

Embedded reconfiguration of TSN

ECRTS 2024

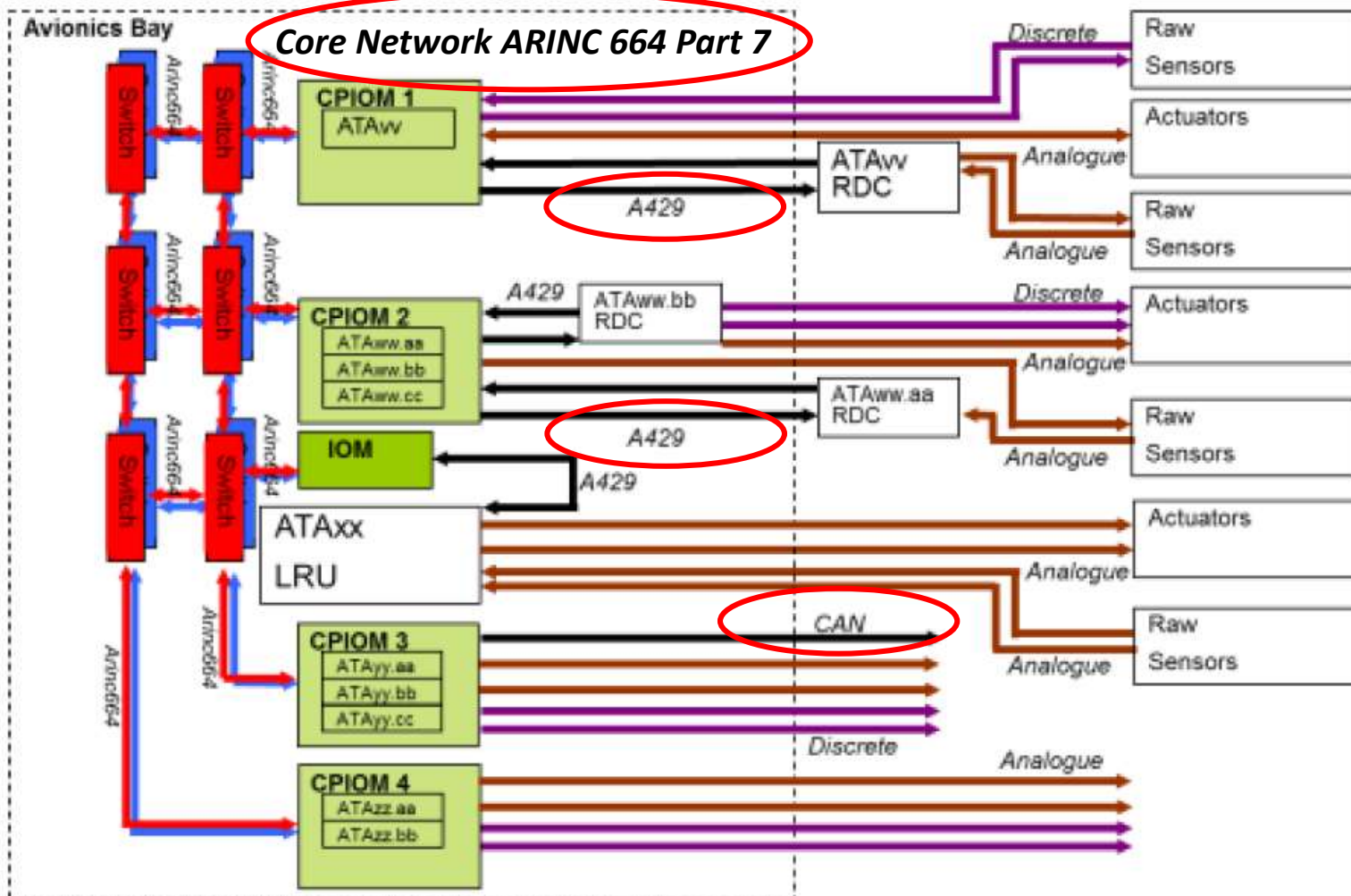
Industrial Challenge session

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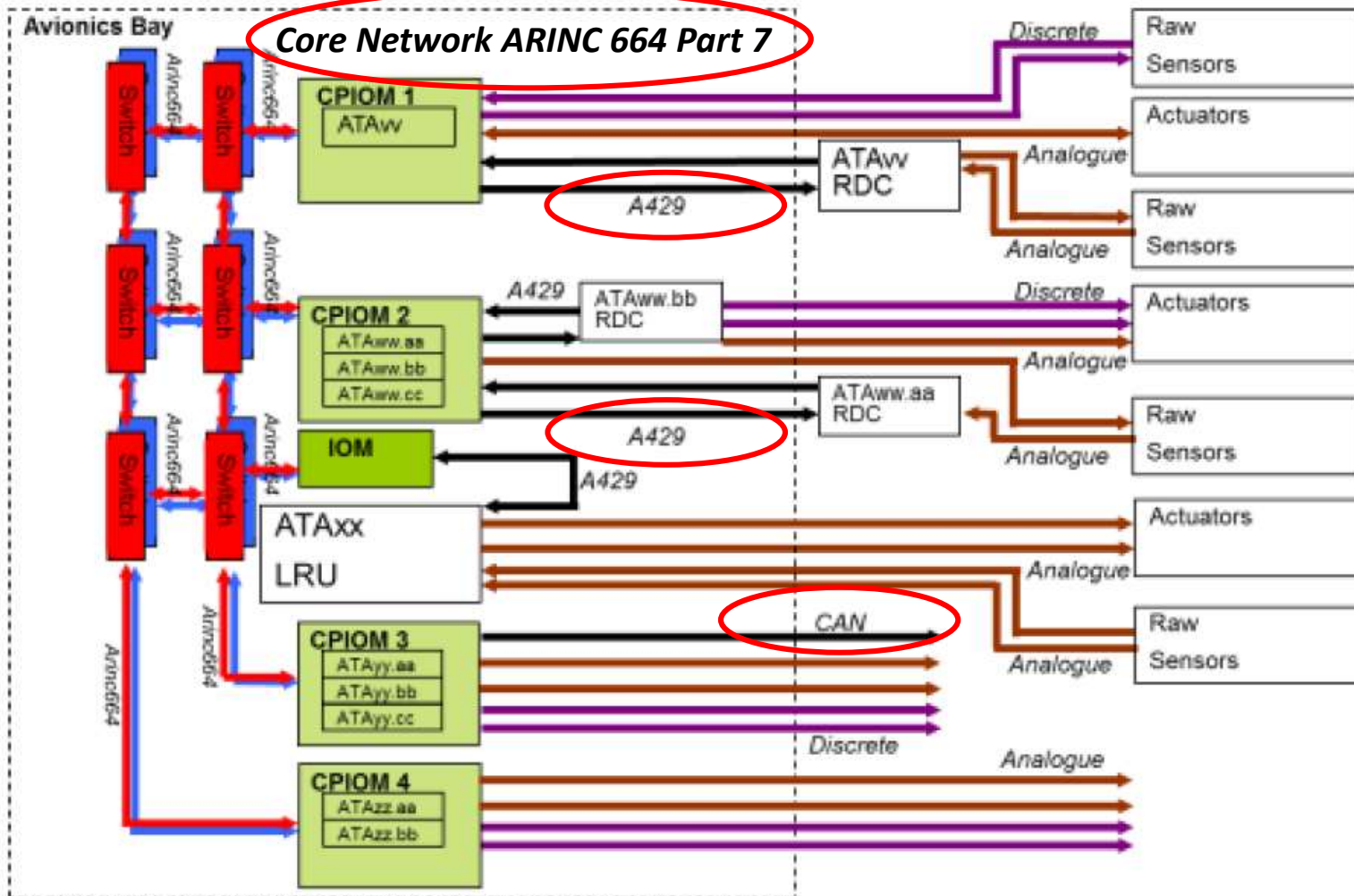
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Global context

