

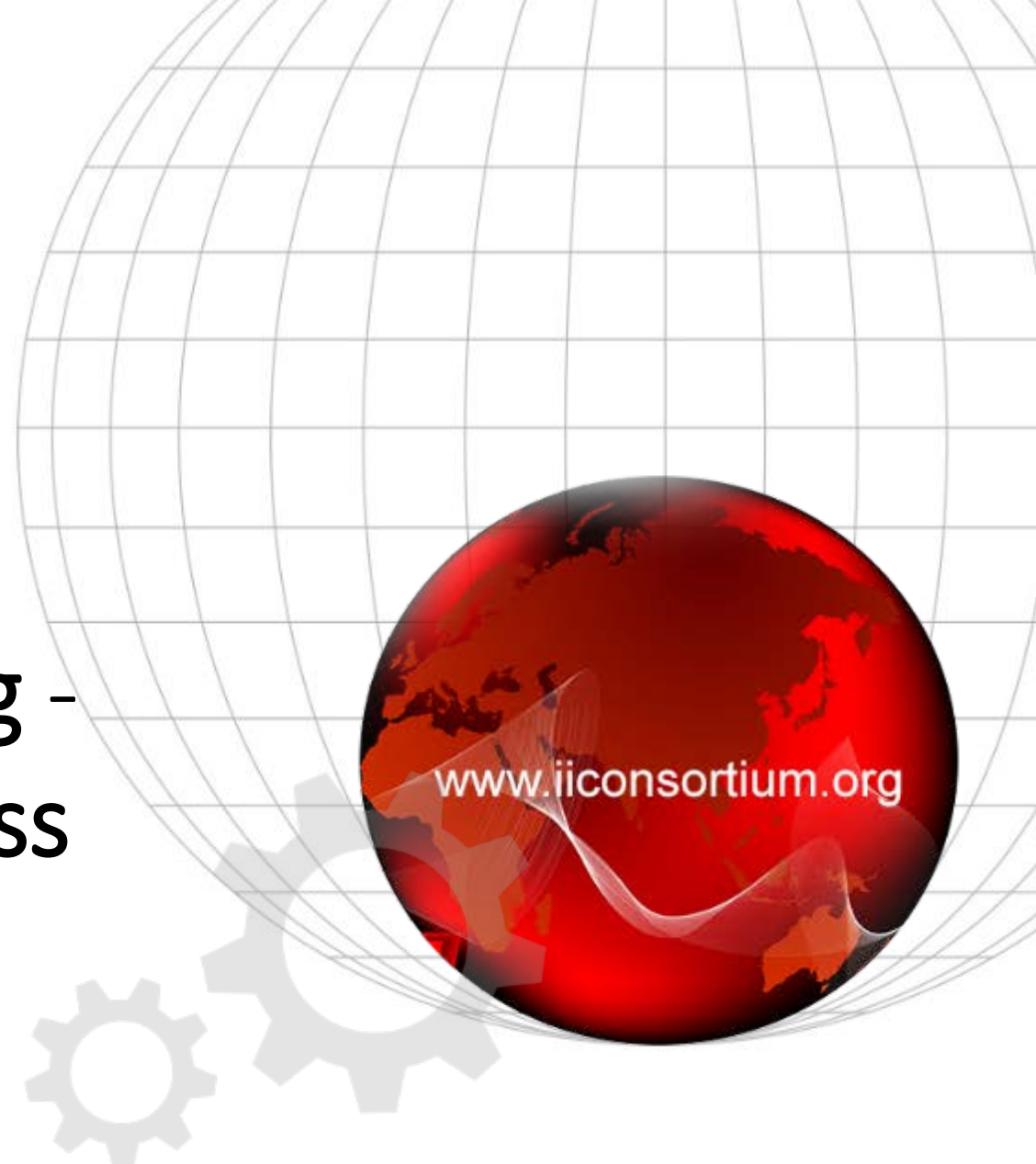


Time Sensitive Networking - Applications and Readiness

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Agenda

1

What is the problem/need?

