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:

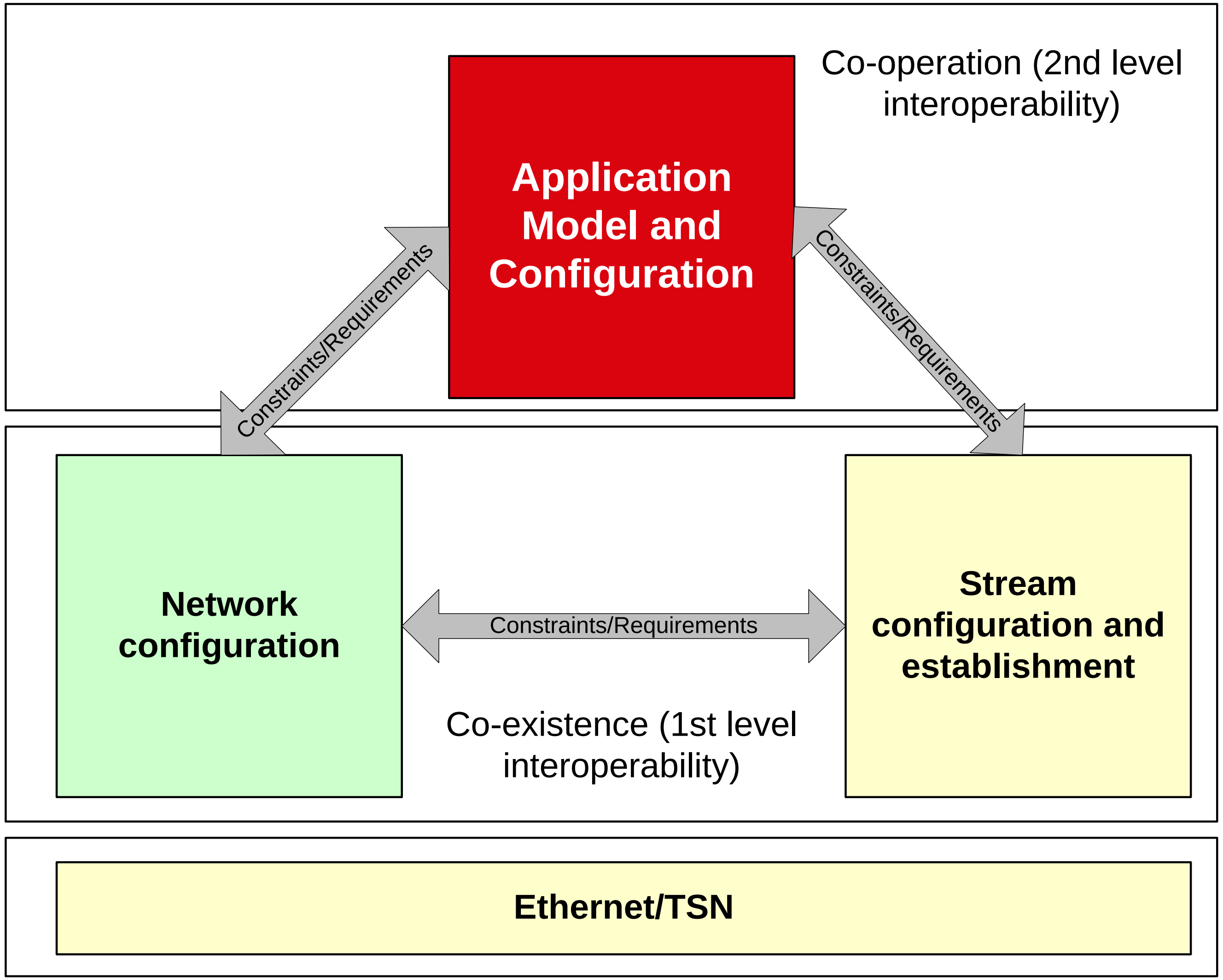
Interoperability Introduction

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, …).



