundation continues its work to enhance the security standard, continuously updating security configuration by onboarding additional security concepts to meet evolving threats.

"Overall, we have significantly reduced complexity. As a young engineer, I started the development of an OPC UA server application that, in those days, took several months to complete. In contrast, today's two-day hackathons – organized by domain specific groups, like the Laboratory and Analytical Device Standard (LADS) – propel developers, giving them a huge jumpstart on an OPC UA server, including a domain-specific information model, facilitating all on-board connectivity, all wrapped up by the end of the workshop," Hoppe said.

OPC UA and MQTT Sparkplug

Direct connection eliminates middleware, simplifies system architectures, reduces costs, and improves data sharing.

"Modern edge devices like PLCs, energy monitors, and flexible I/O systems now include OPC UA servers onboard," said Dan White, Director of Technical Marketing for Opto 22. "Running an OPC UA server directly on an edge device, with built-in support for SSL/TLS, allows standardized and secure communication directly to SCADA systems, MES platforms, and cloud applications."

This direct connection eliminates the need for additional middleware, simplifying system architectures, reducing costs, and improving data sharing between devices. Some of these devices also support MQTT SparkplugB, making it easier, more efficient, and more secure to scale data flows from the edge to central servers or even the cloud.

White said that the next step in IIoT architecture is leveraging the symbiotic strengths of OPC UA and MQTT Sparkplug.

- *OPC UA, built on a poll/response architecture,* excels in managing diverse industrial protocols with a robust ecosystem of native drivers for industrial equipment already on the plant floor.
- *MQTT Sparkplug's publish/subscribe model* enables efficient, real-time edge-originated communication. Together, they complement each other, combining robust data handling with scalable, event-driven messaging for a cohesive IIoT framework.

Technology benefits

OPC UA solutions provide several key technical advantages. Robust driver libraries, offered by servers like Ignition, KEPServerEX, and Matrikon, enable direct communication with a wide range of existing plant floor equipment. OPC UA cross-platform compatibility makes it easy to integrate and communicate across different systems and devices. Building on the trusted legacy of OPC, OPC UA enhances security, scalability, and flexibility while maintaining compatibility with existing systems.

"Cloud initiatives reduce the complexity of on-site systems by shifting data storage, analysis, and monitoring to the cloud. Traditionally, on-site systems required significant infrastructure, including servers, databases, and software, all of which needed regular maintenance, updates, and security measures. On-site setup often meant high costs, extensive IT support, and limited scalability," White said.

"Using cloud platforms, edge devices can securely send data for real-time monitoring


SOURCE: ISTOCKPHOTO

"The PLC-based OPC UA Client enables our PLCnext Controls to act as OPC UA clients. This allows hierarchical communication structures with aggregation layers based on OPC UA." -- Dr. Andreas Würger, Technology Manager, PLC Next Technology, Phoenix Contact.

and analytics without needing local servers or complex hardware. Updates, backups, and scalability are handled by the cloud provider, reducing the burden on on-site teams. This shift allows organizations to focus on operations rather than IT management, enabling faster adoption of IIoT solutions," he added.

Targeted applications

White said the newest OPC UA solutions are targeting individual machine builders who want to offer standardized connectivity directly from their equipment. In the Industrial Internet of Things (IIoT), the "things" are the machines on the plant floor, which historically lacked their own OPC UA servers.

Now, with OPC UA servers embedded directly in edge devices, these machines can communicate securely and efficiently without needing external middleware. This shift simplifies integration, reduces complexity, and provides faster, easier access to production data.

Existing legacy machines can also take advantage of inexpensive edge devices with onboard OPC UA servers. For under $1,000, you can take an existing machine, which was previously a black hole of data, and add an I/O device with an onboard OPC UA server, opening up access to uptime, downtime, and run rates that were previously recorded manually or not at all.

Addressing engineering challenges

"The latest OPC UA systems address key engineering challenges by standardizing communication across devices, eliminating the need for custom interfaces or middleware. They enhance data access by embedding OPC UA servers directly into edge devices, enabling even legacy machines to provide real-time production data without manual collection," White said.

With built-in encryption and authentication, OPC UA ensures secure data exchange, addressing the security limitations of traditional industrial protocols. These systems also support scalability and interoperability, integrating seamlessly with complementary technologies like MQTT Sparkplug to balance poll/response and publish/subscribe architectures.

"Together, these advancements enable engineers to design robust, secure, and scalable IIoT systems that bridge the gap between legacy infrastructure and modern industrial demands," White added.

DaUM and PLC-based OPC UA client

Combines data modeling, security and communication in a number of critical areas.

According to Dr. Andreas Würger, Technology Manager - Business Area Industry Management and Automation for PLC Next Technology, "the most important solutions are our device and update management application (DaUM) and our PLC-based OPC UA client."

"DaUM is an application that can be run on both Windows computers and Edge devices and enables the updating of software on devices via DI Standard (OPC UA specification Part 100). DaUM also contains a Global Discovery Server that can be used to manage and distribute device certificates," Würger said.

"The PLC-based OPC UA Client enables our PLCnext Controls to act as OPC UA clients. This allows hierarchical communication structures with aggregation layers based on OPC UA. Another highly important aspect is the ability to load and map external information models in the OPC UA server of the PLCnext controllers. This enables that all information models defined in the Companion Specifications of the OPC Foundation can be adapted," he said.

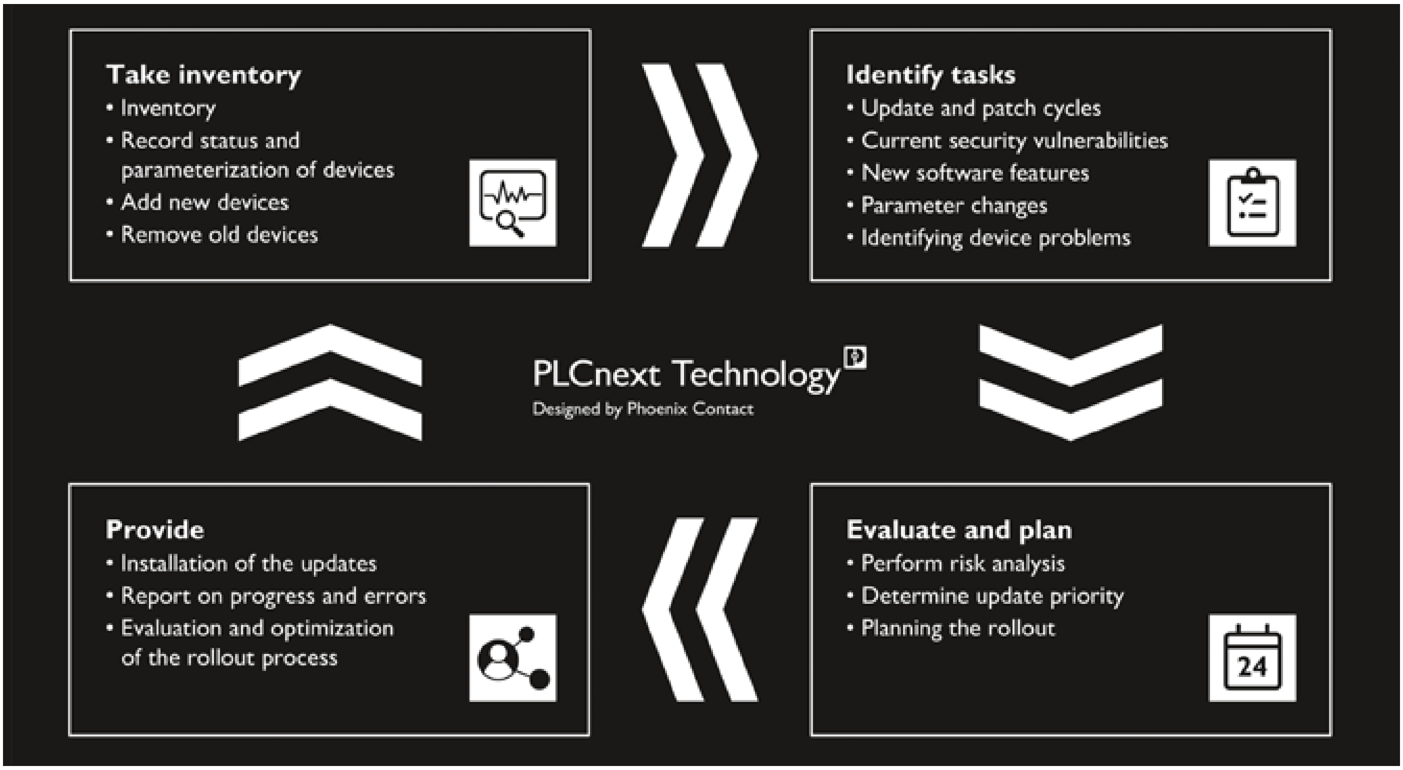
OPC UA solutions

Würger said that OPC UA combines the aspects of data modeling, security and communication in a number of critical areas:

- *Data modeling:* The modeling rules can also be used to create complex information models. There are also various companion standards that define model elements for specific assets or technologies.
- *Security:* OPC UA has built-in security mechanisms, such as encrypted data transfer and role-based access management.
- *Communication:* Various communication paradigms, such as client/server or pub/sub, are available for the transfer of data.

This combination makes OPC UA one of the most important technologies for the future of automation. We also have these three aspects in mind when using OPC UA as a technology, as the solutions mentioned above show.

Würger said that an important aspect for the future will be OPC UA PubSub via MQTT. He views this as the final piece of the puzzle towards end-to-end OPC UA



PLCnext Technology.

communication from the device to the cloud through any intermediate levels without breaks in communication technology, security architecture and data modeling.

DaUM enables the updating of software on devices and certificate management via GDS. DaUM's contribution to IoT and enterprise connectivity is that all devices and their software and certificates are monitored and managed at one central location.

"The PLC-based OPC UA client enables the PLC as a client to establish connections to subordinate servers. As already mentioned above, this allows hierarchical communication structures with aggregation layers to be set up in which a PLC coordinates other PLCs as the master controller," Würger said. "But PLC-based OPC UA Client also takes into account the fact that more and more complex devices have their own OPC UA servers, which can then be connected to the PLCnext controller via the client."

Engineering challenges

DaUM addresses the challenge of keeping the firmware and security of devices up to date. "However, OPC UA is such an important technology, a general engineering challenge that we want to address with our solutions is that the complexity of OPC UA does not exactly make it easy for new users to get started with the technology," Würger said.

For example, a user who only wants to implement a specific use case is quickly confronted with a number of standards, functions and models that are difficult to understand. This is precisely the scenario that Phoenix Contact wants to prevent with its OPC UA portfolio in the context of the PLCnext ecosystem.

