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ResTSN
Resilient Time-Sensitive Networking

THALES

Towards onboard dynamic reconfiguration of TSN real-time network

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DIVERSE Workshop @ ETFA 2024

Outline

- Context: Communication networks in aircrafts
- Introducing TSN in future aircrafts
- TSN dynamic reconfiguration Challenge
  - Challenge context
  - TAS (re-)configuration challenge
  - CBS (re-)configuration challenge
- How to contribute ?

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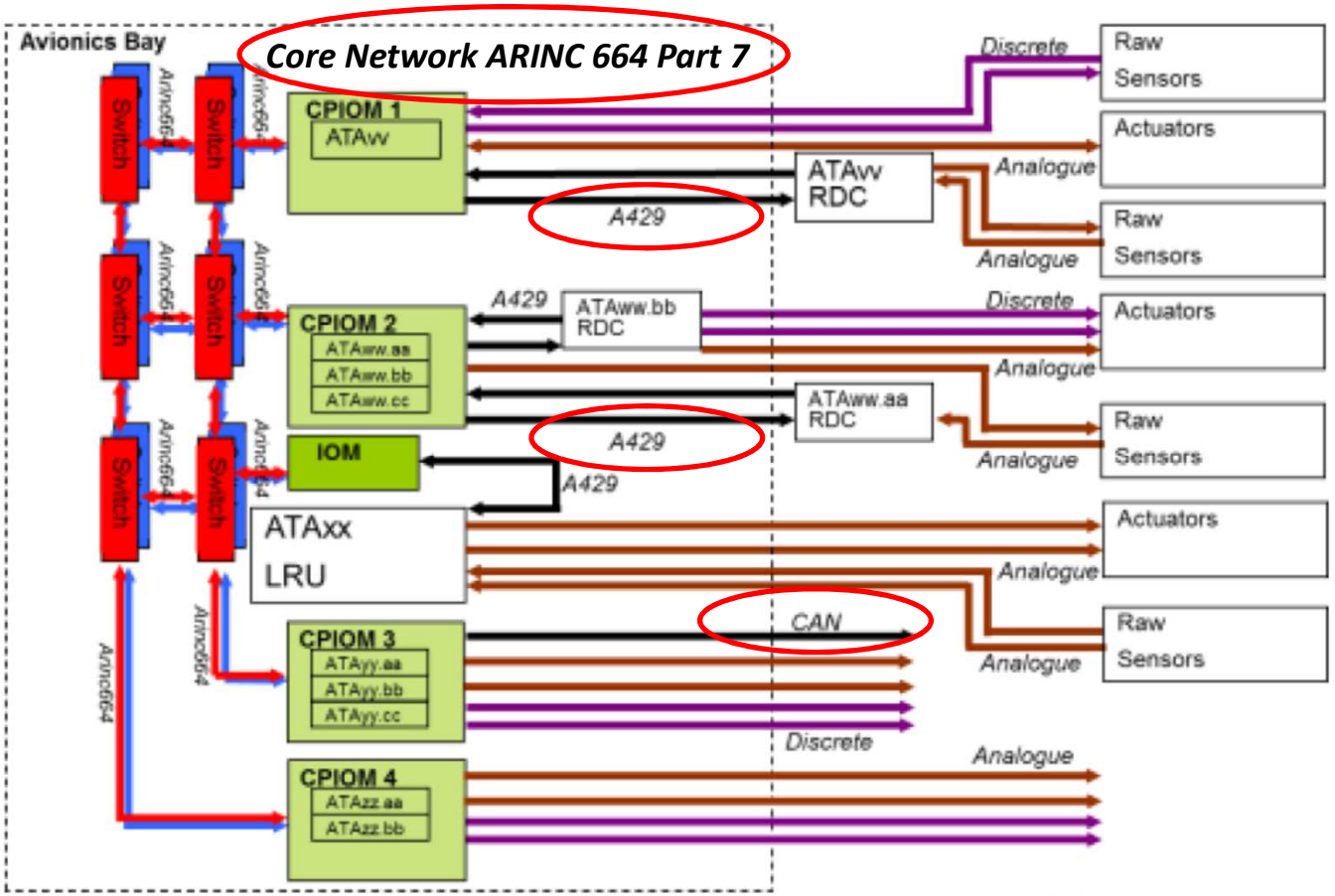
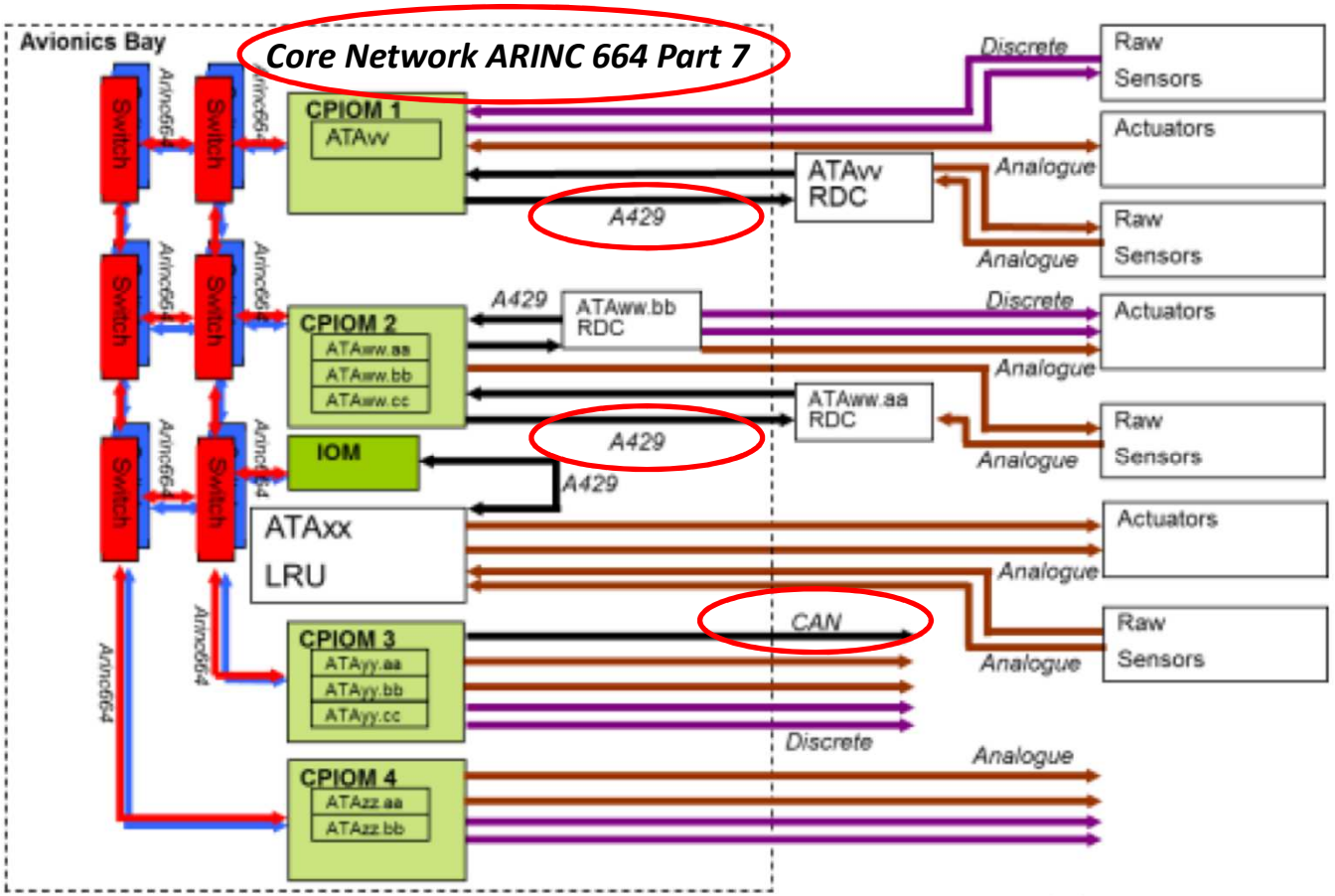
Avionics context



