Coexistence & Convergence in TSN-based industrial automation networks

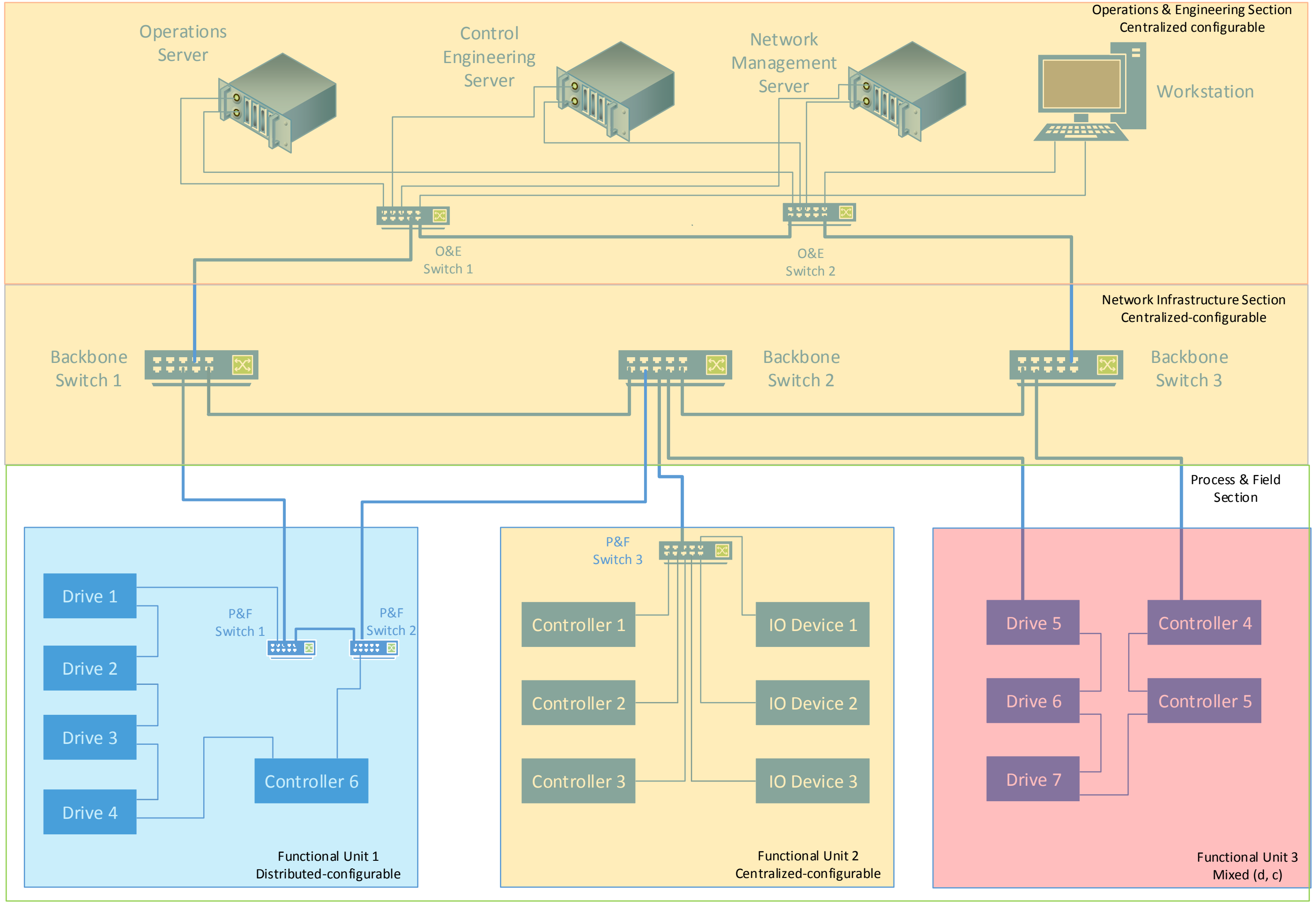
Marius Stanica, IEEE/IEC JP 60802, July 2018, Frankfurt

Topics

- Coexistence of the TSN configuration models
  - Within the same TSN domain
  - Over different TSN domains
- Coexistence of various traffic shaping mechanisms
  - For the same traffic types, in the same TSN domain
- Convergence of network segments supporting various port/media seamless redundancy mechanisms
  - IEEE 802.1 CB, PRP, HSR

Coexistence. Configuration. Problem statement

- System
  - Operations & Engineering
  - Network Infrastructure
  - Process & Field
- Various methods of TSN features configuration
  - Operations & Engineering: fully-centralized
  - Network Infrastructure: fully-centralized
  - Process & Field: mixed
    - Functional Unit 1: fully-distributed
    - Functional Unit 2: fully-centralized
    - Functional Unit 3: mixed (not all devices support the same TSN configuration mechanism)
  - Head-CNC for CNC-hierarchy control
  - One CNC per TSN domain, possible but not required (not present, its function is taken by Head-CNC)
  - TSN domains: Functional Unit 1, Functional Unit 2, Functional Unit 3, Network Infrastructure, Operations & Engineering, All
- System has to work!