He added that, to this end, they rely on a variety of simple and complex application examples for the various communication scenarios, helpful open source software tools and meaningful and intuitive documentation. For the PLC-based OPC UA client, for example, there is a free available test license and simple and complex project examples for free download.

OPC UA automation solutions

Driven by technology to enable edge and cloud connectivity using standardized communication.

"The adoption of OPC UA in automation and control is driven by key technologies such as edge computing, cloud connectivity, and standardized communication," said Andreas Röck, Head of Product Management Nuremberg at Softing Industrial Automation GmbH.

Softing Industrial Automation's OPC UA product portfolio, including solutions like dataFEED OPC Suite, encompass these technologies and provides seamless data integration from shop floor to cloud, enabling interoperability between devices from different manufacturers. Technologies such as PubSub over MQTT and Time-Sensitive Networking (TSN) are accelerating the adoption of OPC UA by supporting real-time communication and enhancing data flow efficiency."

"The next steps in OPC UA adoption involve broader implementation of OPC UA over TSN for deterministic control and increased certification initiatives to ensure device interoperability," Röck said. "Expansion into semantics-based data modeling is also key, as it enhances machine-readable contextualization, supporting applications like predictive maintenance and digital twins."

Standardized protocols

Röck said that OPC UA solutions provide platform independence, secure data exchange, and scalability for industrial environments. Key technical advantages include standardized communication protocols and interoperable data models that simplify system integration. These advantages are met by Softing's OPC UA offerings, such as edgeConnector solutions, which support seamless, secure data transfers between PLCs and enterprise IT systems via OPC UA and MQTT protocols.

New cloud initiatives enhance the ability to aggregate and analyze operational data from multiple sites, fostering global system optimization. Certification programs, like those driven by the OPC Foundation, ensure that OPC UA-enabled products adhere to robust standards for interoperability and cybersecurity. This certification increases trust, reduces integration risks, and enables faster deployment of cloud-based IoT solutions.

Applications

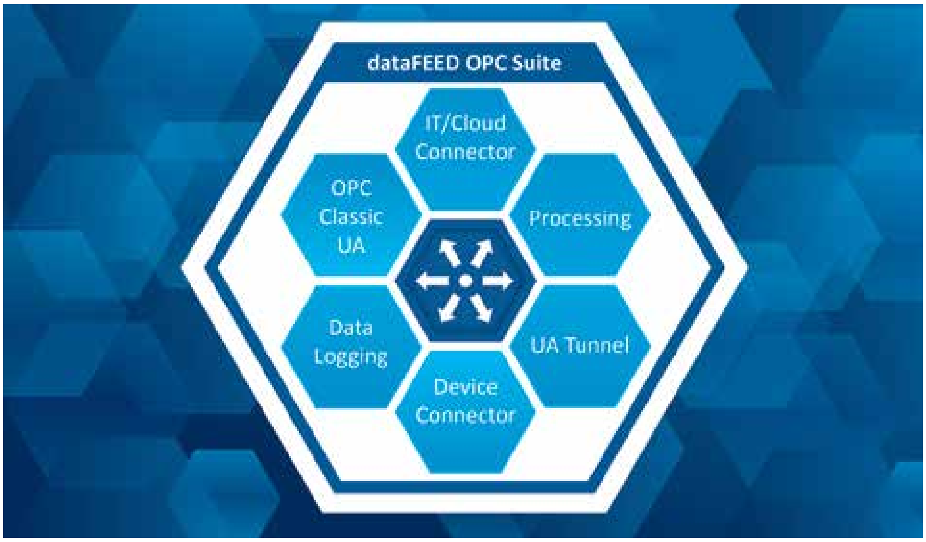
Röck said that modern OPC UA solutions target smart factories, energy management, predictive maintenance, and supply chain optimization. The Secure Integration Server from Softing, in particular, addresses smart data management by leveraging OPC UA to aggregate and secure data exchange between operational technology (OT) and IT systems, meeting industry compliance requirements.

"In IoT ecosystems, OPC UA supports seamless connectivity between sensors, controllers, and cloud applications, facilitating real-time monitoring and decision-making. OPC UA communication also contributes to edge-to-cloud integration, which is essential for scaling IoT infrastructures and achieving comprehensive digitalization," Röck said.

The latest OPC UA systems also address engineering challenges such as data silos, legacy system integration, and cybersecurity concerns.

"To meet evolving industry demands, specifications for OPC UA are enhanced with features like TSN for deterministic communication and information modeling for richer context representation," Röck said. "The development of OPC UA FX (Field eXchange) further supports real-time control and interoperability in factory environments, addressing the need for vendor-agnostic industrial control."

Röck said that Softing's offerings align with these advancements, providing robust solutions for seamless, secure communication across diverse architectures in support of comprehensive Industry 4.0 strategies.



SOURCE: SOFTING

The Secure Integration Server from Softing addresses smart data management by leveraging OPC UA to aggregate and secure data exchange between operational technology (OT) and IT systems.

Docker-based OPC UA software solutions run as containers and offer a flexible and scalable way to use OPC UA functionalities.

OPC UA information model

Visibility into manufacturing operations with a heterogeneous suite of software applications

According to Paul Brooks, senior manager, open architecture management at Rockwell Automation, the common thread in the advancements of OPC UA technology and adoption "is visibility into manufacturing operations with a heterogeneous suite of software applications needing to look at information from common sources to provide that information."

"It may be a machine builder monitoring the causes of downtime on their fleet of machines, or a manufacturer benchmarking energy consumption across lines and plants," Brooks said. "OPC UA became the de-facto standard for interoperable in-plant information gathering and the technology's next task is to establish the same position for plant to cloud information gathering."

Importance of information model

Brooks said that the heart of OPC UA is the information model, allowing endpoints to be self-describing, both of their own model and the context in which they are operating. This is complemented by the companion specification philosophy which allows applications to define the semantics and structure of the information that they gather. In a heterogenous environment, ensuring that both producer and consumer of the data interpret it the same way is invaluable!

"But OPC UA's biggest strength is non-technical; it is the breadth of adoption and the size of ecosystem," Brooks said. "The cloud initiative's biggest strength is that all the relevant hyper scalers are participating, and its success will be determined by their adoption more than specific technical details. To that end, critical mass is also needed for certification to have value - a certified server connected to an uncertified client offers no guarantee of interoperability. Certification must have broad adoption to be meaningful."

He added that the OPC Foundation has two primary initiatives: Field eXchange and Cloud eXchange. While technically very different, they serve a common purpose - driving available information sources as close to the manufactured product as possible (FX) and disseminating that information as wide as possible (CX). The combined outcome is that the number of "things" that can participate in an IoT solution grow, as do the number of IoT applications that can be used by enterprises.

Addressing challenges

Brooks said that industrial users want the same amount of flexibility in their professional lives as they do in their personal lives. It is easy to wear a fitness tracker on your wrist, connect your smart bathroom scale to the internet, and bring them together with your meal planning app, which feeds your local store's shopping list app. All from different vendors with different cloud storage but with a combined outcome of controlled weight loss.

"OPC UA needs to evolve to deliver that level of flexibility and interoperability to the IIoT without the user ever needing to know anything about the underlying technology or what needed to be done to deliver it," Brooks said.


SOURCE: ISTOCKPHOTO

"Industrial IoT (IIoT) is currently a main driver for the use of OPC UA, especially for OPC UAFX, often described in this context as the connectivity from the sensor to the cloud" -- Maik Seewald, Member of IEC and ISA99 industrial security workgroups and Senior Technical Lead, Industrial IoT at Cisco.

Impact of OPC UA FX and TSN

IIoT applications is a main driver using the OPC UA architectural framework.

New technology solutions including OPC UA FX, TSN and the Industrial Internet of Things (IIoT) are driving the adoption of OPC UA automation, control and networking solutions.

"Industrial IoT (IIoT) is currently a main driver for the use of OPC UA, especially for OPC UA FX, often described in this context as the connectivity from the sensor to the cloud," Maik Seewald, Member of IEC and ISA99 industrial security workgroups and Senior Technical Lead, Industrial IoT at Cisco told the Industrial Ethernet Book recently.

Seewald said that OPC UA FX introduces the publish/subscribe pattern in addition to the existing client/server within the OPC UA architectural framework. TSN as the underlying networking technology enables data exchange with guaranteed latency and high availability.

"In the next step, the capabilities of OPC UA FX will provide the opportunity to replace or extend existing M2M protocols to establish connectivity between devices in industrial automation, everything built on open standard technologies," Seewald said. "This pertains to controller to controller as well as to controller to device communication. Ultimately, OPC UA FX supports the architectural approach of virtualized control – moving the control logic (e.g.: PLC) into the cloud with benefits regarding business process integration, maintainability and agility of the entire automation solution."

Multi-platform framework

Seewald said that the OPC UA architecture encompasses a multi-platform framework comprising information model, communication protocols and built-in security. It is designed by taking advantage of a layered model which is extensible and allows the integration of new technologies, for instance wireless such as 5G or Wi-Fi.

OPC UA solutions enable network convergence, allowing services and protocols with different criticality and quality attributes on the same wire. As an example, the use of OPC UA FX in industrial automation supports a network design, where mission critical traffic (automation and control) co-exist with services such as audio and video on the same physical infrastructure without impacting stringent latency and availability requirements.

The use of OPC UA in the context of cloud deployments allows secure end-to-end communication in order to connect devices in the field (process) or on the factory floor (manufacturing) to highly configurable, extensible and business-centric applications, creating real Cyber-Physical Systems in industrial automation.

Certification initiatives such as the TSN Industrial Automation Conformance Collaboration (TIACC) are established to foster interoperability in the open and multi-vendor environment of OPC UA FX when using the TSN-profile for Industrial Automation (IEEE/IEC 60802) as part of the communication stack.

They are important to assure compliance with the underlying standards in order to enable a multi-vendor ecosystem.

Leveraging the IIoT

"The newest OPC UA solutions are evolving in the area of Industrial IoT (IIoT), connecting devices to applications running in the cloud," Seewald said. "This typically starts with simple use cases such acquisition of sensor data from the processes, and might lead to highly sophisticated solutions of virtualized control. Because of its multi-platform and multi-vendor approach, OPC UA allows the creation of secure end-to-end connectivity crossing layers of the automation pyramid (field, control, execution, ERP) and even allowing integration with external systems and processes."

He added that complex solutions built with OPC UA in the area of industrial or process automation require comprehensive planning and configuration, especially if determinism and network convergence are the objectives. Engineering challenges are often related to the provisioning of precise configuration data, especially in setups where multiple departments are involved. The OPC UA framework already contains the means to solve those complex tasks by providing an extensible information model and allowing open standard based network configuration using NETCONF/YANG.

Interoperability standards

Seamless integration makes OPC UA a universal language for industrial automation.

