TSN TECHNOLOGY BRIEF

How To Stay Ahead of The Market

Preparing for the Deployment of Time Sensitive Networking in Automation

Time Sensitive Networking, TSN, is widely seen as crucial for next-generation automation and production systems. It will play an important role in the bigger digitization scenario. And it could allow, for the first time, different cells of automation to exchange data in full synchronization, and to collaborate in real time.

So what is TSN? The clue is in the TSN acronym: Time Sensitive Networking. TSN is based on the concept of common time domains, within which devices and components operate in synchronization. This could include anything from a group of sensors up to collaborative machine clusters. TSN allows time critical data to be shared openly, and control to be more predictably organized across multiple production systems.

Why is it important? TSN is a technology disrupter and is expected to drive major advancements in manufacturing. It is needed to handle transfers of high data volumes and types between disparate systems. It could lead to better collaboration between the "pillars of automation" expected to replace traditional "pyramid" architectures. With TSN, the concept of Virtual PLCs can be realized.

TSN itself is not a product or a protocol, but a set of IEEE 802.XXX extensions to Ethernet supporting the increasing need for the tightly synchronized networking of huge volumes of data at high speed.

The concept originated in work done by the Avnu Alliance, a community focused on Audio Video Bridging (AVB) and Time Sensitive Networking (TSN) standards to integrate different types of data into a more efficient networking architecture. The main goal was to build determinism into Ethernet and solve specific issues such as real-time synchronization, bandwidth reservation, and traffic shaping.

The Alliance sought to create an interoperable Ethernet ecosystem using open standards, with the capability to prioritize data according to type and function. It eventually combined its resources with the IEEE to develop a series of extensions to existing Ethernet IEEE 802.XXX standards.

A wide variety of data types requires far greater network capacity and very rigid latency, prioritization, and management. The likely addition of new functionalities such as fault tolerance, redundancy, Artificial Intelligence (AI) and even blockchain administration compound the challenges. 1GB network speed is a basic requirement.

The IEEE 802 TSN solution addresses Layer 2 of the OSI Model - the Data Link Layer - and therefore is applicable to an infinite range of Ethernet applications across commerce and industry. In industrial automation, next-generation systems must work closely together if the promises of Industry 4.0, Industrial IoT, and digitization are to be delivered. Digital twins, asset maintenance and of course broader concepts such as edge and cloud computing must be supported. Increasing numbers of field devices will be deployed throughout plants, and widely differing data types will need to be transmitted, processed, and stored across multiple resources, including machine vision, images, QR data, audio, SMS messages, reports etc. TSN clearly has a role to play in automation.

CURRENT STATUS

You can think of TSN overall as a universal "tool set" for many settings. The IEEE 802.XXX extensions supporting TSN are far more wide-ranging than are needed in automation. So, to facilitate the adoption of TSN into automation, an IEC project has set out to develop appropriate TSN "profiles" for typical industrial use cases.

A project entitled "IEC/IEEE 60802 TSN Profile for Industrial Automation" is currently under way. Its work is described as follows:

> *"This is a joint project of IEC SC65C/WG18 and IEEE 802 to define TSN profiles for industrial automation. This joint work will provide a jointly developed standard that is both an IEC and an IEEE standard, i.e., a dual logo standard.*
>
> *"This standard defines time-sensitive networking profiles for industrial automation. The profiles select features, options, configurations, defaults, protocols, and procedures of bridges, end stations, and LANs to build industrial automation networks.*
>
> *IEEE 802 standards address a very wide range of networking scenarios. Users and vendors of interoperable bridged time-sensitive networks for industrial automation need guidelines for the selection and the use of IEEE 802 standards and features in order to be able to deploy converged networks to simultaneously support operations technology traffic and other traffic."*

The IEC/IEEE 60802 TSN Profile for Industrial Automation is based on a number of the IEEE 802.XXX TSN extensions, such as (at time of writing):

