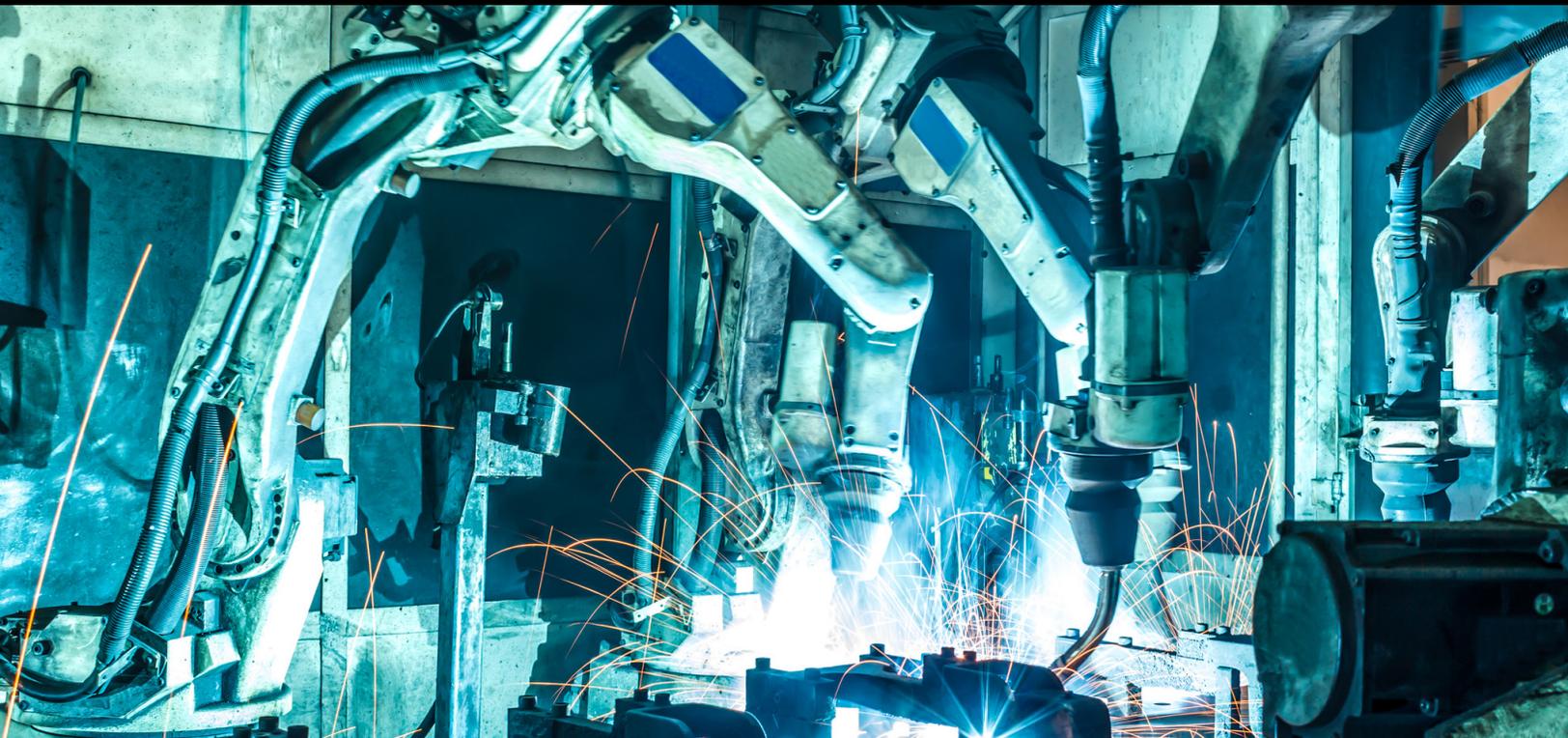# IEEE SA STANDARDS ASSOCIATION

TSN FOR INDUSTRIAL AUTOMATION
IEEE 802 Standards for Time-Sensitive Networking

Implementing Time-Sensitive Networking (TSN) in Industry 4.0

IEEE 802.1 Time-Sensitive Networking (TSN) is an enabler of Industry 4.0, i.e., smart factory of cyber-physical systems. TSN is the foundation to provide connectivity and real-time quality of service to time and mission critical industrial applications on converged networks of operations technology and information technology and converging multiple independent applications in one network enabling real-time communication on the same infrastructure (cables, bridges). TSN meets these requirements by providing interoperability via open standards. TSN provides synchronization and supports real-time communication for, e.g., closed loop control over a single standard Ethernet network.

The IEEE Standards Association (IEEE SA) and the International Electrotechnical Commission (IEC) has established a joint project: IEC/IEEE 60802 "Time-Sensitive Networking Profile for Industrial Automation" to ensure that the right mix of experts are involved in defining the use of TSN for industrial automation. By selecting TSN features and describing their use including configurations and defaults, the IEC/IEEE 60802 standard aims to benefit vendors offering and/or developing TSN products as well as the users of industrial automation technologies.