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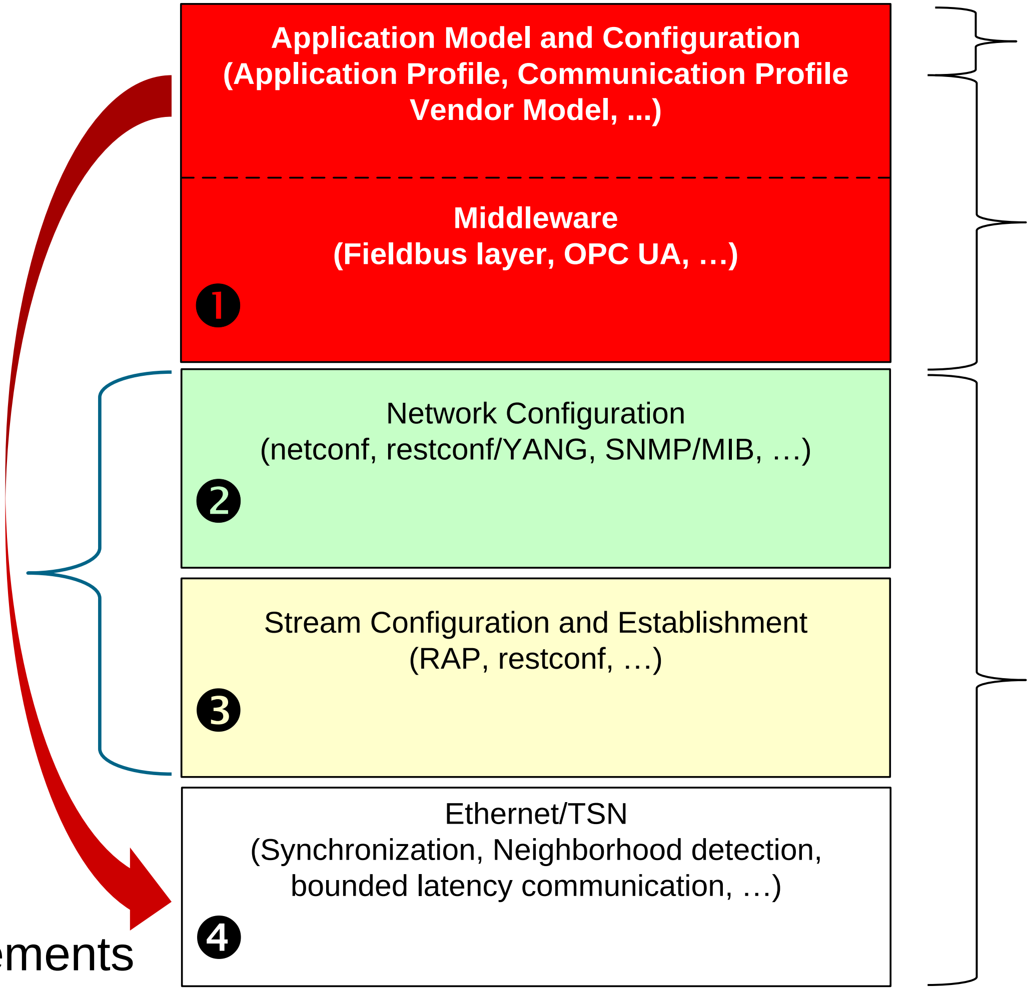
Scope and Challenges of Interoperability



