

# Time Sensitive Networking - Flexible Manufacturing



Time Sensitive Networking (TSN) is key for industrial applications such as process and machine control where low communication latency and minimal jitter are critical to meeting closed loop control requirements. TSN is the first fully open, standard and interoperable way to fulfill these requirements.

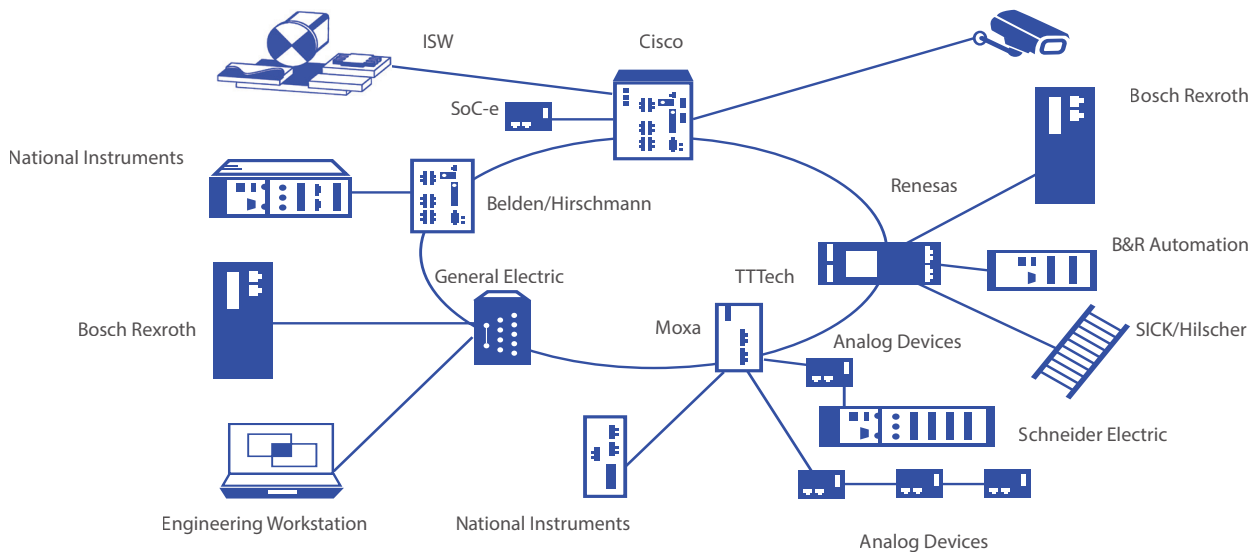
## CHALLENGE

Manufacturing operations requires tight coordination of sensing and actuation to safely and efficiently perform closed loop control. Typically, these systems have been deployed using non-standard network infrastructure or air-gapped (unconnected) standard networks. This approach makes devices and data much harder to access and creates a technical barrier to IIoT which is predicated on the ability to consume data anywhere throughout the infrastructure.

To address these needs of IIoT all the way to the control system, the IEEE organization has been working to update the standards for Ethernet and wireless (IEEE 802) to support time sensitive networking.

## SOLUTION

TSN enables a single, open network infrastructure supporting multi-vendor interoperability through standardization and IT and OT convergence through guarantee of service. The technology will be used to support real-time control and synchronization of high performance machines over a single, standard Ethernet network. This testbed showcases an early implementation of TSN. As such, it will show the value of the technology as well as some of the challenges in implementations from a number vendors. This testbed will not only document the value of TSN, but will provide feedback to the relevant standards organizations on areas of further clarification or improvement.



## Time Synchronization



### IEEE 802.1AS, IEEE 1588

#### Summary:

End-nodes and switches have a common understanding of time

#### Features:

- Synchronization of multiple systems with a precision below 1µs using packet based communication
- Synchronization is possible over very long distances without impact from signal propagation delay

## Traffic Scheduling



### IEEE 802.1Qbv

#### Summary:

Packet transmission from a sender to a receiver is scheduled end-to-end and follows a repeating cycle

#### Features:

- Deterministic arrival of packets affording latency guarantees, extremely low jitter and virtually no packet loss
- Scalable design with ability to assure that multiple flows won't conflict

## System Configuration



### IEEE 802.1Qcc

#### Summary:

Consistent mechanism for network configuration to meet the needs of end application

#### Features:

- Standard mechanism for configuration of all network elements
- Configure "streams" between devices from any supplier

The table below lists all TSN standards. The standards highlighted in red, blue and gold (and referenced in detail above) are the key focus areas of the TSN Testbed, but eventually all TSN standards will be tested.