Konstantin Selnack, Product Owner - Industrial Connectivity Products at Siemens AG said that "the adoption of OPC UA in automation is driven, on the one hand, by the increasing

SOURCE: ISTOCKPHOTO

"The main challenge of data integration is being continuously addressed with a growing offering of OPC UA functionality and implementations." -- Konstantin Selnack, Product Owner - Industrial Connectivity Products at Siemens AG.

need for data acquisition and exchange in an open, interoperable manner across Operational Technology (OT) and Information Technology (IT), which is critical for Industry 4.0 implementations."

"But also, the standard itself, with its compelling capabilities for highly sophisticated communication, is driving the adoption. Continuously providing new features and involving more industrial domains is a convincing factor to apply OPC UA," Selnack said.

"In the end, these developments come together in the products and solutions of the technology providers. Today, OPC UA is not only found in controllers, but also in RFID readers, network management software and even power supplies. At the same time, these products are being expanded with additional OPC UA capabilities, he added.

Seamless integration

Selnack said that, first and foremost, OPC UA is the interoperability standard for industrial communication. It allows for seamless integration of different systems and devices, making it a universal language in industrial automation.

In addition, the information modeling of OPC UA provides the "grammar" which allows industrial domains to build their own semantics within Companion Specifications. The AutoID companion specification for instances, provides a standardized information model for RFID readers, allowing to seamlessly integrate a RFID reader independent from the vendor specifics.

In a nutshell, OPC UA allows for better data management and analysis, leading to process optimization, predictive maintenance, and other Industry 4.0 use cases.

"All this is based on a highly sophisticated communication standard. It uses Ethernet and therefore can be adapted to any network configuration, making it a versatile solution for connecting various systems of different scales within the industrial domain," Selnack said. "But it also provides a robust security architecture, which is essential for industrial communication. OPC UA includes features like authentication, authorization, encryption, and data integrity checks."

Integrating IT and OT

According to Selnack, the core concept of integrating OT with IT remains the primary focus, and OPC UA continues to expand its functionalities to support this integration. He said that a significant development is OPC UA PubSub, which incorporates MQTT to facilitate the connection with cloud-based applications. By utilizing OPC UA PubSub with MQTT, these solutions offer a direct data flow to cloud and IoT platforms, facilitating advanced data analysis and better decision-making, helping enterprises to achieve greater operational efficiency or reduce downtimes and maintenance cost.

But also managing OT devices with OPC UA capabilities is getting more attention. The addition of e.g., standardized REST-interfaces, certificate management via the Global Discovery Service or device updates via OPC UA shows that the adoption of IT technology is of big interest.

Another area of interest is interoperability at the field level. Here, OPC UA FX has been introduced, providing an open communication standard for connection establishment and data exchange of PLCs. UA FX is therefore bringing OPC UA benefits like interoperability or built-in security to the controller level.

Seamless integration

"OPC UA FX is a response to the need for seamless integration between diverse controller platforms, which traditionally has been a complex and painful process for line integrators and end-users. UA FX helps to reduce the integration and maintenance cost in these setups by providing a standardized information model and methods to interconnect controllers with each other," Selnack said. "It also supports the offline engineering of systems - a UA FX machine description will provide the required machine data which has to be exchanged, allowing to do the engineering upfront."

Another challenge is the realization of the increasing security requirements in operational environments. Certificate management for instance is a huge challenge and requires today a high effort. OPC UA Part 12, Discovery and Global Services, introduces the Global Discovery Server, which provides a framework to roll out and maintain certificates for OPC UA devices, providing a solution to this issue.

"Overall, the main challenge of data integration is being continuously addressed with a growing offering of OPC UA functionality and implementations," Selnack said. "Thus, the evolution of OPC UA reflects the ongoing needs of the industry and provides answers to today's and tomorrow's challenges."

*Al Presher, Editor, **Industrial Ethernet Book.***

Wireless Broadband Alliance: Wi-Fi predictions for 2025

The WBA Annual Industry Report 2025 showcases the technology trends that reflect how Wi-Fi is evolving to meet the demands of increased connectivity, higher speeds, better security, the growing number of devices connected to the internet and a greater focus on energy efficiency.

SOURCE: ISTOCKPHOTO

Early adopters of Wi-Fi 7 will include technology-driven industries and enterprises needing high-density, high-speed connectivity.

THE WIRELESS BROADBAND ALLIANCE (WBA), a global industry body dedicated to driving the seamless and interoperable service experience of Wi-Fi across the global wireless ecosystem, has shared ten predictions laid out by its President and CEO, Tiago Rodrigues, for Wi-Fi in 2025.

Detailed in full in the *WBA Annual Industry Report 2025*, these trends reflect how Wi-Fi is evolving to meet the demands of increased connectivity, higher speeds, better security, the growing number of devices connected to the internet and a greater focus on energy efficiency.

Tiago Rodrigues, President and CEO of the Wireless Broadband Alliance said: "The Wi-Fi industry has reached a pivotal moment. As demand for improved Wi-Fi user experience with seamless, secure, and high-performance connectivity continues to surge across homes, enterprises and cities, collaboration within our ecosystem is more critical than ever. At the WBA, we are committed to driving innovation, interoperability, and standards that empower the Wi-Fi and broadband connectivity industry to meet the needs of today while laying the foundation for tomorrow's connected world."

Wi-Fi predictions for 2025 and beyond

Wi-Fi 7 Adoption

Early adopters of Wi-Fi 7 will include technology-driven industries, smart home enthusiasts, and enterprises needing high-density, high-speed connectivity. Large tech companies and advanced enterprises will be among the first to implement Wi-Fi 7 in their office infrastructures to support increased demands from remote collaboration tools, IoT sensors, and high-definition video conferencing.

Smart cities will also lead the charge, adopting Wi-Fi 7 to enable real-time data collection from IoT devices for traffic management, public safety, and environmental monitoring. Public venues like stadiums, airports, and convention centers will adopt Wi-Fi 7 early to manage the connectivity needs of thousands of simultaneous users, providing seamless streaming and data access for fans, travelers, and attendees. Within the consumer sector, tech-savvy users and smart home aficionados will upgrade to Wi-Fi 7 routers to maximize the performance of their growing array of connected devices, such as smart appliances, security systems, and entertainment systems for 8K streaming and gaming.

6 GHz Expansion and AFC

AFC (Automated Frequency Coordination) systems will see phased rollouts across multiple regions, particularly in the United States, Canada, the European Union, and parts of Asia, as regulators increasingly approve 6 GHz use for unlicensed Wi-Fi under AFC management.

In the United States, the FCC will lead AFC implementation for standard-power Wi-Fi operations in the 6 GHz band, with licensed database administrators managing these AFC systems. Following the U.S. model, other countries are anticipated to adopt similar AFC frameworks, accelerating deployment in enterprise and public spaces by ensuring devices can operate at standard power levels in outdoor or high-traffic areas without compromising incumbent communications.

In Canada, AFC approval by regulatory bodies will drive adoption in urban areas and suburban networks, supporting widespread use in places like shopping centers, airports, and sports venues. In Europe, the European Telecommunications Standards Institute (ETSI) will likely coordinate region-specific AFC guidelines, balancing connectivity needs with incumbent protections.

AI-Driven Network Optimization

AI-powered routers and cloud platforms will analyze traffic patterns, adjust bandwidth allocation, and manage devices for optimal performance, particularly in smart homes and IoT-heavy environments. As hardware becomes increasingly commoditized, infrastructure vendors create their respective secret sauces to innovate and differentiate.

Wi-Fi and 5G Convergence

The convergence of 5G/6G and Wi-Fi will ensure seamless, high-quality connectivity by dynamically switching between the best available networks. In a smart city, for example, a person moving from a Wi-Fi-rich office to a 5G-powered urban area will experience uninterrupted service, thanks to technologies like OpenRoaming and Passpoint, which enable secure, automatic connections to trusted Wi-Fi networks. 5G's network slicing further enhances this by dedicating specific network resources to applications like AR/VR and real-time gaming, which can integrate smoothly with Wi-Fi. As enterprises and industries drive this convergence, 6G will add features like terahertz frequencies for nearly instant communication over wide and local areas.

Edge computing, which processes data closer to its source to reduce latency, will leverage both Wi-Fi and 5G/6G to offload tasks to the best network, optimizing real-time performance. Wi-Fi will dominate high-density areas like offices, while 5G/6G will enable broad IoT deployments, paving the way for innovations like smart cities and autonomous vehicles reliant on robust, ubiquitous connectivity.

OpenRoaming™

2025 will continue to see an acceleration for OpenRoaming as global adoption continues to grow. Moving forward on the vision to transform public and guest Wi-Fi user experience, and changing the way we connect to Wi-Fi, from remote communities, to universities, stadiums, retail chains, large

SOURCE: WIRELESS BROADBAND ASSOCIATION

2025 WBA Industry Report.

city deployments and more.

OpenRoaming capabilities are extending into the IoT space, with zero touch provisioning of IoT devices, emergency calling and response and private cellular networks. At same time OpenRoaming expands the opportunity for MNOs and MVNOs to incorporate Wi-Fi as part of their wireless solutions to expand capacity and/or coverage, in particular for indoor scenarios.

TIP OpenWiFi

TIP OpenWiFi adoption is projected to continue expanding, though the pace will likely be uneven across sectors and geographies. The introduction of OpenLAN switching is expected to stimulate growth, particularly in cost-sensitive markets such as India and among managed service providers (MSPs) in the US and Europe looking for alternative, flexible networking solutions. However, TIP OpenWiFi's success will hinge on its ability to navigate challenges in scaling deployments and building credibility against established WLAN providers, who have aggressively invested in AI-driven performance enhancements and customizable features that make their offerings more compelling for enterprise-level CIOs and CTOs.

Increased IoT Device Connectivity

IoT Evolution with Wi-Fi Generations and Wi-Fi Halow – As the number of IoT devices continues to grow, Wi-Fi networks will be optimized to handle large-scale device connections. Wi-Fi 6's and Wi-Fi 7's ability to manage more simultaneous devices will become crucial in supporting smart homes, IoT, and smart cities.

Further, the Wi-Fi HaLow standard will develop as a disruptive connectivity technology for IoT, with the potential to transform the IoT landscape. With its extensive range, superior penetration, and enhanced battery life, Wi-Fi HaLow is poised to revolutionize industries, including agriculture, smart cities, and manufacturing, improving efficiency and data collection. Wi-Fi HaLow is ready for primetime in the IoT ecosystem and is a natural fit, especially for long-range, intelligent applications.