- Avionics networks
 - ARINC 664 Part 7 (AFDX)
 - ARINC 429
 - ARINC 629
 - ARINC 825 (CAN)
 - MIL-STD-1553
 - Commercial Ethernet
 - ...

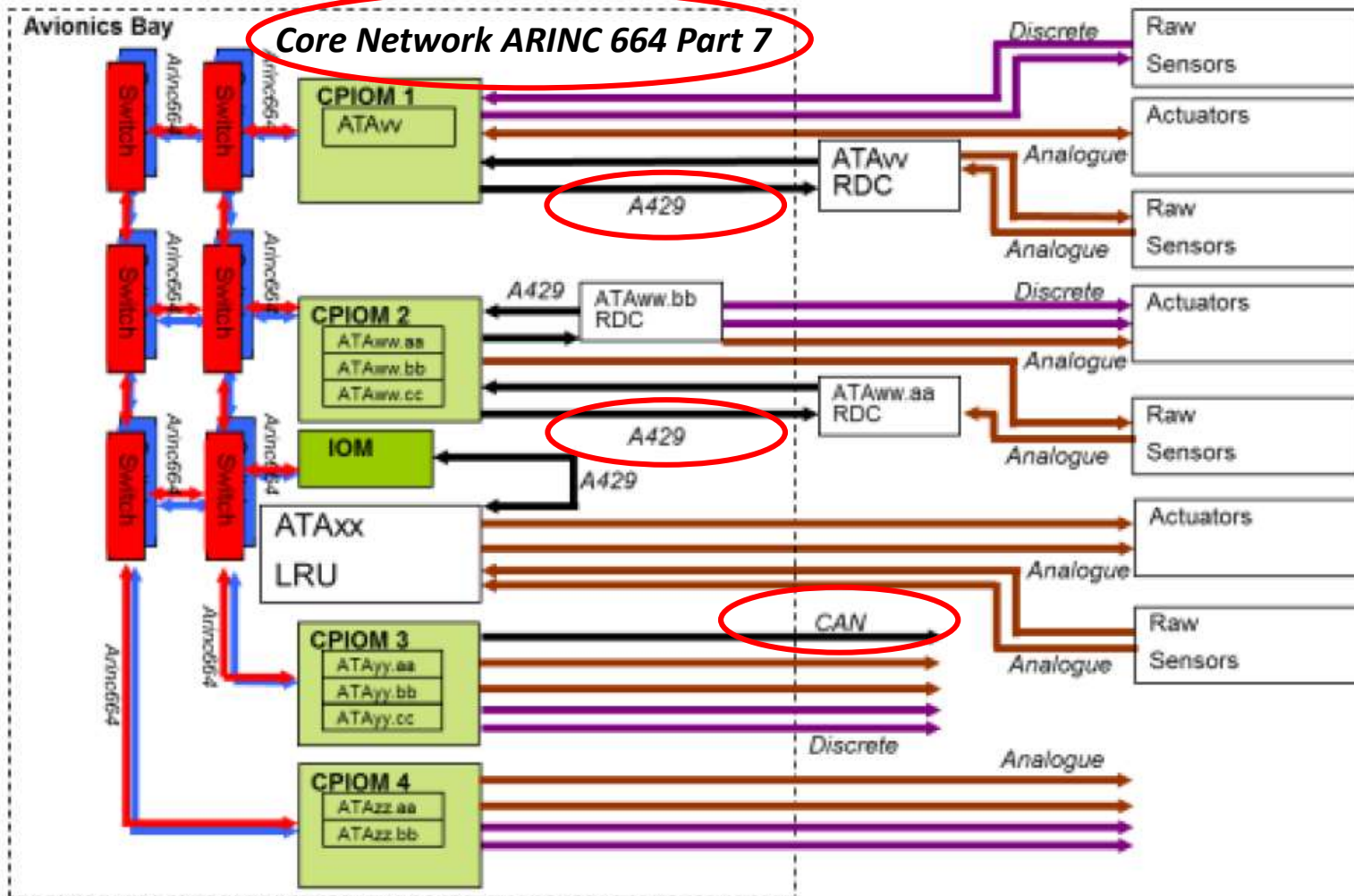


Global context



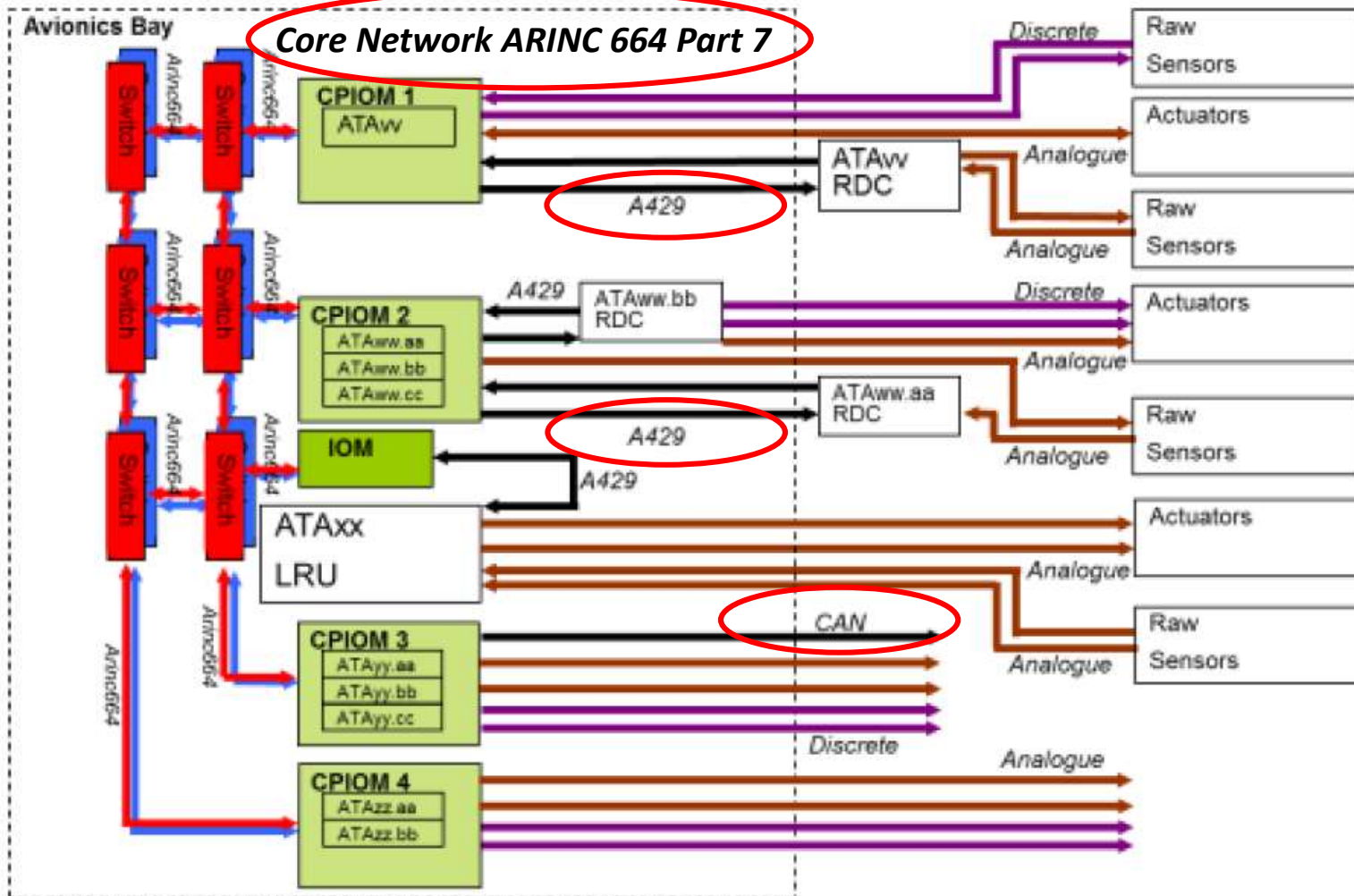
- Avionics networks
 - ARINC 664 Part 7 (AFDX)
 - High critical comm.
 - 4 priority levels
 - Up to 100 Mbps
 - Computers > 100
 - Duplicated to increase the fault tolerance
 - ARINC 429