2

What Time Sensitive Networking (TSN) is and how it solves that problem

3

What the IIC is doing to drive TSN forward



Across Industries Control Networks Are Moving To Ethernet & IP

- Leveraging and hardening the technology of the Internet for use in industrial applications
- Brings benefits across the entire value chain – from manufacturer, to integrator, to end-user
 - Lower cost
 - Greater scalability
 - Easier interoperability
- The key enabler to the Industrial Internet of Things (IIoT)





Smart Cities Promise Many Benefits To Their Citizens

Higher quality of life, improved efficiency and safety, lower costs



- Building automation in public buildings
- Smart busses and trains
- Intelligent traffic control
- Smart street lighting
- Sensor-controlled parking management systems
- Smart electricity grids
- Connected water/waste water treatment
- ...





Network Convergence and IIoT Place New Demands On Industrial Ethernet

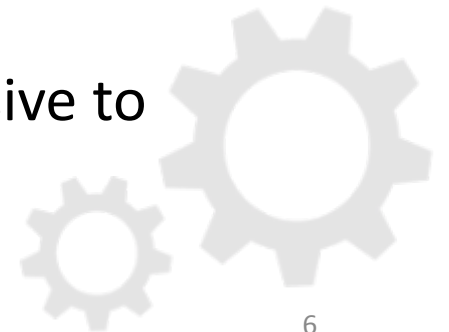
- In enterprise applications, we don't build dedicated networks for individual applications
 - A word processing network, a spreadsheet networking, an email network, a [fill in the blank] network,
- We run multiple services over a common network infrastructure
- This lowers cost & complexity while increasing interoperability





Network Convergence and IIoT Place New Demands On Industrial Ethernet

- But control applications are not enterprise applications
 - Reliability, redundancy, and safety are critical
- Many control applications have exacting needs
 - Low latency – My application can't tolerate delay
 - Low jitter – I need my packets to arrive within a certain time every time
 - Guaranteed bandwidth – My application won't function properly otherwise
- Historically dedicated networks have been used to segregate real time control from other applications (e.g., video)
 - This adds cost & complexity and makes it harder and more expensive to achieve IIoT benefits