API First

The API-first strategy has transitioned from a progressive concept to a fundamental practice. Wi-Fi vendors are now building applications with APIs as the primary focus, ensuring that integration, scalability, and future growth are baked into the DNA of their digital solutions. This approach highlights the critical role of APIs in creating flexible, adaptable, and robust digital architectures. While using APIs provides a log of great flexibility and potential, every API integration project is inherently unique. Usually, a single integration build will take engineers at least several weeks. Once it's built, engineers will likely need to allocate several hours per month to maintain the integration.

Municipalities and governments will continue to expand public Wi-Fi networks

Public Wi-Fi networks will be driven by smart city initiatives, offering free or low-cost connectivity in urban areas. These networks will support everything from smart transportation systems to energy management and public safety. OpenRoaming is set to play a pivotal role in the expansion of public and Smart City Wi-Fi networks. For Smart Cities like Tokyo, Barcelona and others, this seamless transition between networks enables reliable, continuous connectivity for citizens and devices alike, supporting applications like real-time traffic monitoring, public safety systems, and IoT-based services. Municipalities and public Wi-Fi providers will likely prioritize OpenRoaming to enhance user experience, simplify network management, and foster more data-rich urban environments.

Greater Focus on Energy Efficiency

Wi-Fi networks will prioritize energy efficiency, particularly for IoT devices requiring long battery life. Technologies such as Target Wake Time (TWT) will become more prevalent, reducing power consumption in connected devices by allowing them to schedule check-ins with the network.

Read more about these trends and the work of the Wireless Broadband Alliance in the *WBA Annual Industry Report 2025*.

Technology report by ***Wireless Broadband Alliance.***

Download Report

Configuring Quality of Service (QoS) on industrial switches

Learn how to correctly configure Quality of Service (QoS) on managed industrial managed switches. By following the steps outlined in this article, you will be able to configure QoS in a way that ensures more reliable, higher performance connectivity on business networks.

SOURCE: ANTAIRA

Quality of Service (QoS) provides the traffic prioritization capability to ensure that important data gets consistent, predictable delivery.

QUALITY OF SERVICE, OR QOS IS ONE OF THE essential, although frequently misunderstood, features of an industrial Ethernet switch. Essentially, QoS is a set of technologies that prioritizes network resources to an organization's most important applications, data flows, or users.

Sending prioritized packets ahead of other less important traffic guarantees the availability and consistency of network resources for mission critical applications and data integrity during periodic network congestion.

Less important traffic is stored by the network administrator using the Quality-of-Service priority queuing mechanism and is eventually sent when bandwidth becomes available.

Link congestion from oversubscribed industrial switch ports was once a problem for networks. Yet as industrial networks deploy more smart devices heavily reliant on their network infrastructure for bandwidth and availability, network administrators are facing similar congestion management issues. As a result, QoS has made its way from IT to OT.

In this article, we discuss how to correctly configure QoS on managed industrial managed switches. By following the steps outlined, you will be able to configure QoS in a way that ensures more reliable, higher performance connectivity on business networks.

Why Quality of Service is important

Periodic congestion is experienced in all computer networks, large and small. When a router or Ethernet switch is receiving more traffic than it can send out, congestion in network infrastructure occurs, resulting in possible latency and packet loss. A familiar example of congestion is when links are momentarily saturated by a network backup, or at certain times of the workday with high network traffic when employees are running the same application simultaneously.

In a large-scale distributed industrial plant, network congestion is more than a nuisance. It is a threat to productivity and profits. Multiple networked systems and automated devices must work collaboratively in perfectly timed sequences. Throughout the plant floor, various devices connected IIoT sensors rely on networks to communicate real-time information on operational status or machine maintenance requirements. If starved for bandwidth, all traffic shaping an industrial network will experience latency, causing lags in communicating timing controls and operational status. Even a few milliseconds of latency can lead to extremely expensive problems, ranging from downtime to equipment malfunctions. QoS gives critical data streams precedence within an industrial network, preventing the unwelcome consequences of latency and dropped packets.

QoS is equally useful when enabled for "inelastic" business applications like VoIP, video surveillance network data, online training, and videoconferencing, since they have minimum bandwidth requirements, maximum latency limits, minimal latency limits, and high sensitivity to jitter. QoS designates priority to the appropriate packets and strategically allocates bandwidth to ensure the best user experience. Employees depend on these services to get their jobs done, and poor QoS leads to poor work quality.

QoS Models

The three different implementation models for Quality of Service are: Best Effort, IntServ, and Diffserv. While Best Effort is the simplest QoS approach, it can lead to slower speed and less reliable connections on busier networks. The more advanced QoS models "Differentiated Services" (DiffServ) and "Integrated Services" (IntServ) are essential in industries where reliable communication of network data across enterprise networks is crucial, as is the case with factory automation, Intelligent Traffic Systems, or Smart Cities.

Best effort: On a network where QoS is not enabled, data, traffic flows, and packet loss of transmissions are based on "Best Effort" delivery, meaning all transmitted data has an equal probability of being delivered and dropped. This First-in, First-out architecture of high speed of data transmission and

SOURCE: ISTOCKPHOTO

QoS optimization ensures more reliable, higher performance connectivity on business networks

Avoid configuring too many Quality-of-Service classes. It is not necessary to create QoS policies for each and every kind of traffic shaping data flow on one network. The fewer classes there are, the easier it will be to deploy and maintain.

even packet loss distribution is suitable for non-critical data flows or traffic.

IntServ: IntServ utilizes the Resource Reservation Protocol (RSVP) to the existing network bandwidth, to provide end-to-end QoS and bandwidth management for real-time applications with bandwidth, delay, and packet loss requirements to achieve predictable and guaranteed service levels. Call Admission Control (CAC) prevents other IP traffic from using the reserved bandwidth. The downside is that any bandwidth reserved that is not used by an application is a wasted resource.

DiffServ: DiffServ QoS resolves the shortcomings of InServ and Best Effort models. It classifies IP into specific traffic flows, and marks it based on QoS requirements. Every traffic flow class is assigned a different level of service. Compared to IntServ, DiffServ can handle a larger number of traffic flow classes with relatively simple configuration that requires less administrative control. DiffServ has largely replaced IntServ in modern industrial networks.

DiffServ architecture specifies that each packet is classified upon entering the network and processed before exiting it. Depending on the type of traffic being transmitted, the classification will be done inside the layer 2 packet header or layer 3 packet header. In layer 2, the marking is Class of Service (Cos), following 802.1p CoS specifications that categorize traffic from a low to high priority.

Layer 3 packets use Differentiated Services Code Point (DSCP) that categorizes priority as Assured Forwarding, Expedited Forwarding, and Best Effort. This is similar to CoS but DSCP also includes a drop probability assigned to each class of low, medium or high. CoS and DSCP markings will let industrial switches know what class the traffic is assigned to and what actions to take.

Configuration of QoS

Configuring the QoS mechanisms on industrial switches can be a complex process with many concepts beyond the scope of this article. Notwithstanding that, the following truncated steps can help ensure that your switch QoS is set up correctly.

Step 1: Identify the Critical Applications

The first step in configuring end-to-end QoS technologies on industrial switches is to perform an assessment of your network to identify those applications that require high priority. These will include high bandwidth and-heavy industrial control systems, video streaming, and VoIP, among others, that may deteriorate during periods of congestion. A best practice will involve the leaders from every business department, not just network administrators, in deciding which applications are top priorities.

Step 2: Configure Traffic Classes

After identifying your high priority applications, the next step is to configure traffic classes on the network switch. A traffic class is a group of packets that share similar characteristics and require similar treatment. For example, a traffic class might be created for audio and video content traffic, another for VoIP voice traffic, and another for all other types of traffic. Three basic QoS class strategies can be deployed, in general, depending on the granularity of applications running on your network:

- 4-Class QoS Model (Voice, signaling, mission-critical data, default)
- 8-Class QoS Model (4-class model plus multimedia conferencing, multimedia video streaming, network the priority access control, and scavenger)
- 12-Class QoS Model (8-class model plus communication services, real-time phone calls, video call interactive, broadcast voice or video calls, management/OAM, bulk data)

Step 3: Assign Priorities

Once the traffic classes have been created, priorities need to be assigned to them. By assigning a priority, the Ethernet switch will know how to handle the traffic class during congestion by reading the packet header's CoS or DSCP. A priority command will provide a minimum or maximum bandwidth guarantee. Internally, queuing mechanisms permit the less urgent packets to be stored until the network is ready to process.

Step 4: Set Bandwidth Limits

In addition to providing bandwidth and to assigning priorities for data traffic, it is equally important to set bandwidth limits for each traffic class. Each class in traffic types will be assigned a base (guaranteed) and maximum bandwidth. This ensures that high priority traffic does not consume all available bandwidth on the network, leaving little or no usable bandwidth for other types of traffic. Recall that the DiffServ architecture also offers the flexibility to share the unused guaranteed bandwidth of high priority applications with other lower priority applications to further congestion management prevent delays and drops.

Step 5: Test and Fine-Tune

QoS is not a set-it-and-forget-it type project. It is cyclical, ongoing, and requires regular oversight and auditing. After QoS has been configured on the Ethernet switch, it is important to test and fine-tune the settings to ensure optimal network performance. This involves running network tests to guarantee network performance, determine whether critical applications are receiving the necessary priority and adjusting settings as necessary.

Conclusion

In summary, configuring QoS on managed industrial switches requires: identifying critical applications, configuring the traffic types and classes, assigning priorities, setting bandwidth limits, and testing and fine-tuning the settings to ensure optimal network performance. By following these steps, it is possible to configure and implement QoS on industrial switches in a way that ensures an efficient, well-refined, documented network customized to meet your specific needs.

Henry Martel, Field Application Engineer, ***Antaira Technologies.***

Learn More

Cellular routers facilitate substation connectivity

Energie AG leverages B72 450 MHz to seamlessly connect 6000 substations in the Austrian Alps. Cellular routers facilitate the substation connectivity, featuring over-the-air management and integrated protocol conversion.