 - ARINC 629
 - ARINC 825 (CAN)
 - MIL-STD-1553
 - Commercial Ethernet
 - ...

Global context



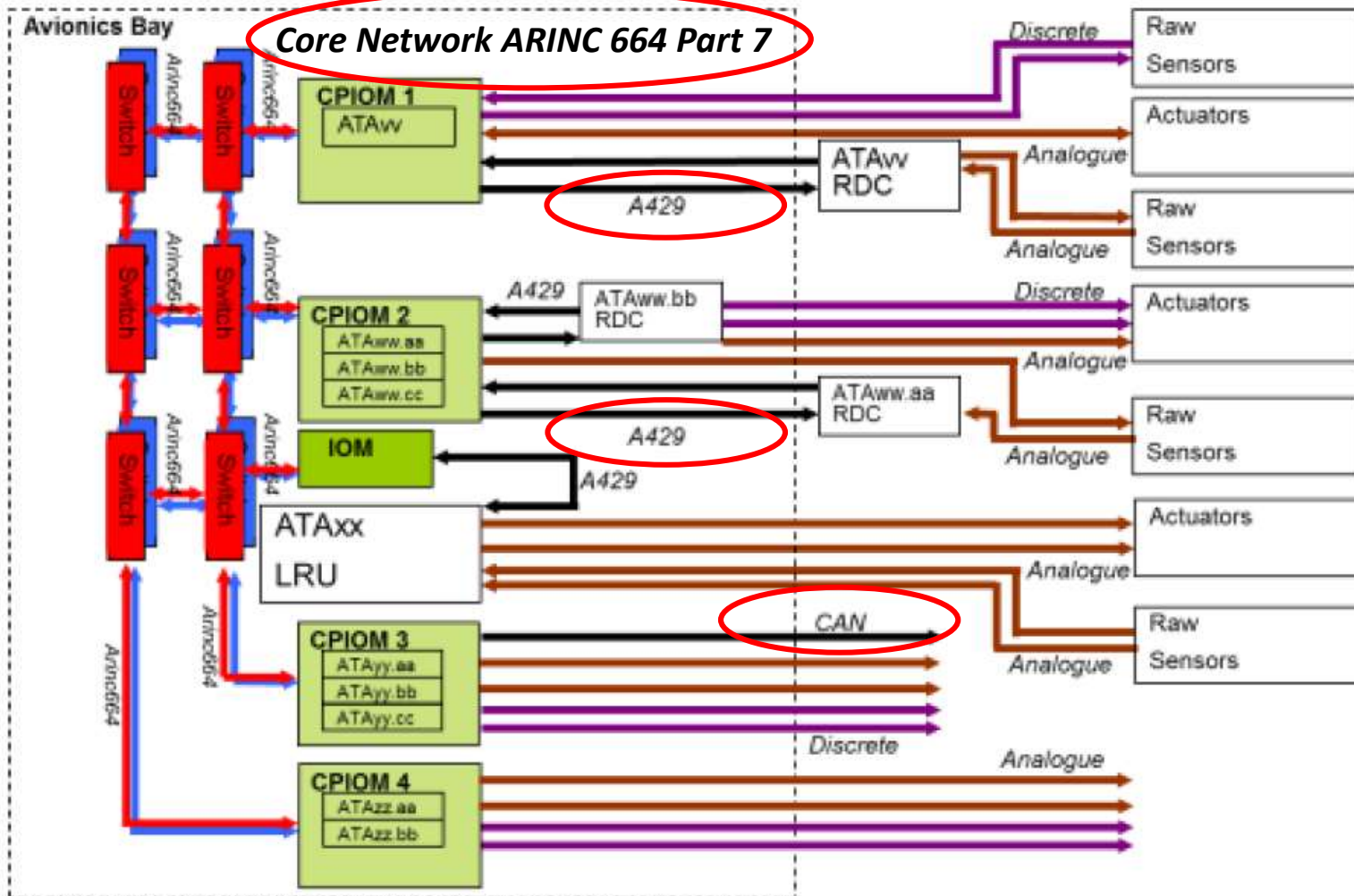
- Avionics networks
 - ARINC 664 Part 7 (AFDX)
 - Duplicated to increase the fault tolerance and ensure that data transmission even in the event of a failure or disruption in the network
 - ARINC 429
 - ARINC 629
 - ARINC 825 (CAN)
 - MIL-STD-1553
 - Commercial Ethernet
 - ...