TSN Time Sensitive Networking™ Powered by IEEE 802

For more information on the IEEE 802.1 Working Group, visit ieee802.org/1

TSN IN SMART FACTORIES

TSN provides guaranteed data transport with bounded low latency, low jitter and extremely low data loss.

- **TIME SYNCHRONIZATION:** IEEE 802.1AS maintains synchronized time (+/- 500 nsec worst case) end-to-end, i.e., including the devices running the control applications. Time synchronization is the basis of multiple TSN Quality of Service (QoS) solutions, e.g., time-based scheduling.

- **BOUNDED LOW LATENCY:** TSN includes multiple solutions to provide bounded low latency, e.g., time-scheduling, preemption, and traffic shaping mechanisms. Time synchronization and TSN QoS solutions can reduce packet delay variation (jitter).

- **RESOURCE MANAGEMENT:** Standard protocols, data models, and interfaces to dedicate resources for time and mission critical traffic.

- **ZERO CONGESTION LOSS:** TSN provides zero congestion loss via the bounded low latency and the resource management solutions.

- **HIGH AVAILABILITY/ULTRA-RELIABILITY:** TSN provides ultra-reliability and high availability in the network up to seamless communication over redundant paths (frame replication and elimination), protection from errant devices (ingress policing), and backup for network timing master (standby grandmaster).

- **SECURITY:** Authentication of installed devices, segregation of traffic types and flows between authorized devices, message integrity, and authenticity are possible.

- **CONVERGED NETWORK:** TSN supports multiple traffic classes that may have very different requirements. Thus, control data traffic in real-time and multiple independent applications using the same network can be carried together with best-effort traffic in the same network infrastructure, increasing economic feasibility of the network.

- **INTEROPERABILITY:** TSN leverages the benefits of existing IEEE 802.3 Ethernet, e.g., diagnostics; thus, TSN is applicable in brownfield deployments. A common information model for the network resources enables common TSN engineering and diagnostics. The harmonized interfaces and the protocols for stream set-up support interoperability. Variants shall be limited by a harmonized TSN profile for industrial automation, i.e., IEC/IEEE 60802 to enable multi-vendor networking interconnecting different bus types used in end stations.

> **For more information on the IEEE 802.1 Working Group, visit ieee802.org/1**
>
> **For a complete list of TSN projects, visit ieee802.org/1/tsn**

PROJECTS CURRENTLY IN PROGRESS:

- **IEC/IEEE 60802 TSN Profile for Industrial Automation**

- **IEEE P802.1Qcw™- Draft Standard for Local and Metropolitan Area Networks** - Bridges and Bridged Networks Amendment: YANG Data Models for Scheduled Traffic, Frame Preemption, and Per-Stream Filtering and Policing

- **IEEE P802.1Qdd™- Draft Standard for Local and Metropolitan Area Networks -** Bridges and Bridged Networks Amendment: Resource Allocation Protocol

- **IEEE P802.1Qdj™- Draft Standard for Local and Metropolitan Area Networks -** Bridges and Bridged Networks Amendment: Configuration Enhancements for Time-Sensitive Networking

- **IEEE P802.1CBcv™- Draft Standard for Local and Metropolitan Area Networks** - Frame Replication and Elimination for Reliability Amendment: Information Model, YANG Data Model and Management Information Base Module

- **IEEE P802.1CBdb™- Draft Standard for LAN/MAN** -Frame Replication and Elimination for Reliability Amendment: Extended Stream Identification Functions

- **IEEE P802.1ASdm™- Draft Standard for Local and Metropolitan Area Networks -** Timing and Synchronization for Time-Sensitive Applications Amendment: Hot Standby

- **IEEE P802.1ASdn™- Draft Standard for Local and Metropolitan Area Networks** - Timing and Synchronization for Time-Sensitive Applications Amendment: YANG Data Model

- **IEEE P802.1ASdr™- Draft Standard for Local and Metropolitan Area Networks** - Timing and Synchronization for Time-Sensitive Applications Amendment: Inclusive Terminology

STANDARDS:

- **IEEE 802.1CB™-2017 Standard for Local and Metropolitan Area Networks** - Frame Replication and Elimination for Reliability

- **IEEE 802.1Q™-2018 Standard for Local and Metropolitan Area Networks** - Bridges and Bridged Networks

- **IEEE 802.1Qcc™-2018 Standard for Local and Metropolitan Area Networks** - Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks Amendment: Stream Reservation Protocol (SRP) Enhancements and Performance Improvements

- **IEEE 802.1Qcr™-2020 Standard for Local and Metropolitan Area Networks** - Bridges and Bridges Networks Amendment: Asynchronous Traffic Shaping

- **IEEE 802.1AS™-2020 Standard for Local and Metropolitan Area Networks** - Timing and Synchronization for Time-Sensitive Applications

- **IEEE 802.1CS™-2020 Standard for Local and Metropolitan Area Networks** - Link-Local Registration Protocol

Visit standards.ieee.org/about/get for details.