SOURCE: WESTERMO

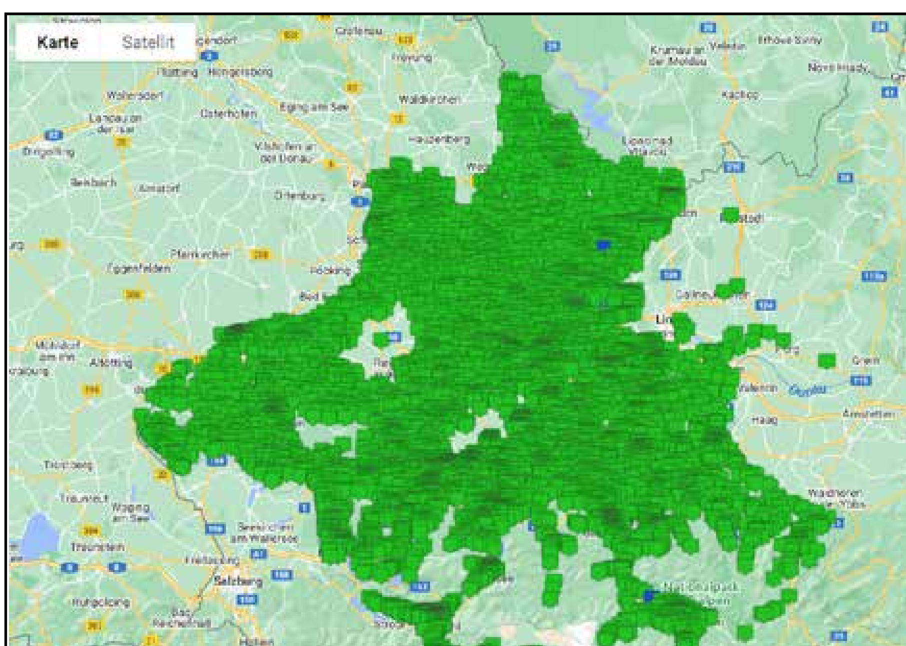
Energie AG is also using the technology to control distributed energy resources such as solar and wind farms.

WESTERMO CELLULAR ROUTERS FACILITATE substation connectivity, featuring over-the-air management and integrated protocol conversion.

Energie AG Oberösterreich, an Austrian utility, chose Westermo cellular technology for the upgrade of 6000 substations from CDMA 450 to LTE 450 MHz. Westermo, via its subsidiary Virtual Access (now named Westermo Ireland), played a role in 2014 when CDMA was selected by Energie AG as the communication solution for the deployment of smart meters. As CDMA reaches the end of its lifecycle and the industry shifts to LTE, Energie AG decided to upgrade their private 450 MHz network from CDMA to LTE technology.

Selecting private over public LTE

The decision to use a private network was driven by cybersecurity concerns and the necessity of ensuring blackout safety. Additionally, maintaining a high degree of control over the network also played a significant role in this choice.



SOURCE: WESTERMO

Energie AG Oberösterreich, an Austrian utility, chose Westermo cellular technology for the upgrade of 6000 substations from CDMA 450 to LTE 450 MHz.

SOURCE: WESTERMO

Operating at a low frequency, 450 MHz covers a vast area with a reduced number of cell towers.

SOURCE: WESTERMO

QoS optimization ensures more reliable, higher performance connectivity on business networks

The features of 450 MHz are ideally suited for the needs of Energie AG. "The topology in our areas is very mixed – we have flat areas, hilly areas and very high mountains. What we have found is that the 450 MHz frequency works very well in all of these topologies", Walter Pesendorfer, Head of the Radio Services Team at Energie AG explains.

Operating at a low frequency, 450 MHz can cover a vast area with a reduced number of cell towers, which Walter Pesendorfer explains was another big benefit for Energie AG. "For us, one of the biggest benefits of 450 MHz is that we don't need so many base stations, which is a big cost benefit".

Applications within the network vary from SCADA to smart meter aggregation. Energie AG is also using the technology to control distributed energy resources such as solar and wind farms.

Choice of networking technology

The private specialized network will be comprised of approximately 8,000 Westermo devices for its communications, spread across the country. Westermo's cellular routers are designed with the needs of utilities and critical infrastructure in mind.

They include technology such as protocol conversion and integrated RTU functionality, which allows Energie AG to connect diverse assets such as Distributed Energy Resources and older equipment easily. The devices can convert SCADA protocols such as 101, Modbus, 104 or DNP3, Digital I/O into a unified format, making maintenance, operation, and testing more straightforward.

Project rollout

By the first quarter of 2024 the project implementation was initiated. By June 2024, 10% of base stations have been implemented with the use of Activator, the proprietary automated provisioning and monitoring software from Westermo, which facilitates the deployment and management of routers.

"We are a small team with a lot of devices to manage, so the key for us is the management system. We rely on Activator and Monitor software for provisioning and monitoring. It is crucial for us, and we consider it the best on the market." Walter Pesendorfer commented.

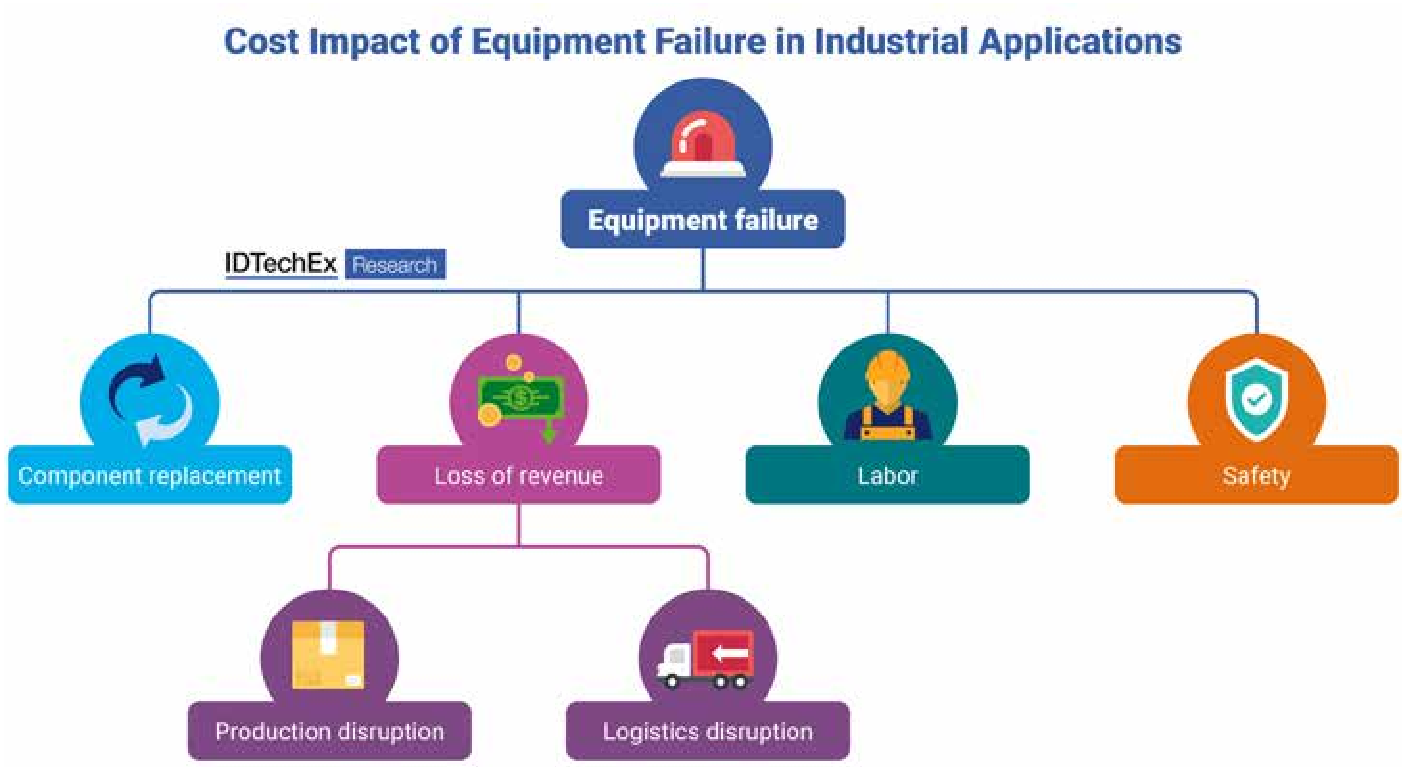
With a successful result, the green light has been given for the rollout of the remaining substations. Pesendorfer expects that the migration process will be completed by end of 2026.

Application story by ***Westermo.***

Visit Website

Emerging smart sensor applications in Industrial IoT

Future industrial IoT solutions will rely on an ecosystem of industrial intelligence to marry sensor data and insight with actionable improvement and optimization of operations. Sensors in industrial robotics are streamlining manufacturing and logistics industries through greater automation.



SOURCE: IDTECHEX

Costs associated with equipment failure in industrial applications come from a wide variety of categories. With technology adoption in mining, manufacturing, and logistics industries driven by the need to maximize productivity and minimize operating costs, IoT sensors play a critical role in collecting data and insight to optimize industrial operations.

THE OLD INTERNET-OF-THINGS ADAGE: 'YOU can't improve what you can't measure' couldn't be more relevant to the industrial sector. With technology adoption in mining, manufacturing, and logistics industries driven by the need to maximize productivity and minimize operating costs, IoT sensors play a critical role in collecting data and insight to optimize industrial operations.

Sensor technology

Industrial IoT sensor technology (IIoT) seeks to enable greater industrial automation, improved worker safety, and streamlined maintenance planning. From cameras, LiDAR, and radar for machine vision in robotics, to skin patches and miniaturized gas sensors in smart personal protection equipment, emerging IIoT applications present growth opportunities for a variety of sensor technologies.

IDTechEx's report, "Sensor Market 2025-2035: Technologies, Trends, Players, Forecasts", predicts that the global sensor market will exceed US$250B by 2035, with industrial sensor technology remaining central to growth over the next decade.

Rising labor expenses and the expansion of e-commerce are propelling mobile robot technologies across warehouses, factories, and fulfillment centers, where they are utilized for a wide range of logistical tasks. Intralogistics, material handling, case picking, and last-mile delivery are growing application markets for IIoT sensor technology in mobile robotics.

Sensors in robots can be used for various tasks ranging from measuring force, detecting objects, navigation and localization, to collision detection and mapping. Recent advances in sensor technologies and data fusion software enable many sensors to be used for multiple purposes. For instance, cameras, together with computer vision systems, can be used for collision detection as well as navigation and localization.

Collision detection sensors are essential for safety and are needed for many types of industrial robots functioning around human operators, such as autonomous mobile robots (AMRs) to collaborative robots. Autonomous mobility in industrial robotics has been popular for a few years, with many AMRs capable of driving themselves with minimal risks. IDTechEx predicts collision detection and autonomous driving sensors used in industrial robotics applications will be key sensor market growth segments.

Augmenting personal protection equipment for greater worker safety

Workplace safety incidents are reported to cost around US$167B every year in the US alone. Manufacturing, construction, transportation, and storage industries experience the highest level of work-related accidents, representing greater than 20% of all incidents. A large


SOURCE: ISTOCKPHOTO

Industrial sensors will play a key role in expanding manufacturing intelligence.

portion of this cost is lost productivity, with 103 million and 35 million working days lost each year due to injury in the USA and UK, respectively.

IIoT sensor technology can potentially mitigate these costs through the measurement and proactive monitoring of key indicators relevant to common industrial workplace incidents. Smart personal protection equipment (PPE), for example helmets, integrated with wearable gas and motion sensors detect hazardous working conditions (dangerously high air quality index) and activity behavior (changes in motion indicative of an accident).