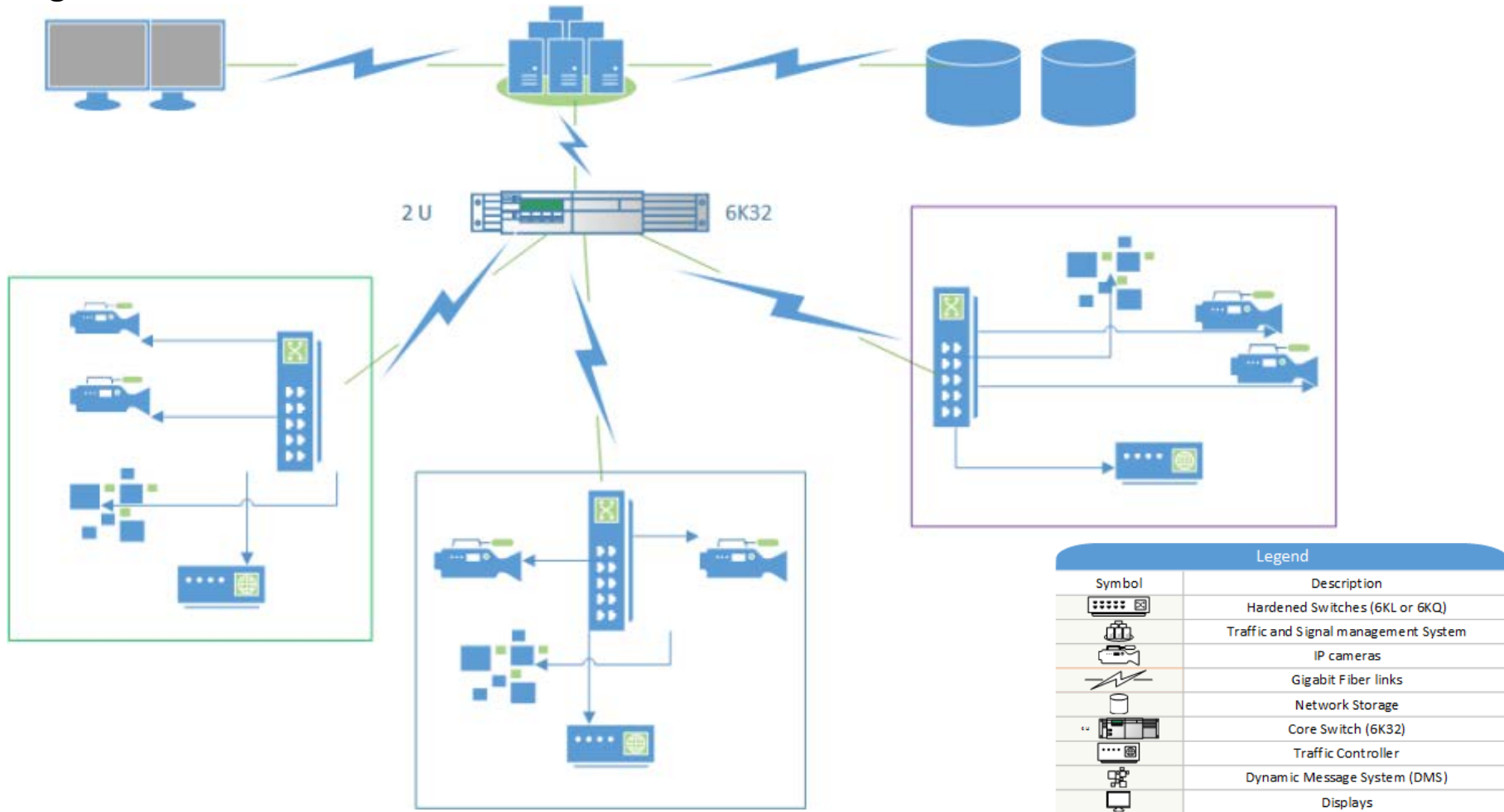




Smart Cities Will Mix Multiple Applications on Common Networks

Time-sensitive control traffic intermixed with high bandwidth traffic

Example: Intelligent Traffic Control





Time Sensitive Network (TSN) is a Standards-Based Solution To This Need

- A family of standards from the creators of Ethernet standards (IEEE 802.1)

| Standard | Name |
|------------------------------|---|
| IEEE P802.1AS-Rev, IEEE 1588 | Timing and Synchronization: Enhancements and Performance Improvements |
| IEEE P802.1Qbu | Frame Preemption |
| IEEE P802.1Qbv | Enhancements for Scheduled Traffic |
| IEEE P802.1Qca | Path Control and Reservation |
| IEEE P802.1Qcc | Stream Reservation Protocol (SRP) Enhancements and Performance Improvements |
| IEEE P802.1CB | Frame Replication and Elimination for Reliability |
| IEEE P802.1Qch | Cyclic Queuing and Forwarding |
| IEEE P802.1Qci | Per-Stream Filtering and Policing |
| IEEE P802.3br | Interspersing Express Traffic |
| IEEE P802.1Qcr | Asynchronous Traffic Shaping |
| IEEE P802.1CS | LRP |

- That meets the need of control applications and the IIoT
 - Deterministic scheduling
 - Resilience via redundancy
 - Converging network structures
 - Interoperability