IEEE 802.1Qbv Enhancements for Scheduled Traffic
IEEE 802.1 AS-2020 Timing and Synchronization for Time-Sensitive Applications
IEEE 802.3br Interspersing Express Traffic
IEEE 802.1Qbu Frame Pre-emption
IEEE 802.1Qca Path control and reservation
IEEE 802.1Qcc Enhancements and improvements for stream reservation
IEEE 802.1Qch Cyclic queuing and forwarding
IEEE 802.1Qci Per-stream filtering and policing
IEEE 802.1CB Redundancy
IEEE P802.1Qcr: Asynchronous Traffic Shaping (in draft)

The first of the use cases, a real-time "machine-to-machine" profile, is currently being developed. A "controller-to-device" profile is expected to follow.

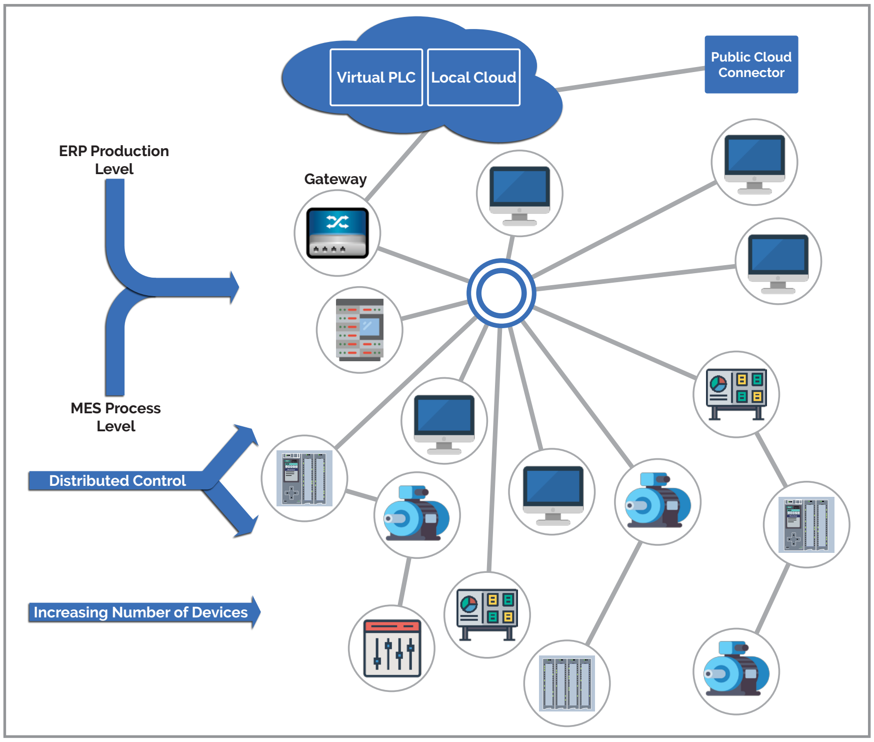
Vendors wishing to collaborate in the market will collectively abide by a chosen profile.

The introduction of TSN to automation will therefore depend on the finalization of the IEC 60802 profile work. Refinements may be necessary in the light of experience. We can predict that, as experience is gained, the TSN profile package will evolve.

IMPLICATIONS FOR AUTOMATION

Current industrial automation practice is based on a "pyramid" of isolated layers, a structure that has evolved over decades. Traditional industrial networks are tuned for latency and control, but are unable to "share the wire", and are usually limited to 100 Mb/s speeds. The integration and visibility of data across layers is difficult or impossible to achieve.

Today, businesses must be as nimble, efficient, and responsive as possible. Manufacturers want to leverage insights from big data analytics and AI to better fulfill customer demands in real time, increase productivity and flexibility, optimize asset management, and reduce costs. Fundamentally, industrial manufacturing needs to catch up with market demands to ensure that more reliable and scalable networks deliver better performance, higher employee and customer satisfaction, and greater growth. TSN is key to achieving this goal.