Coexistence. Configuration. Needed functions

Synchronised and joint (dynamic and static) reservations management

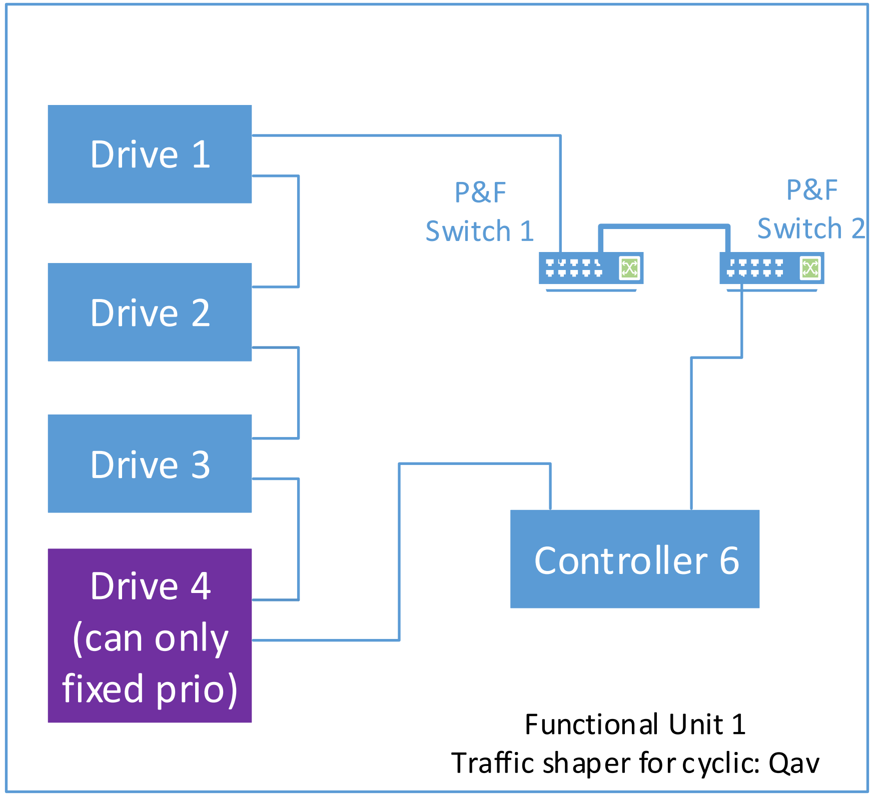
- Actors involved
  - CNC(s), bridges
- Polling
  - CNC(s) poll/s bridges for new Dynamic Reservations entries, per TSN domain
- Resource-related information exchange
  - CNC(s) inform/s bridges about own reservations made over CUC(s), per TSN domain
- CNC-hierachy control
  - Head-CNC polls CNCs of each TSN domain
- Race conditions avoidance
  - Locks must be in place while a poll is ongoing for a bridge, both for bridges and CNC reservations
  - Locks must be also in place in bridges and TSN domain specific CNCs when head-CNC poll happens
- Reservations conflict management
  - Head-CNC must be capable of handling conflicts: identification, analysis, solution, information of all parties
- Security
  - Authentication
- Diagnostics
  - Early identification of misconfigurations
  - Support for troubleshooting in case of misconfigurations
- Nice to have: Dynamic resource-usage optimization
  - Head-CNC may perform regular analysis of the traffic and of application communication requirements and may propose optimizations, following current situation
- Question: what about Functional Safety, in case of dynamic hot plug?

Coexistence. Traffic shaping. Problem statement

TSN domain for Functional Unit 1

- Only cyclic communication traffic type/pattern (for now, let us consider just this example) within this Functional Unit
- Three Drives and a PLC supporting the same traffic shaping mechanism for cyclic communication (i.e. Qav)
- One Drive (Drive 4), supports only another traffic shaping mechanism for cyclic communication (i.e. only fixed priority) and it is brought in, i.e. as a fast replacement (until a new device arrives following order)
- Daisy-chain ring topology
- Bridges support both traffic shaping methods
- TSN configuration model: as presented in Slide 3, thus Drive 4 supports only fully-distributed TSN configuration

- Drive 4 should be integrate-able to this functional unit (then is this functional unit „a safe neighbourhood/TSN domain“ anymore? It should be.)