Global context



- Avionics networks
 - ARINC 664 Part 7 (AFDX)
 - Connecting sensors and actuators
 - Up to 100 Kbps
 - Computers < 20
 - ARINC 429
 - ARINC 629
 - ARINC 825 (CAN)
 - MIL-STD-1553
 - Commercial Ethernet
 - ...

Global context



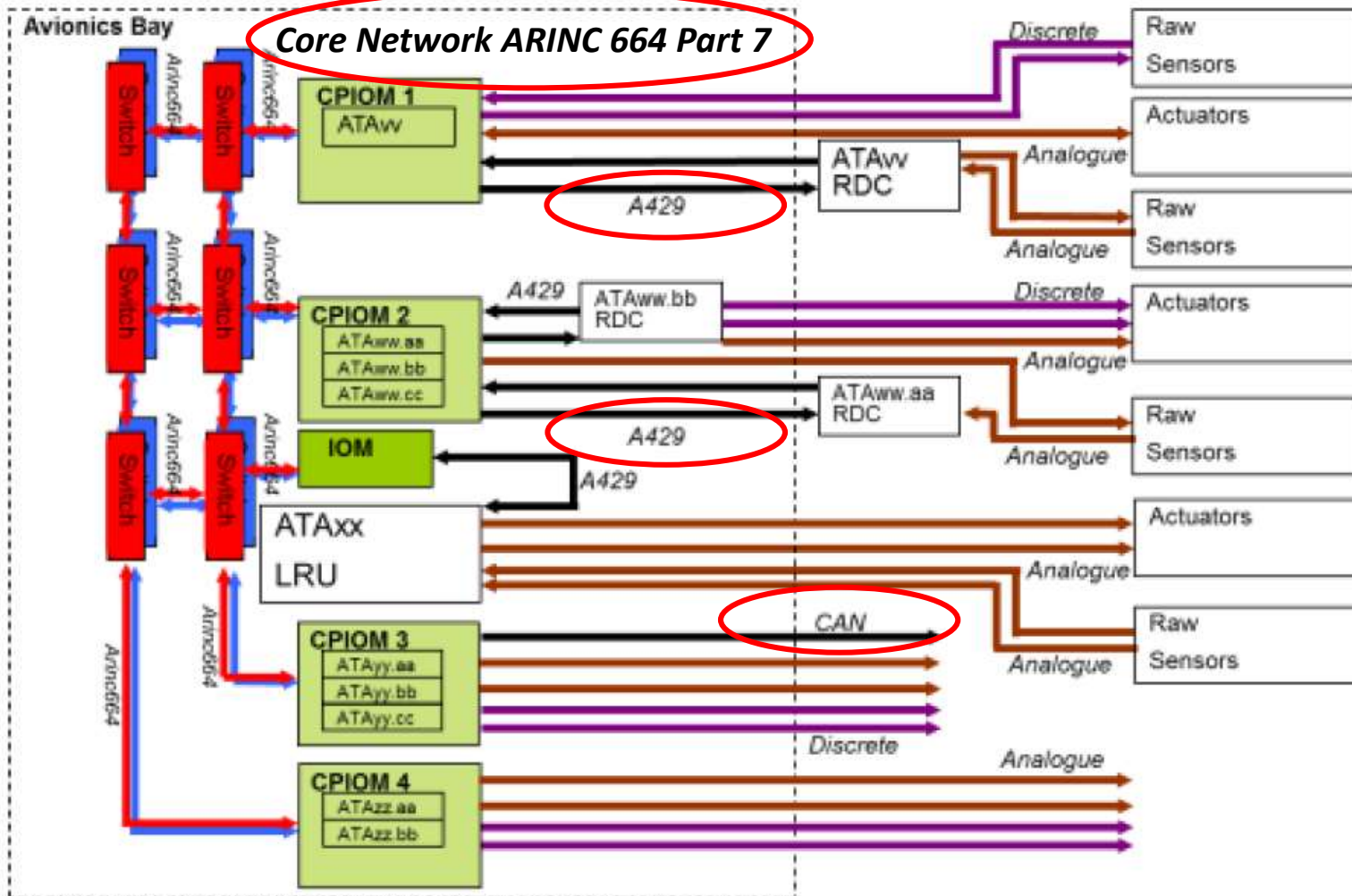
- Avionics networks
 - ARINC 664 Part 7 (AFDX)
 - ARINC 429
 - ARINC 629
 - ARINC 825 (CAN)
 - MIL-STD-1553
 - Commercial Ethernet
 - In-flight Entertainment & Connectivity (BE traffic)
 - Over 1 Gbps
- ...