TSN offers new ways to configure traditional automation architectures that will distribute the control hierarchy and deliver integration of device, machine, ERP and MES data.

As well as allowing diverse devices, systems, and processes to share a single cable, TSN offers new ways to tackle classic manufacturing challenges. It will break down the conventional automation pyramid and see the merging of ERP and MES. And it will support the streaming of data from field to cloud in real-time. In effect, TSN will help complete the integration of Operations Technology (OT) and Information Technology (IT) that has been happening for some time.

TSN will see functionality of multiple PLCs combining centrally, leading to the concept of "virtual PLCs" made up of interconnected devices and systems controlling processes remotely. Eventually this will enable truly flexible manufacturing down to one-offs.

COLLABORATION VS. INTEROPERABILITY

TSN is an Ethernet solution, not an Industrial Protocol standard. The IEEE 802.1Q standards work at OSI Layer 2. According to a Cisco TSN Whitepaper: The forwarding decisions made by the TSN bridges use the Ethernet header contents, not the IP address. The payloads of the Ethernet frames can be anything and are not limited to Internet Protocol. This means that TSN can be used in any environment and can carry the payload of any industrial application.

It was hoped that TSN would support interoperability amongst industrial communications protocols. The reality is somewhat different.

For one thing, it is a huge challenge to cluster PLCs from different vendors and make them operate synchronously in a single "universe". Another reality is that raw data is not "information," (i.e. it lacks descriptions such as pressure, temperature, etc.) so achieving comprehensible data exchange among different protocol systems is difficult. Interactions between machines and systems from different vendors will be possible only when a common language for the data is accepted. It is also inevitable that commercial interests get in the way. However, it is conceivable that some degree of "co-existence" will emerge.

OPC UA may enable TSN to leapfrog the barrier presented by the lack of semantics. By enriching the raw data with real-world descriptions that deliver context, OPC UA will hopefully turn data into recognizable “information.” OPC UA’s ability to publish data from diverse sources in a predictable way could also enhance the co-existence vision. However, many challenges remain.

TSN wireless networking based on 5G will eventually become viable too, although the technical challenges there are significant.

As with fieldbus and Real-Time Ethernet, large end users, such as the automotive manufacturers among others, will determine how TSN products and systems are introduced. A far greater level of cooperation between vendors, integrators and users will be necessary.

WHAT’S NEXT?

While industry is in the early stages of TSN definition and deployment, many are asking: what should we do now? How can vendors and users prepare themselves for the eventual migration to TSN architectures and devices?

This IIC Testbed Demonstrator in Austin, Texas, shows multi-vendor products that were “plug-and-play” tested for interoperability of TSN synchronization. At center is a Hilscher netX chip-based board.

Staying aware of developments as much as possible is a good first step. Keep learning about TSN to be in the best competitive position once the flood gates open. Hilscher is keeping ahead of all technical developments and pioneering many learning opportunities already.

As a networking solutions vendor, Hilscher fully supports the international TSN standardization efforts via membership in organizations, committees and working groups.

Taking it a step further, the company has been demonstrating TSN solutions at trade fairs and in testbeds for several years using its own hardware and software components. These are based on Hilscher’s netX family of network controller chips which are software-configurable and therefore easily adapted as the TSN automation solutions evolve.

At an Industrial Internet Consortium (IIC)/Avnu Testbed Demonstrator in Austin, Texas, multi-vendor products were “plug-and-play” tested for interoperability of TSN synchronization (see photo). Hilscher contributed three products to the Demonstrator to prove its solutions can deliver functional communication over the IEEE TSN Ethernet Standard.

