IEC/IEEE 60802 JP TSN Industrial Profile

Deadline Application Model & Stream Class Based Scheduling Model

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IEC/IEEE 60802 JP TSN Industrial Profile:
Interoperability Introduction

**Interoperability** issues for co-existence and co-operation:
- Application model and configuration
- Network configuration
- Stream configuration and establishment

**Application Model and Configuration** is essential for co-operation and impacts **Network configuration** and **Stream configuration and establishment** and vice versa.

Application Model and Configuration Constraints/Requirements are identical in any location within the production hierarchy (machine, cell, …).
IEC/IEEE 60802 JP TSN Industrial Profile: Scope and Challenges of Interoperability

Challenges:

Control plane:
Centralized and distributed approaches

Data plane:
Application specific requirements

Scope of Vendor, Customer
Scope of IEC61158/IEC61784 IEC62541, ...
Goal: co-operation as 2nd level of interoperability

Scope of IEEE 802 and IEC/IEEE 60802 TSN-IA Profile
Goals:
- co-existence as 1st level of interoperability
- Common hardware requirements

Application Model and Configuration
(Application Profile, Communication Profile, Vendor Model, ...)

Middleware
(Fieldbus layer, OPC UA, ...)

Network Configuration
(netconf, restconf/YANG, SNMP/MIB, ...)

Stream Configuration and Establishment
(RAP, restconf, ...)

Ethernet/TSN
(Synchronization, Neighborhood detection, bounded latency communication, ...)

Goals:
- co-existence as 1st level of interoperability
- Common hardware requirements
Applications: include 1..n Talkers and 1..m Listeners

Deadline: Application defined fixed reference point within network cycle
Network cycle time is e.g. multiple of 31.25 μs

Transmit: Application’s network access is synchronized to network cycle Start
Talker frames are assigned to send cycles, which are multiples of the network cycle time
Transmission of frames as a convoy starts at network cycle Start:
  1st isochronous cyclic, 2nd cyclic real-time
Talker frame sequence inside a traffic class convoy follows “longest path first”

Receive: Listeners expect Talker frames before assigned deadline,
in case of isochronous cyclic: aligned to the network cycle / deadline
Stream Class based Scheduling

→ Deadline Application Model is independent of the realizations of areas 2 and 3:

→ Deadline Application Model does not imply stream specific timing, which avoids per-stream schedule planning.

→ **Stream class based scheduling** suffices the Deadline Application Model:
  - Assign streams to traffic classes
  - Transmit streams as convoy at send cycle start
  - 1st isochronous cyclic, 2nd cyclic real-time
  - Sequence inside a traffic class convoy follows “longest path first”
Stream Destination MAC Address based forwarding on path

Queue based transmission selection:
  - Strict Priority together with e.g.
    • Preemption, and/or
    • Enhancements for scheduled Traffic (e.g. TAS window per Traffic Class)
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Stream Class based Scheduling: Scalability, Strengths

- Ad-hoc stream establishment and removal of streams without any impact on running streams
- No fragmentation of transmission interval - independent from order of stream establishment
- Perfectly fits to seamless redundancy (different latencies on asymmetric disjoint paths)
- Stream class based scheduling allows:
  - lowest bridge latency
  - best bandwidth utilization
- Bridges do not require synchronization if TAS is not used
- Simplifies link speed transitions if TAS is not used
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Stream Class based Scheduling: Lessons learned

→ No benefit from frame-based scheduling combined with deadline model
→ Allows decoupling of application from frame scheduling
→ One application starting time at deadline, independent e.g. from seamless transmission

→ In use for more than 30 years in Industrial Automation
→ Integrated in hardware of technology modules (e.g. drives, counters, positioning, IOs, …)
→ Fulfills all TSN-IA use cases including required topologies and network cycle times,
  
  except “Drives without common application cycle”
- IOC Talker sends frames in convoy using “longest path first” strategy
- Each IOD Talker sends frame at begin of network cycle
Thank You!

Questions?
IEC/IEEE 60802 JP TSN Industrial Profile: Stream Class based Scheduling

“Talker frames are assigned to send cycles, which are multiples of the network cycle time”
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“Transmission of frames as a convoy starts at network cycle Start”

Network cycle time

Isochronous cyclic frames

Cyclic realtime frames

Frames from all other traffic classes

Transfer Time

Safety Margin

Deadline