Time Sensitive Networking Brings Determinism to Ethernet





Time Sensitive Networking: Key Elements

Time Synchronization



Traffic Scheduling

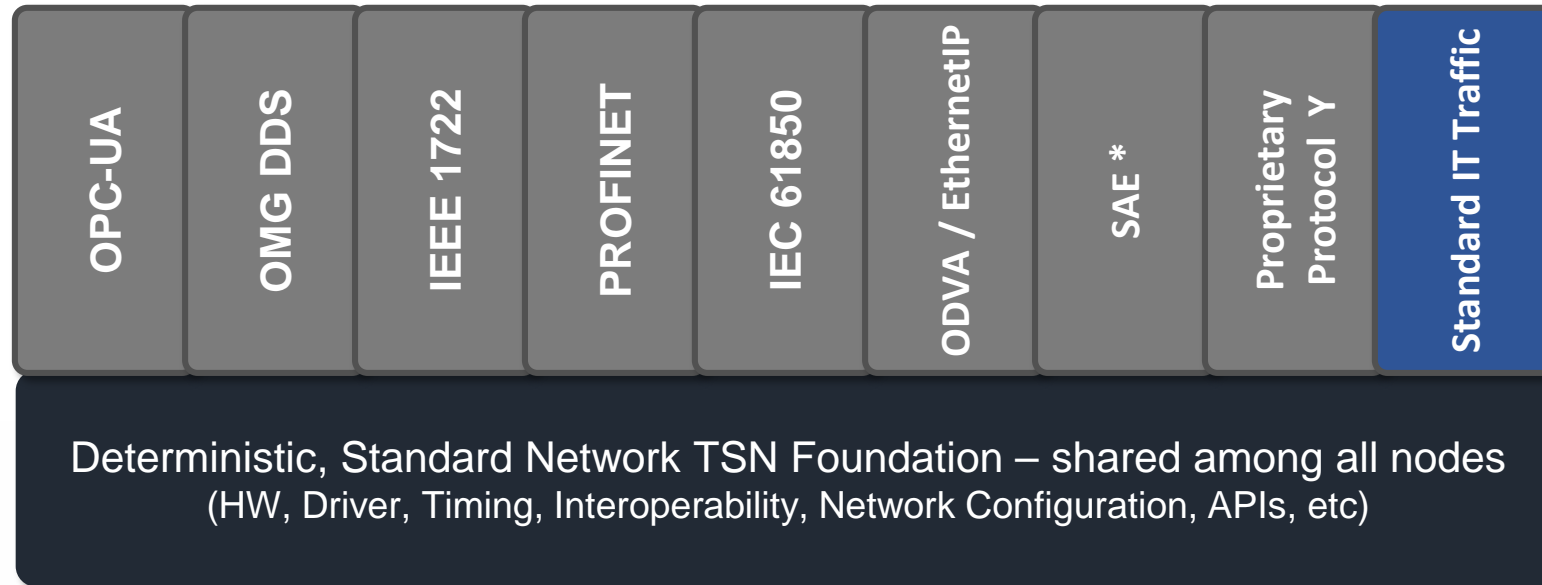


System Configuration





TSN – The Network to Unite them All



TSN enable various protocols to use a single network infrastructure



Why IIC? Role of the Organizations

Testbed and Reference Architectures

- Testbeds to evaluate “full stack” and provide feedback to members and liaison organizations
- Application specific architectures to aid in market adoption
- Outbound marketing to create awareness



Application Layers

- Define data models for end-device communication
- Integration of TSN communications and configuration models into application tools
- Application flow for end-node configuration
- Conformance for data models and end node configuration



TSN Transport Interoperability and Conformance

- Define network services needed by market
- Fill gaps in standards to provide interoperable network configuration services
- Conformance of transport and network services
- Establish certification services



Network standards

- Define standard features to provide Time Sensitive Networking “deterministic communication” capabilities including updates to OSI Layers 1-4
- Assure proper operations and backwards compatibility with IT and OT