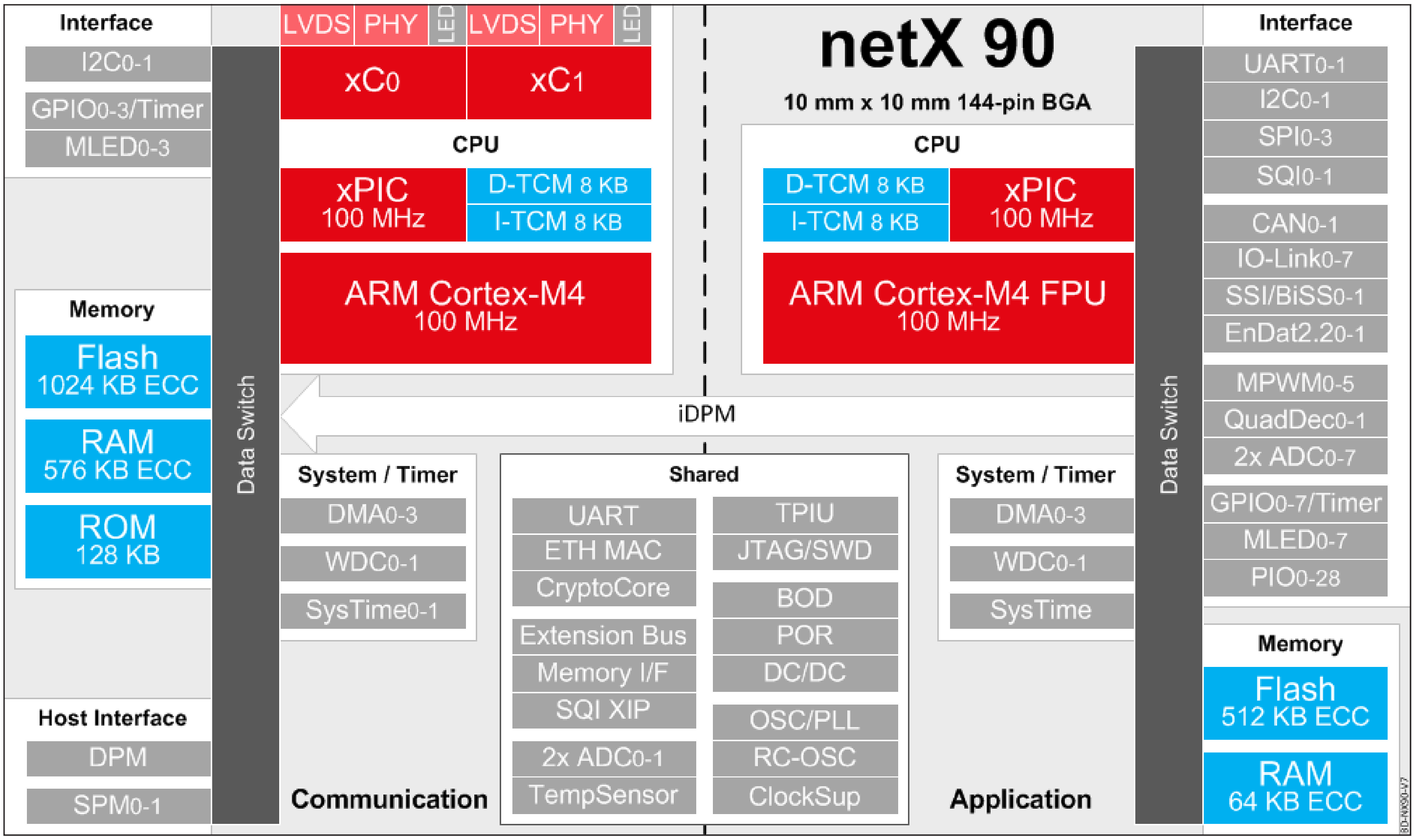
The three Hilscher solutions were: a netX chip connected to a light curtain; a Hilscher Edge Gateway with a netX card slave; and an Evaluation Board used to assist developers in building netX applications. All three products were ready to go out-of-the-box and successfully demonstrated interoperability.

Hilscher’s newest netX chip is the netX 90, an ARM-based interface for connecting field sensors to Real-Time Ethernet and fieldbus networks like PROFINET and EtherNet/IP. This chip is already TSN-enabled and has been used today for prototyping and testing. Prototyping boards, development kits and software tools are available.

