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Supporting time-sensitive applications through converged networking and TSN

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Automation, software-defined systems, connectivity and AI are now commonplace in many sectors, enhancing operational efficiency and safety. This is especially true in the industrial sector, as businesses embrace software-defined controls to drive automation systems, such as assembly line robots, automated data analytics and AI-driven optimizations for processes and business.

Companies sticking with their legacy methods risk being left behind as their more agile competitors modernise workflows. From predictive maintenance in manufacturing to real-time monitoring and control in logistics and industrial processes, automation is transforming how businesses operate, ensuring greater reliability and efficiency across the board.

The benefits of automation

It's clear to see why; the benefits are clear-cut. 32% of businesses have now fully automated at least one element of their operations. In comparison, 88% of small business owners believe that automation enables them to compete with larger companies within their sector, partly due to automation freeing up employees for higher-value tasks. Manual labour, and accompanyingmonotonous tasks like data entry and scheduling, can lead to faster turnaround times and improved resource allocation.

This can be achieved without proportionally increasing overhead costs, meaning businesses can scale their operations and expand into new markets, meeting growing demands while maintaining efficiency and cost-effectiveness. And with the emerging news that only one-third of all work expected to be carried out by humans by 2030, reliable data delivery is paramount.

Issues to overcome

However, when it comes to automated processes, operations quickly live or die based on the availability of computing and connectivity resources. Take an industrial distributed control system

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involving sensors, actuators, and robotic arms carrying out fine manipulation tasks on a production line; for example, it can't function without reliable computing and near-instantaneous data transmission between the system's distributed elements. The same applies to operations with a safety element in an industrial machine or process. Specifically in high-risk environments where lives could be endangered, health and safety are beyond imperative. In any scenario where an emergency stop is ordered, the signal must be delivered instantly to avoid severe, life-threatening consequences.

Legacy and proprietary networks struggle to support new automation and AI applications that demand distributed computing with low latency and high reliability. As more applications requiring reliable communication are deployed, networks must advance to ensure Quality of Service (QoS) guarantees. Legacy networks also face challenges with interoperability due to diverse components from different manufacturers, leading to higher costs and limited capabilities. Successful deployment of automation and AI hinges on achieving seamless interoperability and converging mixed-criticality applications on the same network and computing infrastructure.

Creating a suitable foundation for modern networks

Historically, traditional industrial communication networks have been built to serve specific operational applications, like real-time control systems. In contrast, IT and other types of traffic (voice, video, data) were enabled through different networks. This networking model still exists in many factories today but is clearly ineffective as networking infrastructure for deploying next-generation automation and AI.

Instead, businesses are turning towards converged networking for their operational and IT requirements. In contrast to the traditional networking models, the different data elements are unified within a single integrated infrastructure designed to transmit all types of traffic. The combination of mixed-criticality applications brings greater efficiency and simplicity to operations while helping to reduce overheads.

That's not to say that all traffic is treated the same within this unified infrastructure; converged networking provides the means to prioritise different types of traffic depending on the application requirements. And with the industry developing enhancements to converged networks based on standard connectivity like Ethernet, Wi-Fi, and 5G cellular networks, this makes them a suitable option for industrial applications and key sectors like data centres, aerospace, healthcare, and the performing arts. Embracing these technologies means network design can be streamlined, reducing cabling infrastructure and maintenance costs across these unique sectors.

The role of converged networks and TSN

Underpinning such a crucial networking model is Time Sensitive Networking (TSN). With standards developed by the IEEE 802.1 TSN Task Group and product testing/certification driven by industry groups such as Avnu Alliance, TSN refers to
a set of open industry standards created to ensure precise time distribution and the delivery of data with strict deadlines, specifically within networks based on standard connectivity solutions like Ethernet, Wi-Fi and 5G.

The use of these standards ensures that high-priority traffic- precisely what is required in automated operations – is delivered with both bounded latency and minimal jitter, regardless of the immense volume of data potentially flowing within the same network.

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TSN achieves this through key mechanisms such as time synchronization, traffic shaping, and resource management, which work together to create deterministic network behaviour. TSN capabilities enable real-time communication across sectors by segmenting traffic into scheduled time slots and prioritizing critical data flows. These capabilities make it an essential foundation for modern connected systems where reliability and precision are paramount.

Interoperability is the priority for adopting automation and converged networks - crucial for ensuring that diverse devices can communicate effectively, maintaining precise timing and low-latency requirements. As industries increasingly adopt automation and interconnected systems, TSN is key to enhancing the reliability and predictability needed to support complex, high-performance networking environments. But how can we make TSN more commonplace across all industries? The answer is community-driven standards, testing and certification.

The importance of certification

Certification programs typically involve rigorous testing in accredited laboratories to ensure that products from different manufacturers can work together seamlessly within a given networking framework. Subsequently, manufacturers, device vendors, technology developers and end users can all define current and future TSN conformance requirements, interoperability testing, and certification programs to enable converged networks.

Certification ensures that components from multiple suppliers, potentially addressing multiple markets, comply with the core TSN standards. We now have a certification program that validates capabilities across a range of TSN standards and profiles, like the 802.1AS (timing and synchronisation) and EST (enhancements for scheduled traffic) TSN components and the Switch certification based on the 802.1BA (Bridge) profile.

The level of testing required to achieve certification ensures devices from a range of manufacturers and applications can interoperate and coexist on a shared, open network designed for the benefit of all. As more certified products hit the market, we can expect to see more converged networks using TSN-capable devices.

Looking ahead

2025 will no doubt prove to be a pivotal year to advance converged networking and TSN adoption as more specifications and capabilities are defined. Significant progress is already underway between key industry players on the TIACC (TSN Industrial Automation Conformance Collaboration) unified test specification for the IEC/IEEE 60802 TSN profile for industrial automation.

Certain sectors are expected to see vast growth in converged networking and TSN. The aerospace sector is at the top of the list, with the massive surge in data demands causing manufacturers to act fast. Isolated network islands need to be reduced and converged within aircrafts to facilitate shared data across devices, and converged networking will form the foundations of this going forward. Additional test specifications and certification capabilities are being built to address the upcoming 802.1DP TSN profile for aerospace, which is very close to completion.

The automotive industry is also experiencing a similar transition. Modern vehicles rely on real-time data exchange for critical functions such as advanced driver assistance systems (ADAS), autonomous driving, and in-vehicle infotainment. As with aerospace, TSN has a role to play in the next generation of software-defined vehicle architectures. Avnu has long been part of the Automotive TSN ecosystem by offering an automotive-focused certification program. Expect to see big developments across these sectors soon.

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The future of data delivery

Interoperability holds the key to a more interconnected world. With converged networks and TSN at its core, the vision of seamless communication and deterministic network performance across diverse devices is becoming a reality. The future of converged networking looks extraordinarily promising, driven by widely available connectivity solutions enhanced by the capabilities of TSN standards. These advanced networks are poised to deliver unprecedented reliability, low latency, and seamless interoperability, essential for the efficiency and safety of modern operations, processes and businesses. Momentum is building, and the benefits are clear; watch this space over the next few years to see converged networking and TSN at the forefront of reliable data delivery.

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