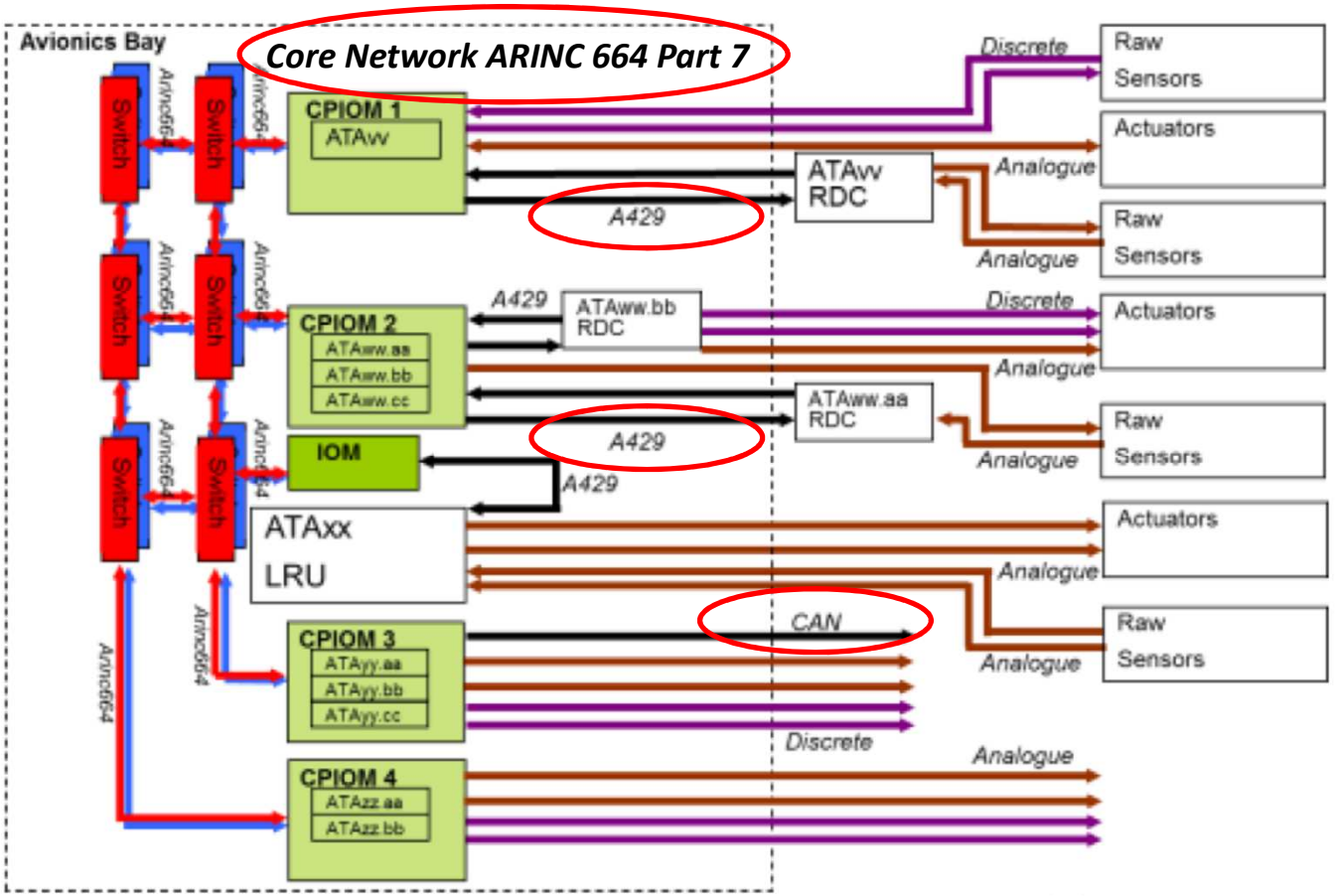
- Avionics networks
  - ARINC 664 Part 7 (AFDX)
  - ARINC 429
  - ARINC 629
  - ARINC 825 (CAN)
  - MIL-STD-1553
  - Commercial Ethernet
  - …