Global context

- Avionics networks
 - A380: 100,000 different wires, totaling 530 kilometers



Aircraft cabling

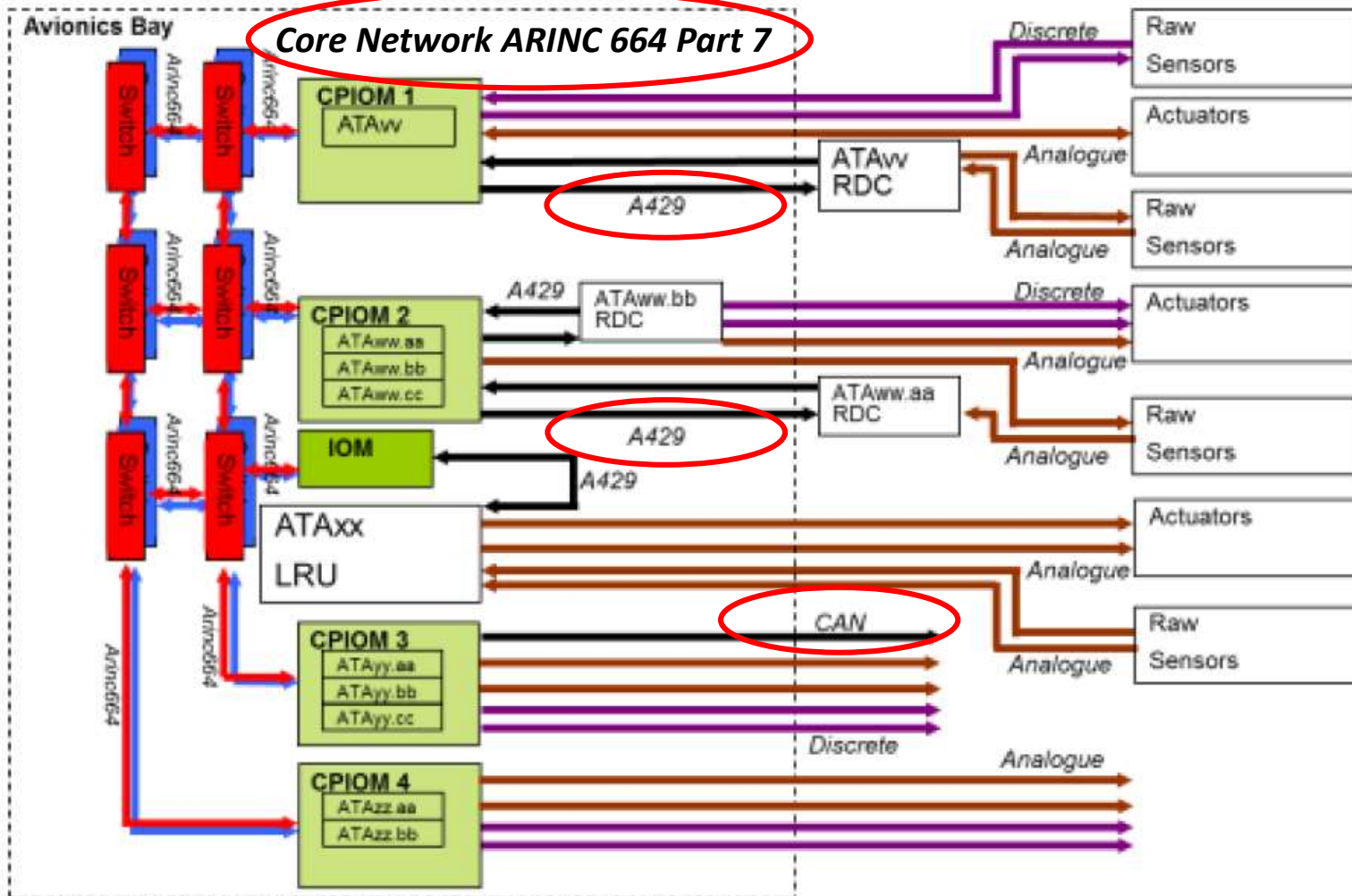


Global context

- Avionics networks
 - Challenges: reduce SWaP (Size, Weight and Power), maintenance and certification costs

