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.
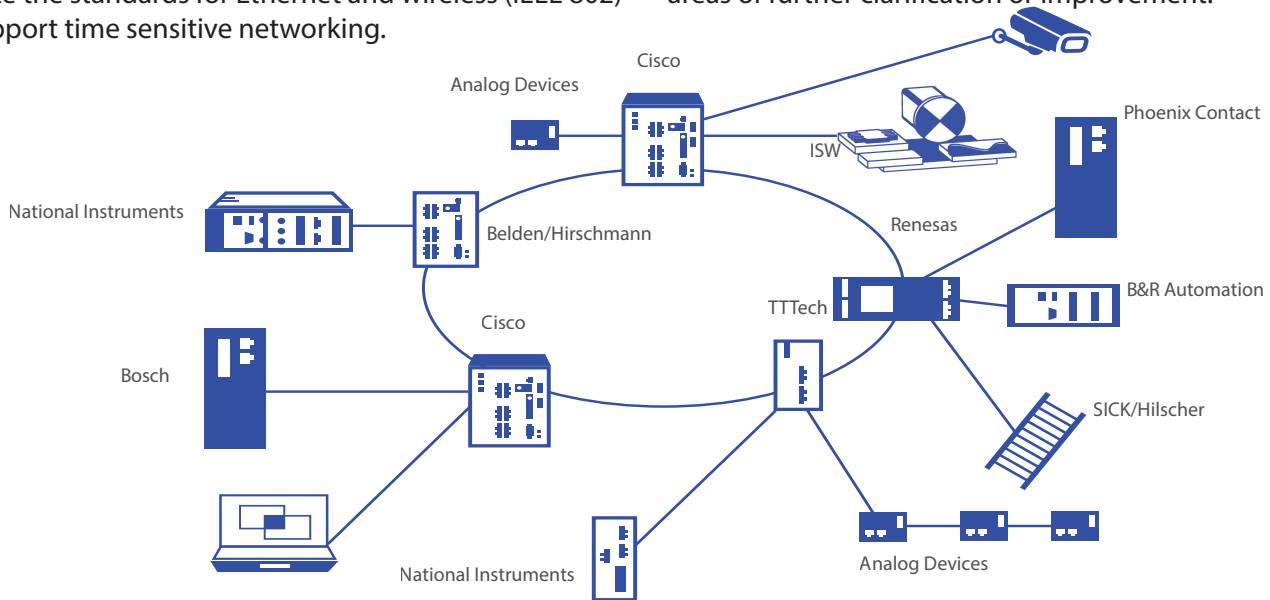
Time Synchronization

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

- 23 Vendors participating (chip makers, vendors of switches, automation devices and testing products)
- 8 Plugfests conducted since testbed establishment in US, Austria and Germany with ever-improving levels of interoperability and functions
- 2 Testbed locations at NI in Austin, TX and BoschRexroth in Erbach, Germany
- Winner of 2017 IoT Solutions World Congress "Best Testbed" Award
- Winner of Q1 IIC Testbed Showcase, where IIC testbed leaders present and are judged by their peers on strategic value
- Demonstrations at 6 major shows (IoT-SWC, SPS Drives, Hannover Messe, NI Week, IOT World, DE Forum)
- Collaboration with multiple standardization bodies: IEEE, IETF, AVNU Alliance, OPC Foundation and ODVA
- Marketing Material Developed: Brochure, JOI Article, Press Release

BENEFITS

- The TSN Testbed is actively driving accelerated market adoption of this critical IIoT/Industrie 4.0 technology
- TSN will open up critical control applications such as robot control, drive control and vision systems to the Industrial Internet. This connectivity enables customers, suppliers and vendors to more readily access data from these systems and to apply preventative maintenance and optimization routines to these systems.
- Support for rapid manufacturing reconfiguration reduces plant downtime
- Increased uptime through integration of plant diagnostics

## BUSINESS VALUES DERIVED FROM DETERMINISTIC, STANDARD NETWORKS

- Higher availability of lines, machines and equipment
- Reduced time-to-market of new products
- Reduced cabling TCO
- 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 Time Sensitive Networking (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.

MARKET SEGMENT

- Flexible Manufacturing providing tight coordination of multiple machines and Industrial-IoT (IIoT) integration.
- The TSN Testbed is envisioned to be useful for a wide range of applications, including FactoryAutomation, Utilities, Automotive, Transportation, Oil and Gas. The insights and concepts proven in this testbed may be replicated into a number of other testbeds in the future.
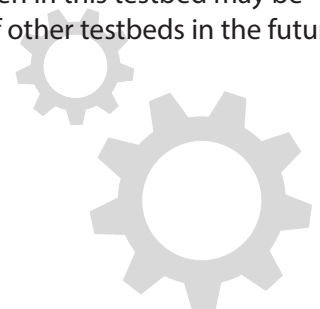
To learn more, visit the TSN Testbed webpage at **www.iiconsortium.org/time-sensitive-networks**, our article in the IIC Journal of Innovation (**www.iiconsortium.org/journal-of-innovation**) or email **info@iiconsortium.org**.

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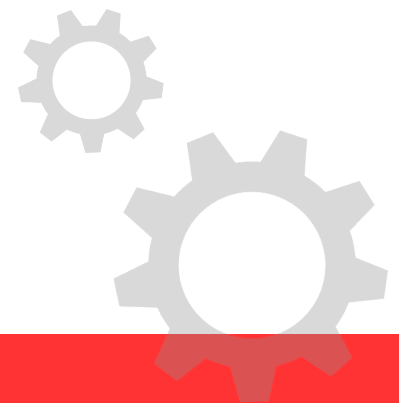
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