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

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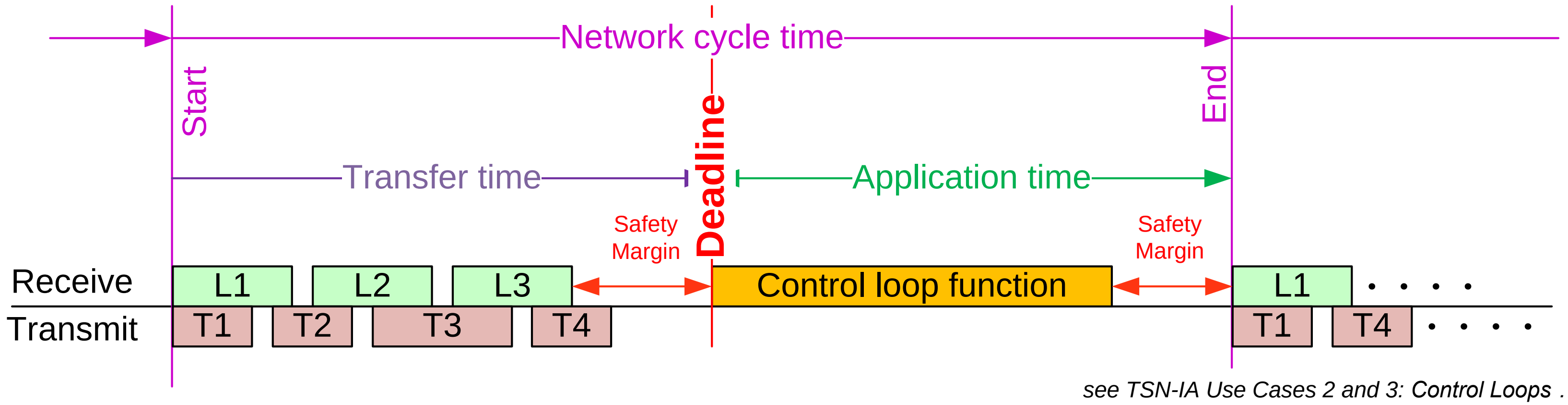
Deadline Application Model



see TSN-IA Use Cases 2 and 3: Control Loops …

- **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 ❷ and ❸.

→ 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 Class based Scheduling in Network / Bridges

- 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)

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

Stream Class based Scheduling: Lessons learned

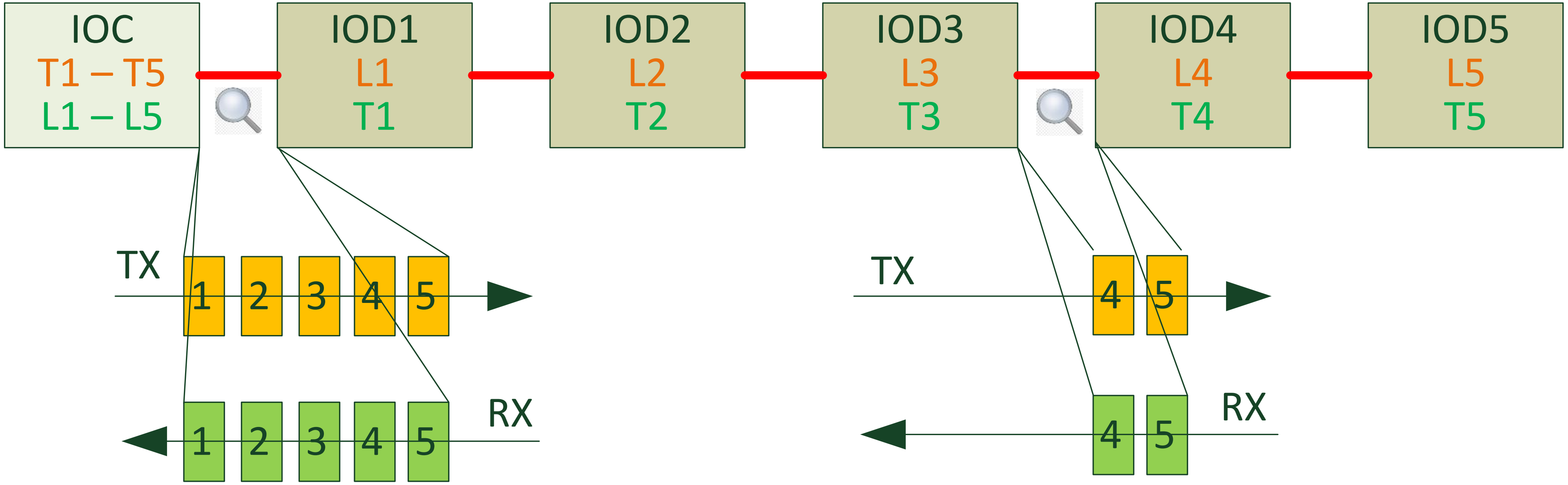
- → No benefit from frame-based scheduling combined with deadline model
- → Allows decoupling of application from frame scheduling
- → One application starting time at deadline, independent e.g. from seamless transmission