STANDARD	DESCRIPTION
IEEE 802. 1ASrev, IEEE 1588	Timing & Synchronization
IEEE 802. 1Qbu & IEEE 802. 3br	Frame Preemption
IEEE 802. 1 Qbv	Enhancements for Scheduled Traffic
IEEE 802. 1 Qca	Path Control & Reservation
IEEE 802. 1 Qcc	System Configuration
IEEE 802. 1Qci	Per-Stream Filtering & Policing
IEEE 802. 1 CB	Seamless Redundancy
...	Continual Evolution of the Standard

The vision of the TSN testbed is to prototype, evaluate and thus enable flexible manufacturing for Industrial IoT and Industrie 4.0 through deployment of open, standard deterministic networks within production facilities.

**GOAL:** To support real-time control and synchronization of high performance machines over a single, standard Ethernet network, supporting multi-vendor interoperability and integration.

## OUTPUTS & RESULTS

- The TSN Testbed is actively driving accelerated market adoption of this critical IIoT/Industrie 4.0 technology
- Over 30 Vendors participating (chip makers, vendors of switches, automation devices and testing products)
- 14 Plugfests conducted since testbed establishment in US, Austria and Germany with ever-improving levels of interoperability and functions
- 2 Testbed locations at National Instruments in Austin, Texas and ISW - University of Stuttgart, Germany
- TSN Description of Converged Traffic Types White Paper - Published April 2018
- TSN Testbed results article in IIC Journal of Innovation
- Winner of 2017 IoT Solutions World Congress "Best Testbed" Award
- Winner of 2017 IIC Testbed Showcase
- Demonstrations at major shows (IoTSWC, SPS Drives, Hannover Messe, NI Week, IOT World, DE Forum, IMTS, Electronica)
- Collaboration with multiple standardization bodies: IEEE, IETF, AVNU Alliance, OPC Foundation and ODVA

## TSN BENEFITS

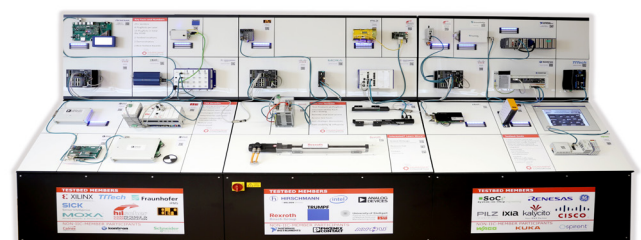
- TSN is an IEEE-based open networking standard that now supports real-time control and synchronization of high performance machines
- TSN will support critical control applications such as robot control, drive control and vision systems to the industrial internet
- TSN connectivity enables customers, suppliers and vendors to more readily access data from these systems and to apply preventative maintenance & optimization routines to these systems

## BUSINESS VALUES DERIVED FROM DETERMINISTIC, STANDARD NETWORKS

- Higher availability of lines, machines and equipment
- Reduced time-to-market of new products
- Reduced cabling TCO
- Reduced plant downtime with support for rapid manufacturing reconfiguration
- Increased uptime through integration of plant diagnostics
- More secure operations
- Improved quality of products
- Large ecosystem of suppliers of standard components
- Open to innovations within standard networks

## TSN TESTBED FEATURES

- Combine different critical and best-effort traffic flows on a single network based on IEEE 802.1 TSN
- Demonstrate the real-time capability and vendor interoperability using standard, converged Ethernet
- Show ability for IIoT to incorporate highly performance and latency sensitive applications
- Provide integration points for smart edge-cloud control systems into IIoT infrastructure & application
- Mixed reconfigurable manufacturing with robotics, multi-axis motion machines, vision, IO and machine health/diagnostics
- Integration at M2M level and IIoT level



## TSN TESTBED PARTICIPATION BENEFITS

- Access TSN testing resources including an interoperability rack, testing tools and expert vendors, including remote access
- Test your technology in frequent plugfests in Germany and the USA
- Collaborate on ongoing testing and strategic discussions
- Influence industrial standards shaping the future of manufacturing and other industries
- Gain broad visibility and recognition of your participation
- Participate in the TSN demonstrator showcased at global industry events
- Leverage IIC's ecosystem of technologies, industry & technical experts, resources and best practices

## NON-MEMBER PARTICIPANTS



## TO LEARN MORE, VISIT:

- The TSN Testbed webpage: [www.iiconsortium.org/time-sensitive-networks.htm](http://www.iiconsortium.org/time-sensitive-networks.htm)
- The Resource Hub's TSN page: [ow.ly/X0QA30mmovJ](http://ow.ly/X0QA30mmovJ)
- The TSN Testbed White Paper: [www.iiconsortium.org/white-papers.htm](http://www.iiconsortium.org/white-papers.htm)

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The Industry IoT Consortium™



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