Time Sensitive Network (TSN) Protocols
And use in EtherNet/IP Systems

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Time Sensitive Network (TSN) Protocols and use in EtherNet/IP Systems

1. Objective and Industrial Application requirements
2. IEEE Time-Sensitive Networks Initiatives
3. TSN Systems perspective
4. Summary
Agenda

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Industrial Implies a Diverse Set of Applications

High Traffic Mix, Deterministic, Low Latency, Secure, Reliable, High Throughput
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time synchronization</td>
<td>Enables common clock for transmission scheduling, correlated I/O, etc.</td>
</tr>
<tr>
<td>Latency provisions</td>
<td>Enables deterministic control loops</td>
</tr>
<tr>
<td>Reserved bandwidth</td>
<td>Enables applications to operate reliably in the presence of network congestion or network component failures</td>
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<tr>
<td>Redundancy</td>
<td>Enables fault tolerance due to component failures, etc.</td>
</tr>
<tr>
<td>Converged network</td>
<td>Enables coexistence with best effort traffic and potentially multiple industrial protocols</td>
</tr>
<tr>
<td>Topology flexibility</td>
<td>Enables common industrial network topologies including line, ring, tree</td>
</tr>
<tr>
<td>Scalability</td>
<td>Can grow from small systems to large systems (in both node and stream count)</td>
</tr>
<tr>
<td>Security</td>
<td>Support safely integrating into IIoT systems</td>
</tr>
</tbody>
</table>
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# IEEE Time-Sensitive Networks Overview

<table>
<thead>
<tr>
<th>Standard</th>
<th>Area</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 802.1ASrev, IEEE 1588</td>
<td>Timing &amp; Synchronization</td>
<td>Enhancements and Performance Improvements</td>
</tr>
<tr>
<td>IEEE 802.1Qbv</td>
<td>Forwarding and Queuing</td>
<td>Enhancements for Scheduled Traffic – Time-Aware Traffic Shaping</td>
</tr>
<tr>
<td>IEEE 802.1Qbu &amp; IEEE 802.3br</td>
<td>Forwarding and Queuing</td>
<td>Frame Preemption and Interspersing Express Traffic</td>
</tr>
<tr>
<td>IEEE 802.1Qca</td>
<td>Path Control and Reservation</td>
<td>Path Control and Reservation</td>
</tr>
<tr>
<td>IEEE 802.1Qcc</td>
<td>Central Configuration Method</td>
<td>Enhancements and Performance Improvements</td>
</tr>
<tr>
<td>IEEE 802.1Qci</td>
<td>Time Based Ingress Policing</td>
<td>Per-Stream Filtering and Policing</td>
</tr>
<tr>
<td>IEEE 802.1CB</td>
<td>Seamless Redundancy</td>
<td>Frame Replication &amp; Elimination for Reliability</td>
</tr>
</tbody>
</table>
EtherNet/IP System
TSN and Time Synchronization

[Diagram of TSN and Time Synchronization]
TSN and Time Synchronization
TSN and Time Synchronization
Time Aware Traffic Shaping

Scheduled Traffic Queue
Reserved Traffic Queue

Best Effort Traffic Queue

Credit Based Shaper

Transmission Selection

Periodic Control and IO Traffic

Scheduled Traffic Slot

Periodic Control and IO Traffic

Scheduled Traffic Slot

Periodic Control and IO Traffic

Scheduled Traffic Slot

Periodic Control and IO Traffic

Scheduled Traffic Slot
Frame Preemption

Periodic Control and IO Traffic

Scheduled Traffic Slot

Whole Frame

Scheduled Traffic Slot

Periodic Control and IO Traffic

Frame part 1

Frame Part 2

Scheduled Traffic Slot

Failed

Scheduled Traffic Slot
Stream Reservation Protocol – SR Class A
Stream Reservation Protocol – SR Class B
Path Control and Redundancy (Seamless) - 1CB
Path Control and Redundancy (Seamless) – PRP/HSR
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• **Summary:** Distribute schedules to TSN network elements
  - Schedule to be read / written in switches is in a standard format
  - Defines format of schedule
  - Improved performance and scalability to previous SRP

• **Relevance:** Allows standard, consistent way to set schedules for TSN traffic in switches from various vendors.
TSN System with Bridging TSN End-points
TSN System with Non-TSN End-points
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We think the ODVA should review the TSN technology for potential adoption. Some of the enhancements, in particular those around time synchronization, may require changes or enhancements to ODVA capabilities such as CIP Sync. But, the benefit of the technology to the vendors, customers and overall industrial ecosystem are significant and warrant the work to change or enhance ODVA standards and products to use TSN.
THANK YOU