- → 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”

Stream Class based Scheduling: Example

- IOC Talker sends frames in convoy using "longest path first" strategy
- Each IOD Talker sends frame at begin of network cycle

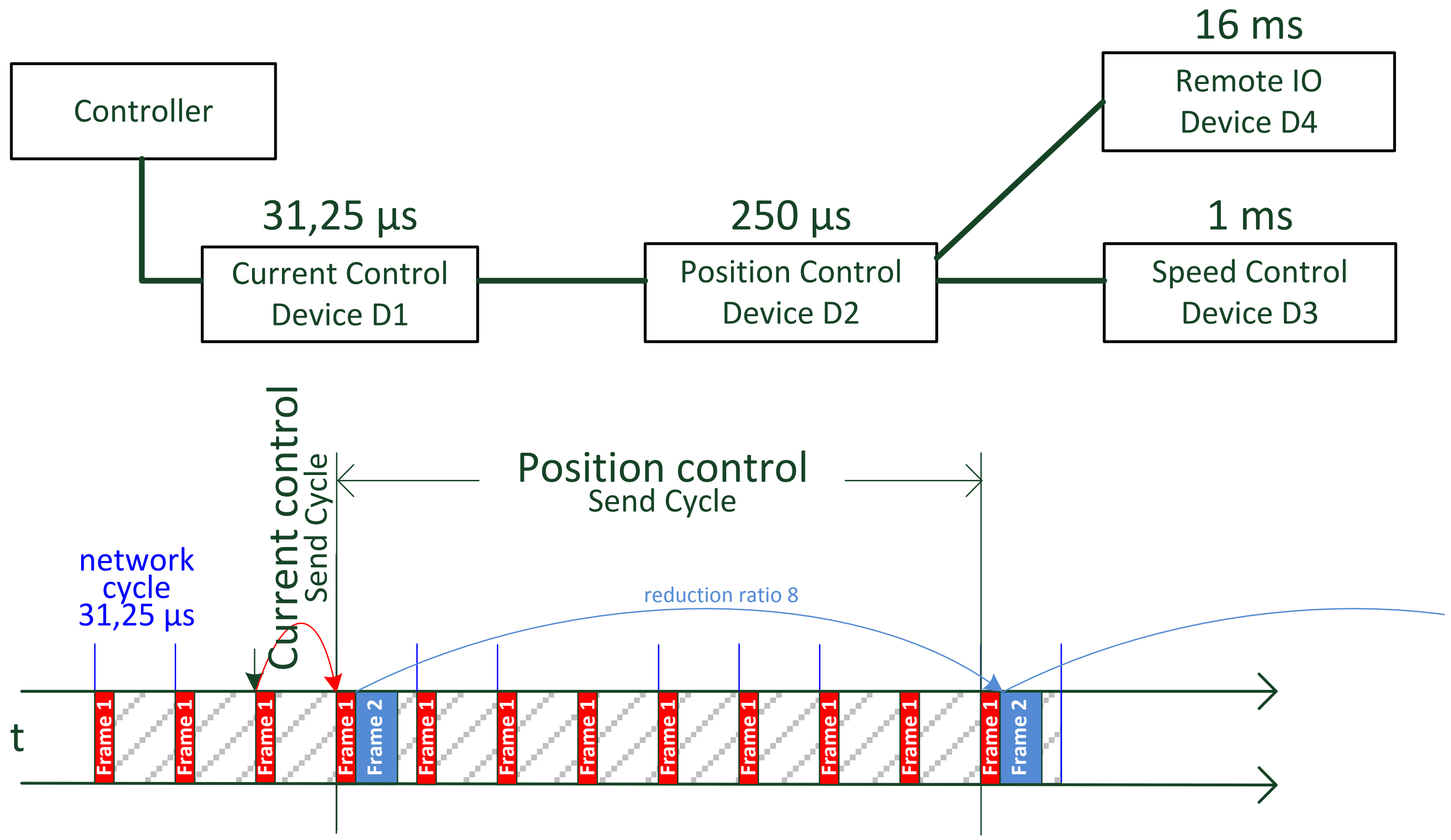


Thank You!

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”