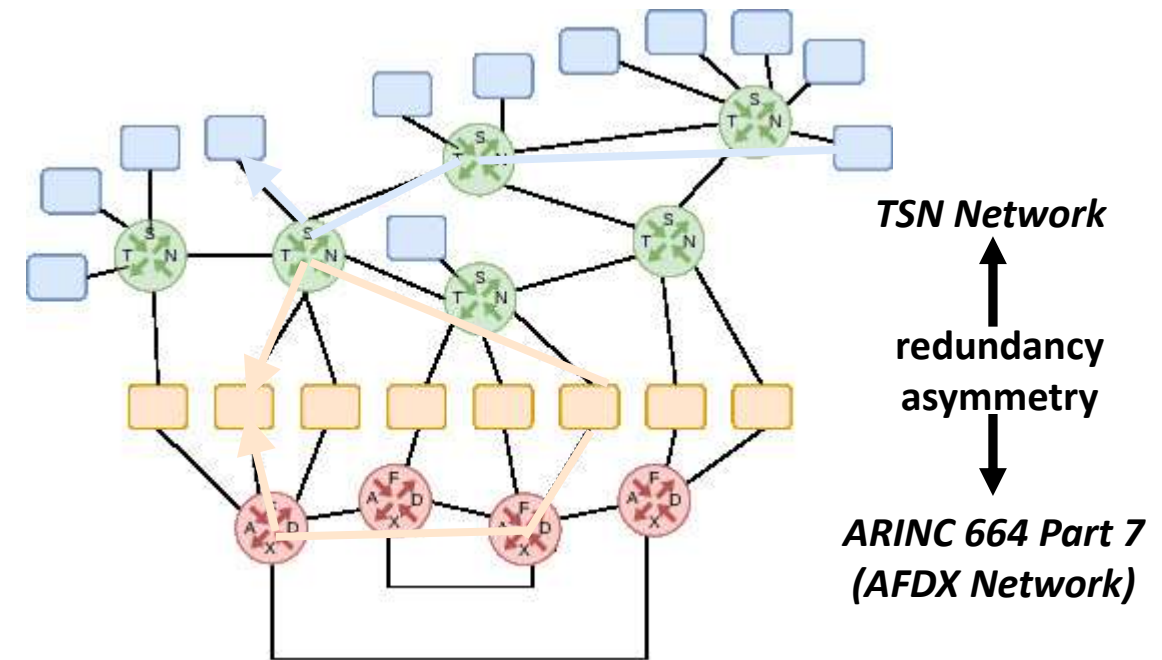


Aircraft cabling



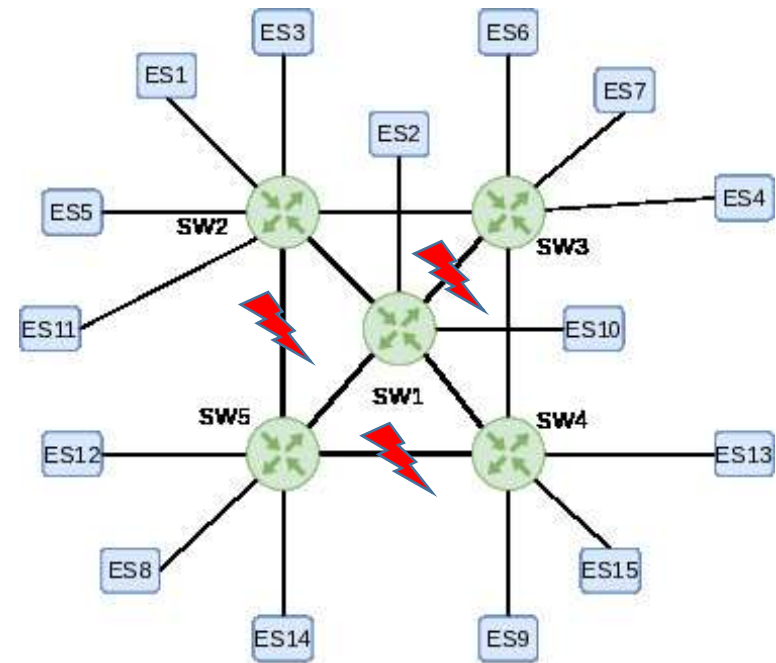
Global context

- TSN: the new real-time Ethernet
- Candidate as future avionic data backbone
- Hosting both
 - Critical data flows (in redundancy with legacy AFDX)
 - And non-critical data flows



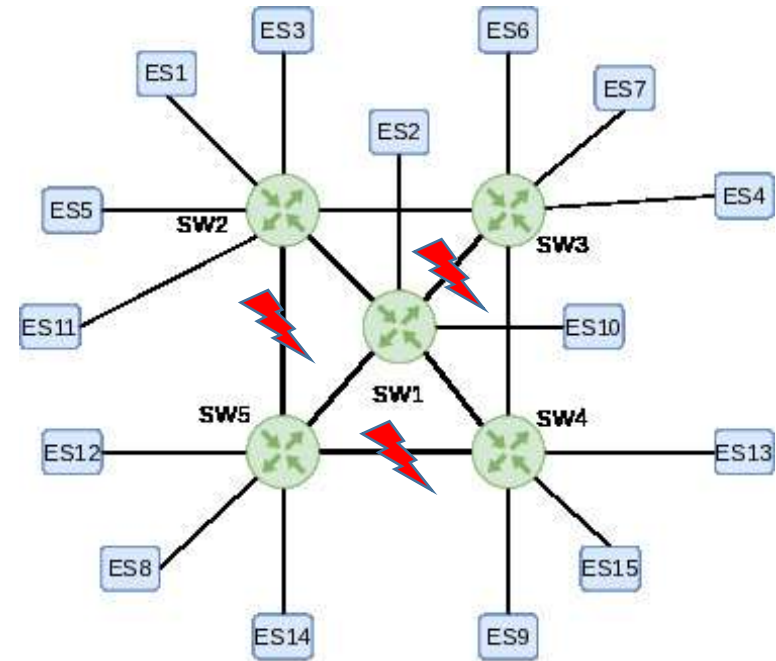
Challenge context

- TSN-only
- Set of real-time data flows (*streams*)
- Initial static configuration
- Possible faults



The challenge itself

- In case of faults
 - Computing a new configuration
 - Still ensuring real-time guarantees
 - At least for most critical flows
 - Notion of flow utility/criticality
 - In short amount of time
 - Using embedded resources
 - While maintaining service



The challenge limits

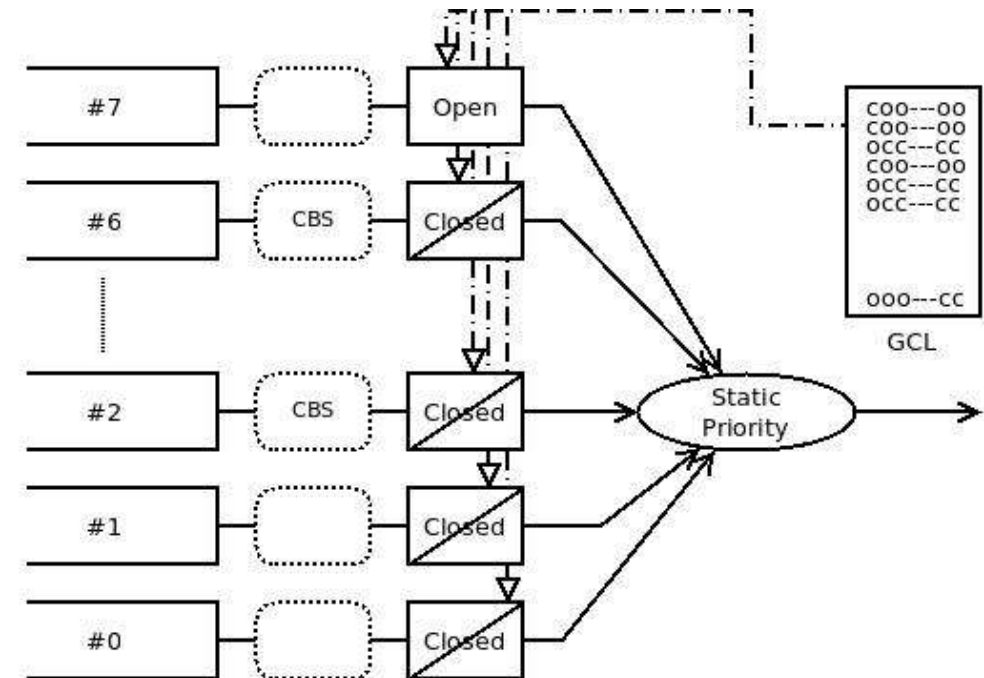
A subset of TSN

- One Time Aware Shaper queue (#7)
- A few Credit-Based-Shaper queues (#6-#2)
- Best-effort traffic

TAS / TT
/ TDMA

CBS

BE



Is it really a challenge?