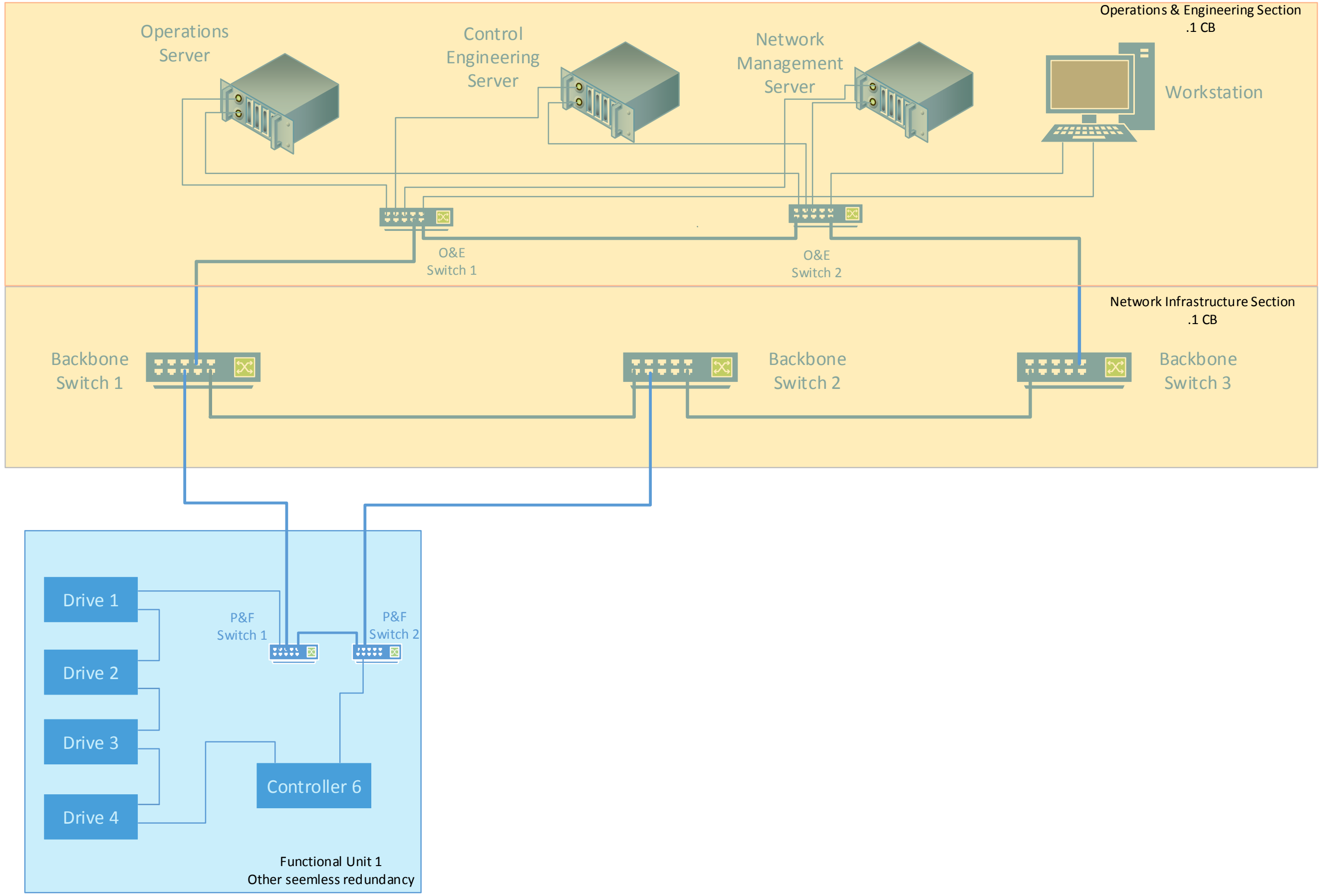


Coexistence. Traffic shaping. Needed functions

- Synchronization between traffic shaping mechanisms
  - It depends on which exact traffic shapers do we refer to
    - The example with Qav and Fixed Priority is rather easy and can be handled by the fully-distributed TSN configuration model
    - If the preponderent traffic shaper would have been Qbv and the added device would only support Qav, then the fully-distributed TSN configuration model would not be enough (as of todays Qcc) to support such an use case, without the support of a CNC
    - Configuration coexistence concepts from the previous chapter would be a good fit
- Head-CNC must be capable of
  - Understanding which traffic shapers are supported in the system
  - Calculate the correctly needed reservations
  - Send the reservations towards the bridges of Functional Unit 1

Convergence. Redundancy. Problem statement

- Same system as in Slide 3
  - Seamless media redundancy model is IEEE 802.1 CB in the Operations & Engineering and Network Infrastructure
  - Seamless media redundancy model in Functional Unit 1 is a different one: i.e. HSR, PRP,…
  - Could be also viceversa than in the pictured example: there is a functional system working on a given seamless media redundancy (i.e. HSR, PRP,…) and an new functional unit based on IEEE 802.1 CB is added
- Functional Unit 1 should be integreatable without the need of additional hardware



Convergence. Redundancy. Needed functions

- Compatibility between mechanisms of doubling/elimination of double frames must be achieved
- Non-seamless media redundancy protocols (i.e RSTP, MRP) are already coexistent with 802.1 CB
- Needed improvements in 802.1 CB?
  - To be further discussed
  - PRP, HSR are interoperable with 802.1CB (at least partly?)
  - Others?