Wearable skin patches for hydration and sweat analysis are emerging within mining, and oil and gas industries. In these industries, the risks of not rehydrating can include cognitive impairment which leads to injury, as well as the physiological effects of dehydration itself. Wearable hydration sensors provide workers with personalised alerts to help them rehydrate more proactively. For example, Epicore Biosystems, an emerging leader in the industrial wearable sensors market, provides 'skin-like' wearable microfluidic solutions for sweat analysis in industrial safety applications.

Workplace safety can potentially be a high-volume market for emerging IIoT sensor technology. Integration of wearable IIoT sensors into PPE will require affordable products supplied with an accompanying data monitoring platform and demonstrate tangible risk mitigation in related use cases. One route to market for sensors in smart PPE could be offering worker monitoring as a service instead of hardware solutions alone – offering a ready-to-use product solution with an accompanying risk management platform would reduce the barriers to adoption for industrial customers.

Minimizing downtime with machine health monitoring and predictive maintenance

Equipment failure is a major time and money sink in industry, with the impact of disruption on operations reported to represent up to 15% of total production costs. The biggest cost impact is lost revenue due to production downtime and logistics disruption. Labor is another major factor, in addition to the cost of replacing defunct components or equipment.

IIoT sensor technology promises to reduce equipment failure, and thus downtime, through machine health monitoring solutions. Gyroscopic sensors attached to machines can measure up to 2 kHz vibrational frequencies, characteristic of imbalance, looseness or misalignment issues. MEMS accelerometers are suitable for higher frequency measurement, identifying issues with gearing and lubrication (3-10 kHz), as well as fan bearings and cooling failures (10-100 kHz).

Diagnosing machine health issues through anomalous vibration profiles of equipment can identify problems proactively, enabling scheduled maintenance of aging and failing parts before failure.

The rise of edge computing technology sees sensor manufacturers increasingly integrate edge AI into industrial IoT sensors. Analog Devices, STMicroelectronics, and TDK are amongst several OEMs in the sensor market integrating pre-trained machine learning models onto sensors to provide predictive maintenance functionality. As these technologies emerge, reducing the total cost of ownership will be a key challenge. Maintenance costs are low when equipment is operating as usual, therefore there is limited capital available for investment in predictive maintenance solutions.

Conclusions and outlook

Future industrial IoT solutions will rely on an ecosystem of industrial intelligence to marry sensor data and insight with actionable improvement and optimization of operations. Sensors in industrial robotics are streamlining manufacturing and logistics industries through greater automation.

Industrial worker safety is rapidly emerging as a growth market for wearable sensors, offering environmental condition and activity monitoring to manage risk in hazardous work environments. Global trends in edge computing and AI are renewing interest in machine health monitoring, where smart vibration sensors are being deployed to enable predictive equipment maintenance.

The industrial IoT sensor market remains key to established and emerging technology providers, although growth is historically slow to materialize. The absence of one-size-fits-all solutions applicable to a broad range of industries lengthens product development and implementation time, posing a persistent barrier to demonstrating value to customers. This challenge is often compounded by the complexities of integrating new sensor technology into aging legacy infrastructure. In the face of this, sensor success in industrial IoT will require a reduction in total cost of ownership and the long return on investment periods of IoT solutions.

IDTechEx's report, "Sensor Market 2025-2035: Technologies, Trends, Players, Forecasts", critically evaluates key sensor applications in industrial IoT, environmental IoT, and consumer IoT markets. The report provides a comprehensive overview of the global sensor market, with insights and critical analysis of emerging sensor application markets in future mobility, IoT, wearable technology, printed electronics, and edge computing. The report contains ten-year global sensor market forecasts from 2025-2035, segmented by sensor technology, including semiconductor sensors, gas sensors, automotive and aerospace sensors, biosensors, sensors for future mobility, quantum sensors, image sensors, and silicon photonic sensors.

Dr. Jack Howley, Technology Analyst at ***IDTechEx.***

Learn More

New lineup of industrial PCs

Key features include the use of the latest industry-standard processor generations, high-quality and demand-optimized flash memory, and the long-term availability version of Windows 11.

SOURCE: BECKHOFF

The broad Beckhoff portfolio of industrial PCs, embedded PCs, and industrial servers is constantly benefiting from the latest developments in the IT world.

Beckhoff Industrial PCs with new processor generations and Windows 11 offer increased performance through consistently implemented IT developments.

PC-based control technology from Beckhoff has always benefited from the convergence of automation and the IT world. Current examples include the use of the latest industry-standard processor generations, high-quality and demand-optimized flash memory, and the long-term availability version of Windows 11.

Latest generation processors

The latest CPU generations include the Intel Atom® x6 processors, the 11th generation of the Intel® Core™ i and Core™ i U processors, the 12th and 13th generation of the Intel® Core™ i processors, and the 5th generation of the Intel® Xeon® processors. They result in significant performance increases and thus more powerful controllers or reduced hardware costs while maintaining the same computing power.

The new Intel® Core™ i processors, which have a structure size of 10 nm, offer particularly high innovation potential, resulting in a significant leap in performance and efficiency. Furthermore, TwinCAT Core Boost can be used.

In the case of the ultra-compact C6025 and C6030 Industrial PCs with 11th generation processors, it can even be implemented in an extremely small form factor. With TwinCAT Core Boost, the clock frequency of the processor cores can be configured individually and as required, so they no longer all have to be clocked at the same rate.

The clock rate can be set for each core for real-time transmission and user-mode applications. It is also possible to operate individual cores continuously and in real time in what is known as turbo mode. Application benefits include up to 50 % more computing power for one or more processor cores or the possibility of using more cost-effective CPUs. The 13th generation Intel® Core™ i processors (with up to 24 cores) used in the ATX industrial PCs offer additional benefits alongside TwinCAT Core Boost due to their hybrid architecture featuring performance and efficiency cores, which can be easily differentiated in TwinCAT.

Industrial solid state drives

The industrial SSDs (solid-state drives) from Beckhoff deliver excellent reliability and performance when it comes to data storage in challenging operating environments. 3D TLC flash memories are used, which are operated in pSLC mode via firmware configuration. This mode enables a long service life with over 50,000 write cycles and up to 5200 MB/s write speed.

The crucial factor when using the latest IT developments is their long- term availability. This also applies to the Windows operating system, which is used in its LTSC version (Long-Term Servicing Channel).

Windows 10 IoT Enterprise is currently, and will continue to be, available but it will be joined in the future by Windows 11 IoT Enterprise – the latest Windows platform.

Beckhoff Automation

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Safety I/O modules

The new LioN-Safety I/O modules support the PROFIsafe and CIP Safety protocols, and a compact, ruggedized product uniquely designed to support the real-time data transmission required in highly automated operations.

SOURCE: BELDEN

New LioN-Safety I/O modules with PROFIsafe or CIP Safety easily integrate safety and non-safety signals into PLC environments.

Belden has introduced new safety I/O modules for functional safety in highly automated operations.

The new LioN-Safety I/O modules with PROFIsafe or CIP Safety easily integrate safety and non-safety signals into PLC environments.

The expansion of the Lumberg Automation LioN family with its new LioN-Safety I/O Modules is designed to support functional safety efforts in industrial operations, the modules streamline the transmission of safety and non-safety-related data over existing networks.

The new LioN-Safety I/O Modules support the PROFIsafe and CIP Safety protocol, with the latter expected to be available in the fourth quarter of 2024, and give manufacturers a compact, ruggedized product uniquely designed to support the real-time data transmission required in highly automated operations. The safety solution from Belden enables the exchange of safety-relevant data and diagnostic information through existing network connections, saving valuable time, resources and space.

Features and benefits

With the LioN-Safety I/O Modules, users benefit from:

- *Easy Integration:* Protect workers and machines by integrating modules into a PLC's engineering tools with PROFIsafe or CIP Safety via standardized device description files that transmit safety data and diagnostics.
- *Maximum Flexibility:* Connect safety inputs/outputs, non-safety I/Os and IO-Link signals – and communicate with the cloud – for added versatility and functionality.
- *High Performing, Safe Operations:* Use PROFINET/PROFIsafe I/O modules in applications with conformance class C and Netload class III or CIP Safety, and benefit from TÜV Rheinland-certification up to SIL 3, Cat 4 and Performance Level e (PLe).

"As industrial automation increases, the challenge – and urgency – to ensure the safety of plant workers becomes more critical," said Jeremy Friedmar, Director of Product Management, Data Ingestion & Firewalls. "LioN-Safety I/O Modules streamline the transmission of essential safety and diagnostic information – from machine-to-machine and machine-to-human – to protect workers, as well as the machines themselves, and the overall plant environment."

Designed with a space-saving, compact metal housing, LioN-Safety I/O Modules ensure durability and reliability even in the harsh environments of automotive manufacturing, consumer packaged goods, machine building, metals and logistics.

For more information on the new LioN-Safety I/O Modules, please visit https://www.belden.com/products/I-O-Systems/Safety-I-O-Modules.

Belden

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Ethernet I/O software support

The NT Ethernet I/O modules provide an OPC UA server and MQTT client in addition to the fieldbus protocol stacks (Modbus TCP/IP, Ethernet/IP, and PROFINET).

SOURCE: ACROMAG

IIoT support is now available for Acromag's Ethernet I/O Modules to simplify cloud connectivity and data sharing across the network.

Acromag's BusWorks® NT series remote I/O modules now offer a cost-effective solution for Industrial Internet of Things (IIoT) applications. The NT Ethernet I/O modules provide an OPC UA server and MQTT client in addition to the fieldbus protocol stacks (Modbus TCP/IP, Ethernet/IP, and PROFINET).

This integrated IIoT functionality offers a standardized data exchange to simplify industrial communication in an increasingly complex environment. Applications for these high-performance Ethernet I/O modules include remote data acquisition, status monitoring, actuator control, predictive maintenance, energy management, and more.

The new OPC UA and MQTT support make data sharing and connecting to the cloud very easy and secure. Users can combine Ethernet protocols with IoT protocols for real time and IoT data transfer over the same network cable. An abstract data object model eliminates hassles with protocol details. The user application simply reads and writes data that is transparently fed into the IoT protocols and information models. Input, output and configuration data objects closely resemble fieldbus I/O tags to simplify data exchanges.

NTE Ethernet I/O models have dual RJ45 ports and a webserver for monitoring or controlling its I/O channels to interface sensors and actuators with system controllers. Each I/O module offers up to 16 input or output signals for voltage, current, temperature, and relay control signals. Connecting up to three NTX expansion I/O modules enables interfacing an additional 48 channels with a mix of I/O functions networked on a single IP address.