The netX 90 incorporates all the components needed to connect sensor devices (on the field-facing side) to industrial protocols on the network side. Processing resources are included to allow interfacing applications to be run on-board.

Security is embedded in the chip. Based independently on multiple ARM processors, the two sides of netX 90 operate separately so attack vectors across the network cannot interfere with applications (see diagram). There is a set of common utilities, plus a range of shared features including security (e.g. secure boot, root of trust, key-based communications, etc.) to ensure that the device cannot be interfered with. IEC62443-compliant architectures can be created with netX 90.

Configuration of the field-facing features (including the pin-outs and sensor protocols) is carried out internally, with major sensor protocols supported.



Hilscher's netX 90 network controller chip is TSN-ready and includes all the components needed to connect sensor devices (on the application field-facing side) to industrial protocols on the network communication side.

The Real-Time Ethernet protocol running on the network side is determined by loading firmware. This firmware approach, along with easily configured sensor communications, means that a single product design can meet many different market needs. In addition to supporting all popular fieldbus and Real-Time Ethernet protocols (including fully certified EtherNet/IP, PROFINET, as well as EtherCAT stacks), netX 90 can be configured to easily accommodate changes to the TSN specifications as and when they occur.

CONCLUSION

The introduction of TSN to automation promises much. Hilscher expects it to become a standard for controller interfacing based on Gigabit Ethernet, and to enable clustering of controller devices and functions. This will allow different machine controls to co-exist in distributed systems and promote higher operating effectiveness, potentially allowing even different machine topologies under the label of smart manufacturing.

Hilscher's netX 90 interface chip is quickly and easily configured for slave device communications. It can meet virtually all industrial market RTE/sensor needs and can be upgraded to accommodate changes in the TSN standards.

In terms of market acceptance and deployment, historical experience with fieldbus and Real-Time Ethernet shows that a decade or more can elapse before widespread usage occurs.

Hilscher is well connected with the standards-making processes and has been demonstrating TSN (based on latest specifications) for several years. The standardization process is expected to be completed in 2022 and any changes and updates to the specifications will be incorporated in Hilscher chips.

Most Industrial Ethernet protocols have developed "companion" specifications for facilitating the migration to TSN once the IEC 60802 profiles become available. Since netX chips can work with all popular RTE protocols, they are ideal for deploying TSN in next-generation products.

ABOUT HILSCHER

Hilscher Gesellschaft für Systemautomation mbH (www.hilscher.com) is a global specialist in network connectivity solutions for device makers, OEMs, and end-user manufacturers. Founded in 1986 and with locations worldwide, Hilscher focuses on industrial communications, with solutions spanning single-chip ASICS, embedded modules, PC cards, protocol converters and gateways, along with supporting software and development tools and services.

Hilscher's own netX "system-on-a-chip" network controller is at the heart of every solution. netX allows for universal Master and/or Slave connection to all popular communications protocols, including: Fieldbuses, such as DeviceNet, Modbus, CC-Link and PROFIBUS; Real-Time Ethernets, such as EtherNet/IP, EtherCAT, PROFINET, Modbus TCP, CC-Link IE, POWERLINK, Sercos; TSN; and IIoT protocols, such as OPC UA and MQTT.

To bring the benefits of Industry 4.0 and the Internet of Things to its customers, Hilscher has developed the netFIELD portfolio, a solutions platform for simplifying IIoT deployment. The netFIELD portfolio comprises: netFIELD Sensor-level Devices; netFIELD Edge Gateways; netFIELD Cloud, with a Software-as-a-Service Platform and Portal; and netFIELD Applications to provide functions such as configuration and connectivity to automation protocols and commercial clouds.

Hilscher North America, Inc., based in a Chicago suburb, is a wholly owned subsidiary of Hilscher Gesellschaft für Systemautomation mbH.