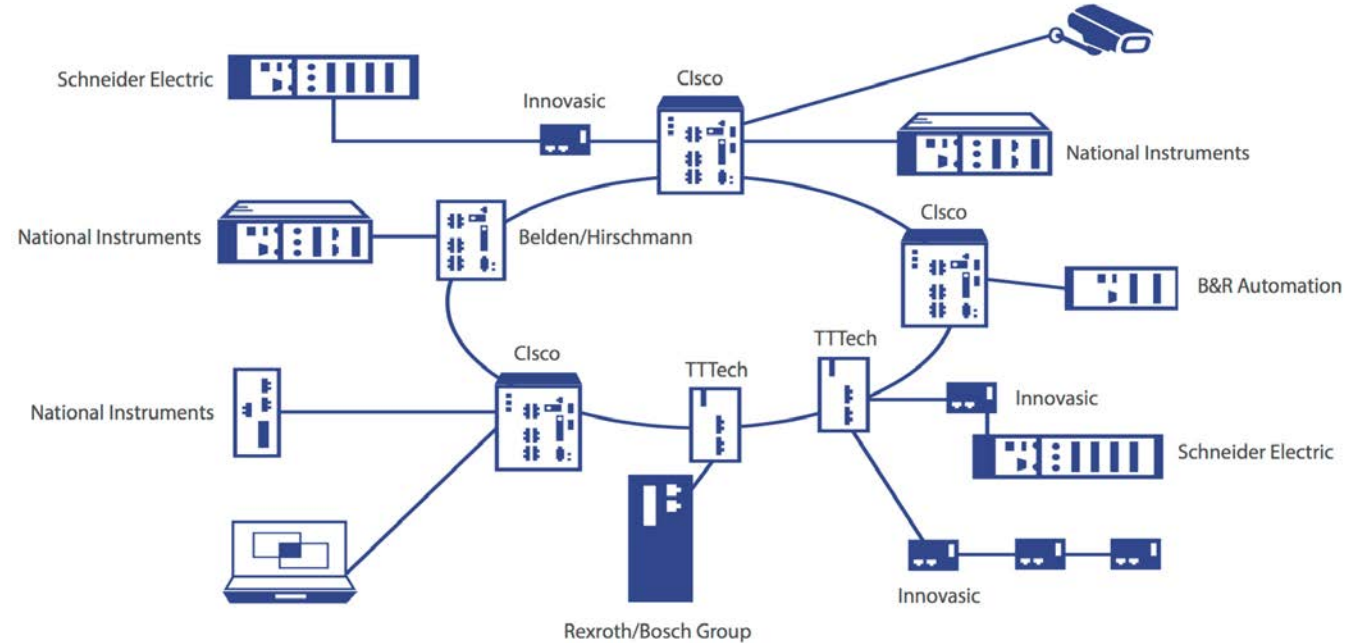
Growing Ecosystem of TSN Vendors at IIC

The Industrial Internet Consortium's Testbed for Time Sensitive Networks



Key Facts:

- **19 Vendors** participating (chip makers, switches, automation devices and testing products)
- **6 Plugfests** conducted over the last year in US, Austria and Germany
- **2 Testbed instances** at NI in Austin TX and BoschRexroth in Erbach Germany
- **Demonstrations at 6 major shows** (IoT SWC, SPS Drives, Hannover Messe, NI Week, IoT World, DE Forum)
- **Collaboration with multiple standards:** IEEE, IETF, AVNU, OPC and ODVA
- **Winner of Q1 IIC Testbed Showcase**



Testbed Innovation and Experimentation

Innovation & experimentation:

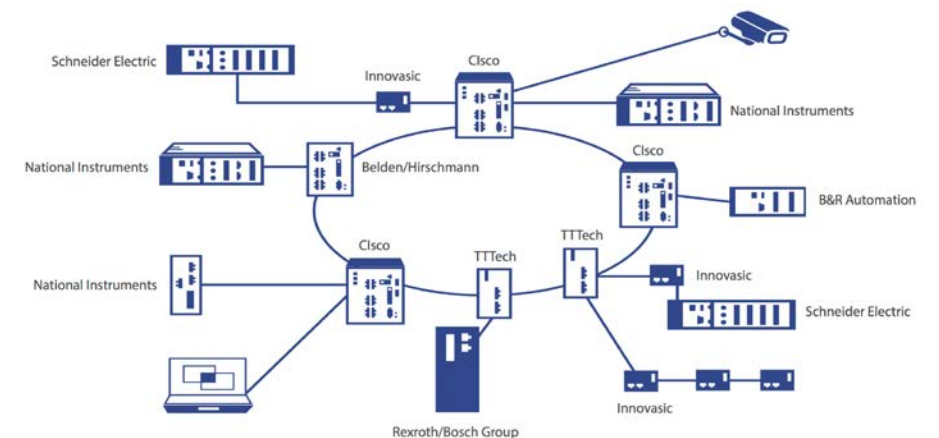
- Prototype and validate new TSN standards as they are being finalized
- Clarify vague areas in the standards to foster interoperability
- Derive system-level requirements based on practical experience
- Provide feedback to ongoing standardization and certification efforts

Identify challenges:

- Testing tools are required to validate results
- Debugging is challenging in face of multi-vendor environment and new technology



The Industrial Internet Consortium's Testbed for Time Sensitive Networks - Flexible Manufacturing for Robotics and Automation Cells





Thank You!