"With the addition of OPC UA and MQTT capabilities, NT Series Ethernet I/O modules make data from remote equipment available for sophisticated applications in the cloud or on edge gateways," explains Robert Greenfield, Acromag's Director of Business Development.

The NT2000 Series offers a broad variety of I/O signal processing options. Fifteen I/O configurations are available as either NTE Ethernet I/O or NTX expansion I/O models. Analog I/O models feature eight differential or sixteen single-ended inputs for monitoring current or voltage signals. Analog output modules drive eight channels of process current or voltage signals to control various field devices. Discrete I/O models provide 16 tandem input/output channels with either active high/low input and sinking/sourcing output. A six-channel mechanical relay output model is also available. For temperature monitoring, thermocouple and RTD input models support many sensor types, as well as resistance and millivolt ranges. More models will release over the coming months for additional I/O functions.

In addition to the new IIoT protocols, each module will also support all three industrial Ethernet protocols which are selectable using any web browser to configure the network settings and I/O operation. The modules typically function as a network server, but also offer Acromag's i2o® peer-to-peer communication technology to transfer data between modules directly or multicast without a host or master in between. Conditional logic capabilities let users control operations with IF/THEN/ELSE statements.

Acromag

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Edge-to-cloud IoT solution

Digi International drives digital transformation with the launch of Digi X-ON, designed to remove the barriers of integrating, deploying and scaling industrial IoT systems.

Secure, reliable and scalable edge-to-cloud IoT solution drives fast, measurable results and ROI for customers.

Digi International has announced the launch of Digi X-ON, a breakthrough edge-to-cloud IoT solution that provides the components needed for IoT systems from one trusted and reliable supplier.

Designed to remove the barriers of integrating, deploying and scaling industrial IoT systems, Digi X-ON integrates hardware, software, and cloud connectivity into a single, secure, and reliable platform that delivers measurable business value — supporting many different applications and use cases such as connected cities, smart utilities, industrial IoT and smart agriculture.

"With customers deploying Digi X-ON in a range of use cases, we are seeing excellent results, such as greater visibility into the health of large livestock herds, automation in buildings, and digital transformation in supply chain use cases, as well as improved return on investment," said Mike Rohrmoser, VP of Product Management, OEM Solutions at Digi International.

For example, a lead customer, Fever Tags, empowers ranchers, feedlots and dairies to take a proactive and innovative approach to animal health, enabling early detection of illness, and allowing for timely intervention to reduce extensive antibiotic treatments, prevent death loss and disease spread. This not only improves animal welfare but also contributes to the animal's continued weight gain and a more sustainable and responsible approach to livestock management.

"With a FeverTags solution, we can identify and treat sick cattle up to 72 hours before they show signs of illness that you can detect visibly," says John Greer, CEO of FeverTags. "Anytime you can keep an animal healthy, and eating and drinking, you deliver an immediate financial impact and an ROI to the cattle owners."

Greer added, "FeverTags provides immediate cost savings by early sickness identification and treating only sick animals instead of giving antibiotics to the entire herd." This reduces costs for veterinarians, bankers and insurers who can monitor individual animals or entire herds from their phone or computer.

In addition, Greer said, "We also provide other features, such as traceability and predictive values we can use to identify if cattle originating from a particular location are all prone to sickness, which helps cattle owners to isolate and treat health problems quickly. The herd's data captured in our software presents a predictive value to cattle and dairy organizations, providing early actionable treatment that results in an immediate ROI."

The Digi X-ON platform communicates several miles omnidirectionally, so the tags can cover a 250,000-head feed yard, or a 40,000-acre ranch or a dairy, as structures and buildings do not impede the communication signal.

"Digi's WDS custom engineering services designed and manufactured the custom tag for monitoring animal health around the Digi XBee® LR for LoRaWAN," said Rohrmoser. "The XBee module allows the sensor to be pre-activated, so tagging a cow and activating the tag on a rugged tablet takes just seconds as a cow enters the feedlot, a key benefit of Digi X-ON's scan-and-go provisioning.

Deploying IoT networks requires a diverse set of components and systems, from sensors and gateways to connectivity, software, and cloud platforms. As industrial IoT adoption accelerates, organizations deploying LoRaWAN networks struggle with fragmented technology ecosystems, which leads to higher costs, integration complexity, and disjointed support that slows down their digital transformation.

"Digi X-ON changes industrial IoT from a complex multi-vendor puzzle into a single, seamless solution that drives real business results," said Rohrmoser. "Customers can now focus on achieving their business goals instead of wrestling with the complexities of technology integration, scaling from concept to production with remarkable simplicity, speed, and scalability."

With industrial IoT set to reach $2.5 billion by 2032, Digi X-ON empowers businesses to lead their industries by eliminating complexity and accelerating time to value with a future-ready, scalable solution.

Digi X-ON development kits, produced by SparkFun, are available worldwide. These kits provide businesses with everything they need to start building their IoT solutions today. For more information, visit www.digi.com/X-ON.

Digi International

Visit Website

Safety controller simplifies designs

Using certified hardware and flexible preconfigured logic strategies, the FS1B Safety Controller easily handles what would otherwise take multiple modules.

SOURCE: IDEC

The FS1B lets designers create streamlined machine safety systems with multiple safety channels by using any of 24 preset safety logic strategies selected with DIP switch configuration—with no programming required.

IDEC Corporation is launching the FS1B Safety Controller, an upgrade of the popular FS1A device providing additional features. The FS1B lets designers create streamlined machine safety systems with multiple safety channels by using any of 24 preset safety logic strategies selected with DIP switch configuration—with no programming required.

Supplanting separate modules

Standard safety circuit designs often use many safety relays to accommodate multiple inputs from emergency stop (E-stop) buttons, light curtains, and other safety devices to provide a safety interlocking output for de-energizing associated equipment. The FS1B consolidates this functionality into a compact, standalone form factor, with convenient and reliable push-in terminals.

DIP switches and a single "enter" pushbutton provide quick and easy setting of the safety logic strategy, inputs, and power off delay timer, and these settings can be locked in with a protective cover secured by a marked cable tie to prevent accidental changes. Colored LEDs and seven-segment numeric displays provide clear at-a-glance device and input/output status.

The FS1B includes 12 universal discrete inputs (assignable as up to 6 safety channels). For safety devices, each dual-channel pair of inputs can be used in the default setting, or it can be changed as follows: direct opening input, dependent input, NO/NC input, or safety input II—each with or without synchronization monitoring. Alternately, individual inputs can be set to monitor non-safety devices, such as reset or other external signals, as part of the logic. Four safety outputs provide the capability to de-energize multiple equipment or systems.

Simple safety setup

Other safety products may require multiple devices, configuration software and programming, drivers, and then additional program certification. The FS1B overcomes these shortcomings with 24 built-in safety logic strategies, each of which are certified on this device by a trusted independent body to ensure proper and reliable performance. This pre-certification enhances system safety, simplifies the design process, and streamlines the overall approval process for machinery certification.

Some examples of typical safety logic strategy options include partial stop, mode switching, switch/sensor combined, OR logic, and two-handed logic control. A web-based online simulator allows users to quickly select their application requirements, determine the best configuration, and obtain a circuit diagram output to document the settings.

The FS1B carries applicable IEC 61508, ISO 13849, UL508, and other approvals. Depending on the application, the safety performance can be up to SIL 3, PLe, Category 4. Powered by industry standard 24V DC, with a wide operating temperature range of -10 to +55 Deg C, and robust vibration resistance, the FS1B will excel in most any control panel location, whether on-board or external to the protected equipment.

Flexible safety for a multitude of applications

Whether for small-scale systems and production processes, or as part of a larger safety control system, the FS1B streamlines designs while improving safety. Typical industries and machines/equipment with these needs include injection molding, semiconductor manufacturing, metalworking, pharmaceuticals, food processing and packaging, robotics, automated guided vehicles (AGVs), autonomous mobile robots (AMRs), and others.

Of special interest for OEMs or other designers of equipment with multiple options or configurations, the FS1B can be designed into the controls once, and then adjusted with the safety logic strategy to adapt for various types of inputs. This allows for a standardized design supporting flexible equipment options, minimizing development effort, while simplifying stocking and control panel fabrication.

IDEC

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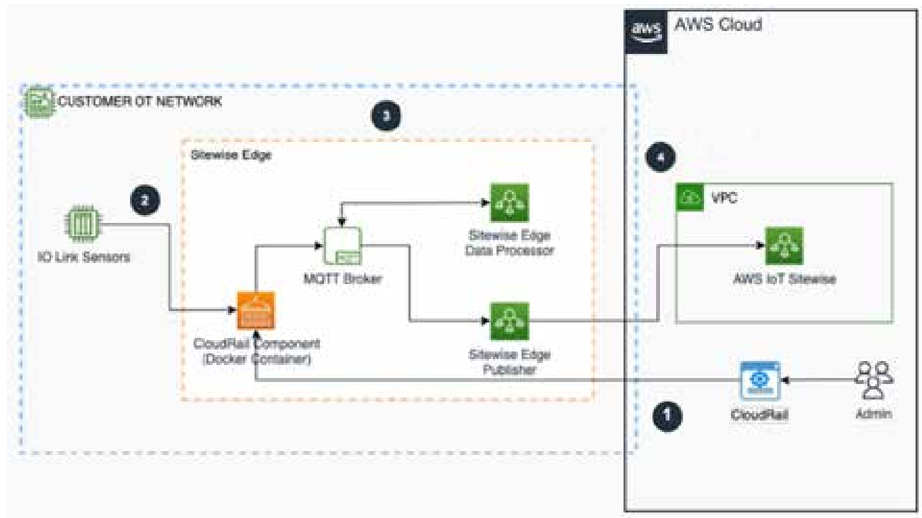
Cloudrail supports AWS IoT SiteWise

New integration with AWS IoT SiteWise Edge streamlines connection to Amazon Web Services Cloud.



SOURCE: BELDEN

Belden has announced integration of its CloudRail software functionality with AWS IoT SiteWise. CloudRail enables cloud-based device management that allows users to roll out, manage and update edge devices globally. Its fully managed solution pre-processes data locally before sending it to any cloud. This integration brings together AWS' data services and CloudRail's protocol management software for brownfield and greenfield data acquisition, providing customers a complete data solution.

The combined solution enables customers to effortlessly connect their industrial assets and sensors to the AWS cloud using CloudRail's proven software capabilities. CloudRail is designed to streamline and standardize the discovery, acquisition and normalization of data from any industrial environments, delivering it in a ready-to-use format. The collected data is then seamlessly ingested into IoT SiteWise Edge for local processing, monitoring and storage, while also being synchronized with SiteWise in the AWS cloud for enterprise-wide visibility and advanced analytics.