TAS configuration challenge

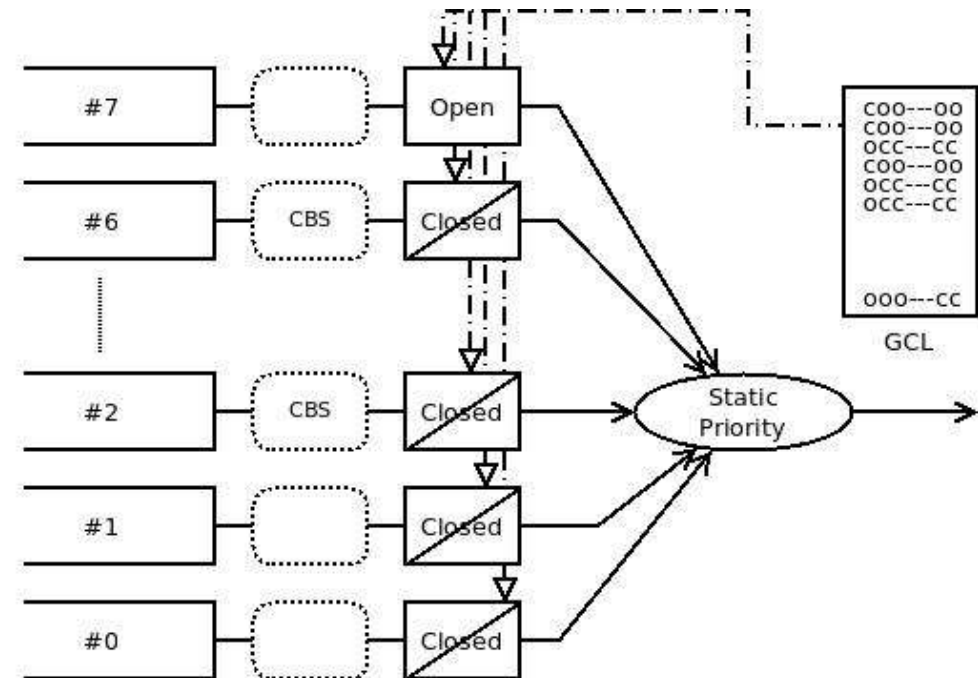
- TAS : Time Aware Shaper Hard
- Basic idea: Time-Triggered schedule
 - Cyclic behavior
 - One time window = one frame
- End-to-end schedule
 - Alignement of windows allong the path
- TAS with TSN: queuing semantics
 - Based on gate schedule
 - Sends the head of queue Harder