Key benefits of the CloudRail and AWS IoT SiteWise Edge integration include:

Accelerated Time-to-Value: CloudRail's plug-and-play access to over 12,000 sensor definitions, combined with data normalization capabilities, significantly reduces the time and effort required to connect industrial assets to AWS IoT SiteWise, enabling customers to start leveraging their data within hours.

Simplified Edge-to-Cloud Data Flow: With a single, unified solution, customers can seamlessly acquire, process and transfer data from the edge to the cloud, eliminating the need for complex integrations and ensuring data consistency throughout the journey.

Belden

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Edge-AI GPU computer

High-performance Edge-AI GPU computer for demanding AI applications in extreme environments.

SOURCE: FORTEC

FORTEC Integrated presents the new PE8000G from ASUS IoT. This state-of-the-art Edge-AI GPU computer has been designed for use in harsh industrial environments. With its robust construction and exceptional computing power, the PE8000G enables real-time AI inferences directly at the network edge. “It supports up to two 450-watt GPU cards as well as the latest Intel® Core™ processors from the 14th, 13th, and 12th generations,” explained Thomas Schrefel, Product Manager Embedded at FORTEC Integrated. “This makes it ideal for data-intensive, AI-driven applications.” Typical applications include medical technology, smart industrial systems, video surveillance, and transportation systems.

The PE8000G series includes several system variants, such as the PE6000G, PE5101D, PE5100D, and PE4000G, catering to different performance and configuration requirements. It is designed to handle the most demanding AI tasks. With the ability to support two high-performance GPU cards, each with up to 450 watts, the system is perfectly suited for neural networks, advanced image processing, and real-time AI inferences. Tasks can be intelligently distributed across GPUs and processed in real time, ensuring maximum performance, stability, and precision. Additionally, the PE8000G ensures future-proof applications by meeting the ever-growing demands for computing power. Combined with powerful Intel® Core™ processors and up to 64 GB of DDR5-SDRAM, this Edge-AI computer is an ideal platform for extremely data-intensive computations.

FORTEC

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Private 5G networks made easy

Moxa Arm-based computers simplify upgrade of wired infrastructures to 5G private networks.


SOURCE: MOXA

For uninterrupted operations, today's manufacturers rely on real-time system monitoring. Standard practice is to deploy edge computers to gather and transmit data to distributed control systems via cables. As networks expand, however, operators of cable-based infrastructures face mounting challenges with installation, maintenance and flexibility, leading to higher costs. As a solution, manufacturers are shifting to 5G private wireless networks. These dedicated, self-contained mobile networks are owned and operated by the enterprise. Utilizing 5G technology, the networks offer high-speed, low latency connectivity. Being private, they give the enterprise the flexibility to control network access and prioritize different applications.

Moxa has made upgrading to 5G private wireless networks easy with its UC-4400A computer. The UC-4400A is an Arm Cortex-A53 quad-core 64-bit computer that comes equipped with built-in LTE/5G and Wi-Fi 6E capabilities, offering an all-in-one solution combining data collection, processing, and wireless connectivity. It simplifies network infrastructure and enables hassle-free relocation or expansion of equipment without additional wiring. The UC-4400A reduces the complexity of legacy physical networks, improves scalability, and future-proofs industrial operations to meet evolving needs. Cyber attacks are always a concern for industrial networks. Moxa UC-4400A computers are embedded with robust security features compliant with IEC 62443-4-2 SL2, safeguarding against evolving security threats.

Moxa

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FactoryTalk DataMosaix app builder

FactoryTalk DataMosaix from Rockwell Automation offers ease and speed to visualization.


SOURCE: PHOENIX CONTACT

Rockwell Automation introduces FactoryTalk® DataMosaix™ App Builder, a low/no code application development builder that's tightly integrated with FactoryTalk DataMosaix, an industrial DataOps solution providing flexible options that fit most business needs. FactoryTalk DataMosaix enables customers to manage the application and their data, if required, on cloud platforms such as Microsoft Azure, Amazon Web Services (AWS) and Google Cloud Platform (GCP), or in an on-premise datacenter.

Now, with the App Builder, customers can easily and quickly configure new dashboards with a variety of pre-defined visualization tools in a drag-and-drop interface. Render content on a desktop or mobile device and easily select contextualized data from FactoryTalk DataMosaix.

With this innovative solution, rapidly build static reports that are automatically generated and shared with teams: schedule automated reports on a defined frequency, export PDF reports and set up email distribution lists to automatically share reports with stakeholders. And quickly view data in charts without creating or changing existing dashboard and visualizations.

Industrial DataOps is about breaking down data silos and optimizing how industrial data is used across the organization. Domain experts and data scientists need simple access to complex industrial data to solve tough problems that drive transformational outcomes in productivity, quality and sustainability. The solution brings data to the people who need it across the organization for a new level of productivity and innovation.

Rockwell Automation

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Strategic collaboration

Rockwell Automation and Microsoft deliver shared vision to accelerate industrial transformation.

Rockwell Automation and Microsoft have announced an expanded strategic collaboration aimed at revolutionizing industrial transformation. Together, the companies will provide manufacturing customers with advanced cloud and AI solutions that deliver data insights, streamline operations and enhance scalability – driving operational efficiency and sustainable growth across industry.

This relationship uniquely combines Rockwell's deep industrial automation expertise with Microsoft's cutting-edge cloud and AI capabilities. Together, the companies will bridge the gap between traditional industrial practices and modern digital applications, creating integrated solutions designed to unlock the full potential of industrial data.

"We are excited to strengthen our partnership with Microsoft as we work to meet the evolving challenges faced by today's manufacturers," said Jessica Korpela, director, global customer innovation at Rockwell Automation. "This enhanced collaboration fuses cloud and AI technologies with our extensive expertise in industrial automation, enabling our customers to reach unprecedented levels of efficiency, innovation and resilience in their operations."

The Rockwell-Microsoft partnership represents a bold step forward in the digital transformation of the manufacturing sector, setting a new standard for connected, AI-driven operations that empower both companies and their customers to thrive in a rapidly changing world.

SOURCE: ISTOCKPHOTO

Collaboration to deliver advanced cloud and AI solutions, empowering manufacturers with enhanced data insights and operational efficiency.

Unlocking the power of data for enhanced efficiency

At Automation Fair, Microsoft introduced its latest solution, Azure IoT Operations, which integrates with Rockwell's digital offerings, including FactoryTalk® Optix™. This newly available combined solution will allow manufacturers and production companies to capture critical insights from existing sites without extensive retrofitting. The adaptive cloud approach will simplify the integration of shop-floor data with cloud-based applications, enabling advanced analytics and improving scalability across multi-site environments. By leveraging this streamlined integration, customers can gain actionable insights to optimize production and drive data-informed decisions across their operations.

FactoryTalk Design Studio Copilot, powered by Microsoft A

Rockwell has expanded its FactoryTalk Design Studio software-as-a-service design software with a new Generative AI Copilot, developed in partnership with Microsoft. The latest feature, powered by Microsoft Azure OpenAI Service, enables engineers to use natural language prompts for tasks like product guidance, code generation, troubleshooting and code explanations, making system design faster and more intuitive. Accessible through a web browser without downloads or installs, FactoryTalk Design Studio provides a collaborative, multi-user environment with integrated version control and is continuously updated with new capabilities to enhance productivity and efficiency in industrial automation system design.

Enhancing digital applications with AI to empower the workforce

The collaboration will also introduce Rockwell's FT Optix Food & Beverage model, enabled through Rockwell's digital and service offerings, into the Microsoft AI model catalog, The model brings the power of AI and Generative AI (GenAI) directly to the manufacturing floor. The adapted AI model, which leverages the power of Microsoft's Phi-3 small language models (SLM), will provide machine operators with AI-guided instructions, assisting in process and device operations via the familiar FactoryTalk Optix interface. With specifically trained models, workers can easily access contextualized AI guidance to enhance productivity, reduce errors, and accelerate decision-making.

Driving industry impact and value

This strategic partnership will deliver substantial benefits to manufacturers, helping to navigate the challenges of today's rapidly evolving industrial landscape. Through these advanced digital solutions, companies can drive greater efficiency, reduce operational costs, and increase productivity, ultimately empowering organizations to realize the full potential of their digital transformation journey.

Rockwell Automation

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AI-equipped servo system

Servo drives offer AI for ultra-high precision automatic tuning complementing the abilities of experts.

The new compact MINAS A7 servo drive family from Panasonic Industry is the industry's first commercialized AI-equipped servo system. The devices use Panasonic Industry's independently developed precAIse tuning, making full use of AI technology to achieve highly precise automatic tuning without any need for an expert engineer. This also reduces setup time by up to 90%.

MINAS A7 motors and drives improve equipment performance while simplifying installation and operation. Thanks to the integrated AI the servo system can even automate tasks in areas where experts are needed to spend time for tuning machines manually due to unsatisfactory performance from conventional automatic tuning functions. The product also achieves the industry's highest level of motion performance with an encoder resolution of the servo motor with 27 bits and 134,217,728 pulses/time. The speed response frequency, which indicates the control performance of servo amplifiers, reaches an industry high of 4.0 kHz or greater. Furthermore, the servo motor achieves a maximum rotation speed of 7,150 r/min which contributes to shorter cycle times. The MINAS A7 impresses with a compact design saving space and resulting in cost effectiveness. Last but not least, MINAS A7 servo drives are backward compatible to MINAS A6 devices.

SOURCE: PANASONIC

They are 1:1 replaceable thanks to the same interfaces and flange size.

Panasonic

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Edge compute module for ControlLogix

Enhance ControlLogix with in-chassis edge device supporting Docker containers.

The Embedded Edge Compute Module builds on Rockwell Automation's recent history of enabling computation functionality expanding the power of the ControlLogix® platform. This in-chassis edge solution provides key scalability and remote support functions to today's workforce. At first release, the Embedded Edge Compute Module enables FactoryTalk® Optix™ software and provides a communication path to REST API, OPC UA, and MQTT to meet the needs of various applications.

The latest firmware update for the Embedded Edge Compute Module introduces the Docker Engine, which enables the hosting and deployment of containerized apps, including Rockwell Automation apps, third-party apps (such as Node-Red and Grafana) and low-code apps allowing users to build, integrate and deploy applications quickly and efficiently. This update significantly enhances the module's capabilities, emphasizing IT/OT convergence and simplifying control software management.

Like all Rockwell products, this module offers flexibility while offering a premier integration experience with the ControlLogix hardware and software ecosystem. The module allows a consistent user experience, with Studio 5000® environment with ControlFLASH Plus™ and FactoryTalk Linx.

SOURCE: ROCKWELL AUTOMATION

The introduction of this module and its continued enhancements offers a level of IT/OT interoperability which allows users to make digitization easier, faster, and scalable, supporting a wide range of applications.

Rockwell Automation

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