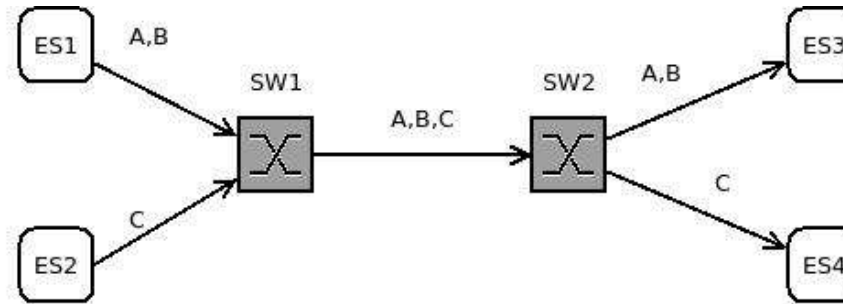
Harder

TAS / TT
TDMA

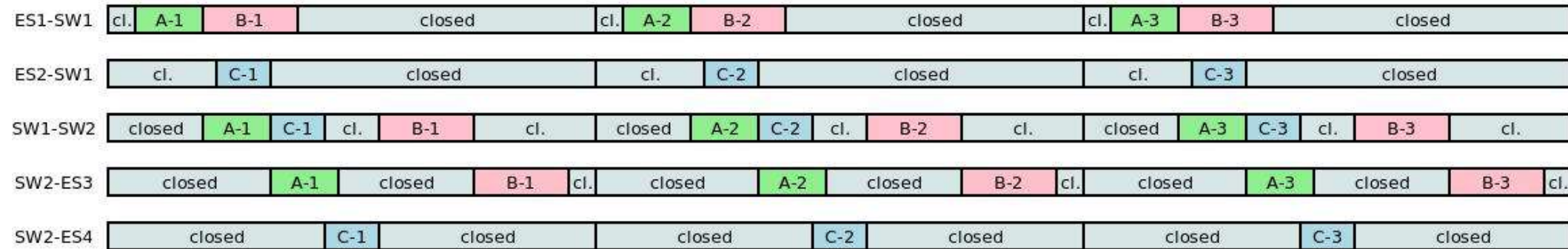
CBS

BE

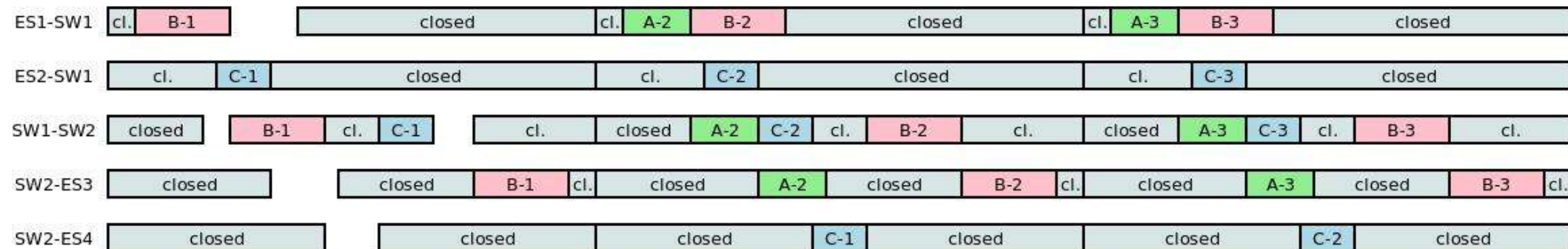




Nominal TAS behavior



Loss impact



TAS re-configuration challenge

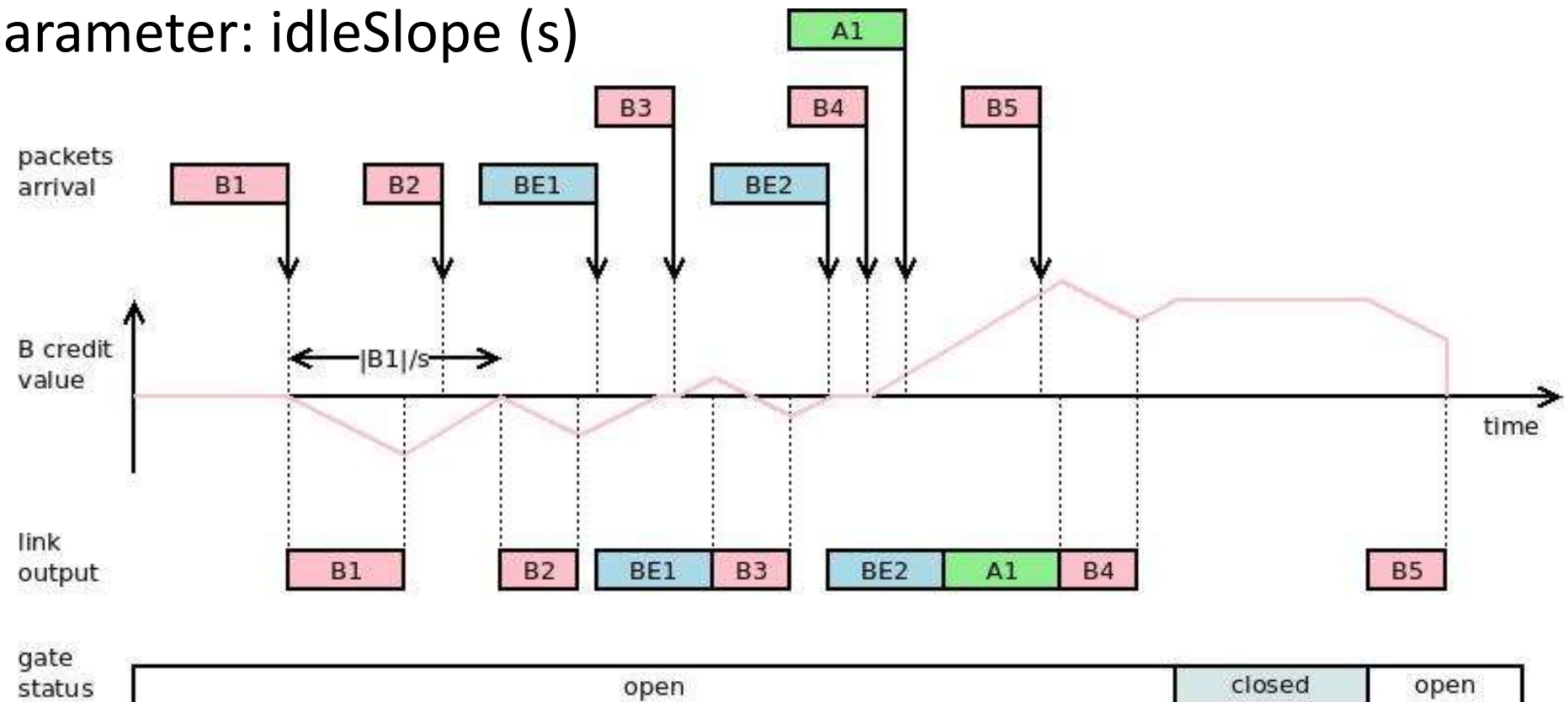
- Short configuration time (s – mn)
- Incremental schedule (keep existing windows, as much as possible)
- But re-schedule based on utility
 - Ex: route of flow f is broken
 - No (route,schedule) is found
 - Some lower utility flows can be removed: which ones? How many?
- The coherence problem

The coherence problem

- Removing a flow: cf. loss and queueing semantics
- Adding a flow (because of re-routing)
 - Need add of dedicated time window
 - In each node along the path
- Problem: deployment of new configuration along all paths

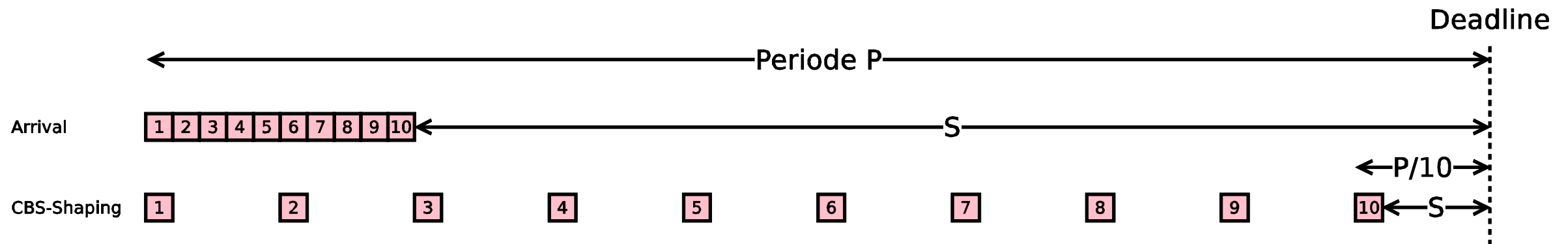
CBS configuration challenge

- CBS: Credit-based Shaper / Based on evolution of a credit
- Per queue parameter: idleSlope (s)



CBS configuration challenge

- Configuration: set one slope per queue along the path
- The trivial (false) idea:
 - Let r_i the throuput of flow i
 - Let $F(p)$ be the set of flows crossing port p
 - Set $s(p) = \sum_{i \in F(p)} r_i$
- Exemple: 10 flows, same (source, dest, size, period), implicit deadline



CBS configuration challenge

Configuration main steps

- Assign a local deadline per queue (same for all flows in the queue)
- Evaluate interferences of
 - Higher priority flows
 - Gate closing (TAS interference)
- Compute a slope

CBS re-configuration challenge

Configuration main steps

- Assign a local deadline per queue (same for all flows in the queue)
- Evaluate interferences of
 - Higher priority flows
 - Gate closing (TAS interference)
- Compute a slope
- In short amount of time

Conclusion

How to contribute?

- github.com/ecrtsorg
 - Textual description of the challenge
 - Full Data set (topology, flows characteristics)
 - Mailing list