Avionics context



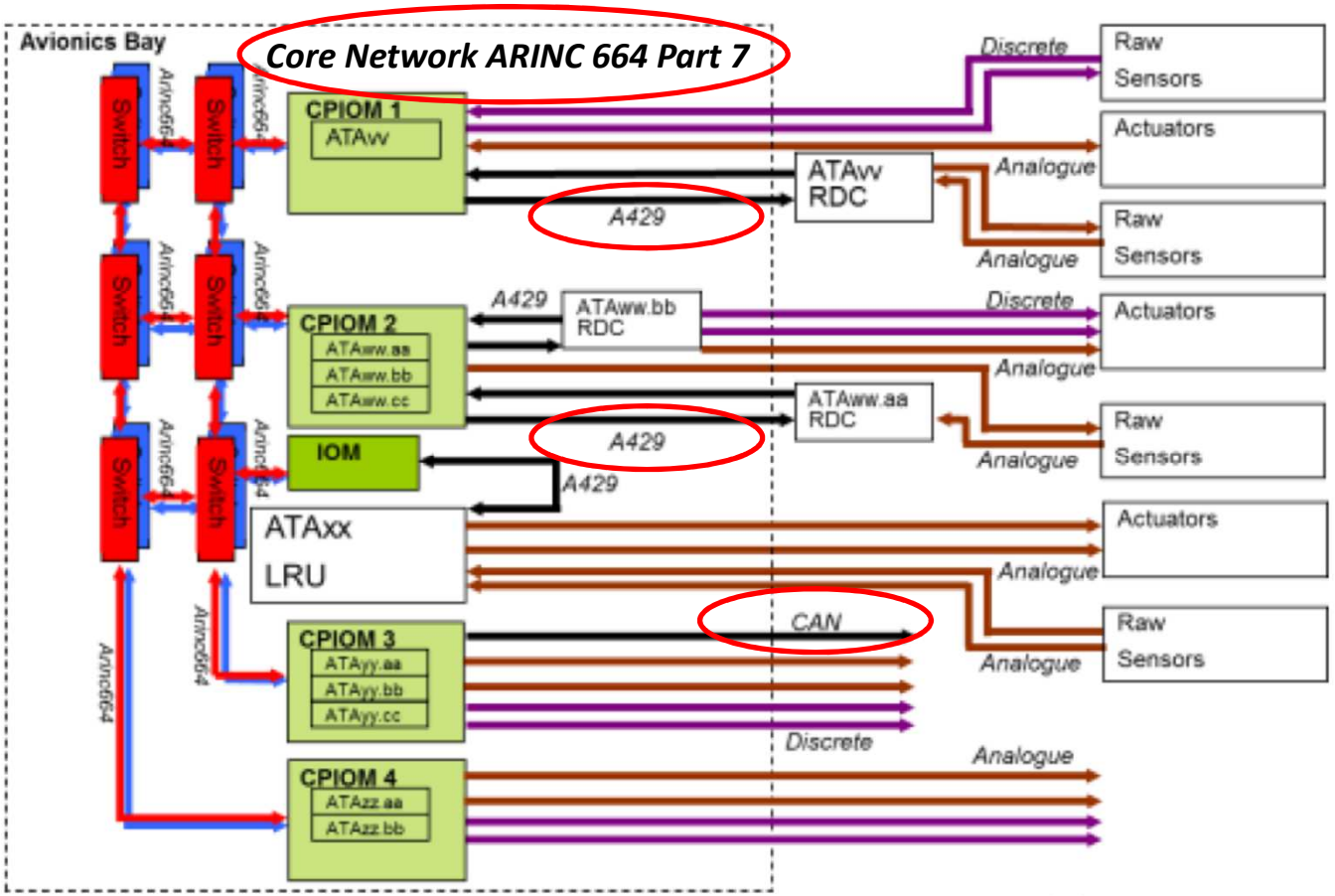
- Avionics networks
  - ARINC 664 Part 7 (AFDX)
    - High critical comm.
    - 4 priority levels
    - Up to 100 Mbps
    - Computers > 100
  - ARINC 429
  - ARINC 629
  - ARINC 825 (CAN)
  - MIL-STD-1553
  - Commercial Ethernet
  - …

Avionics context



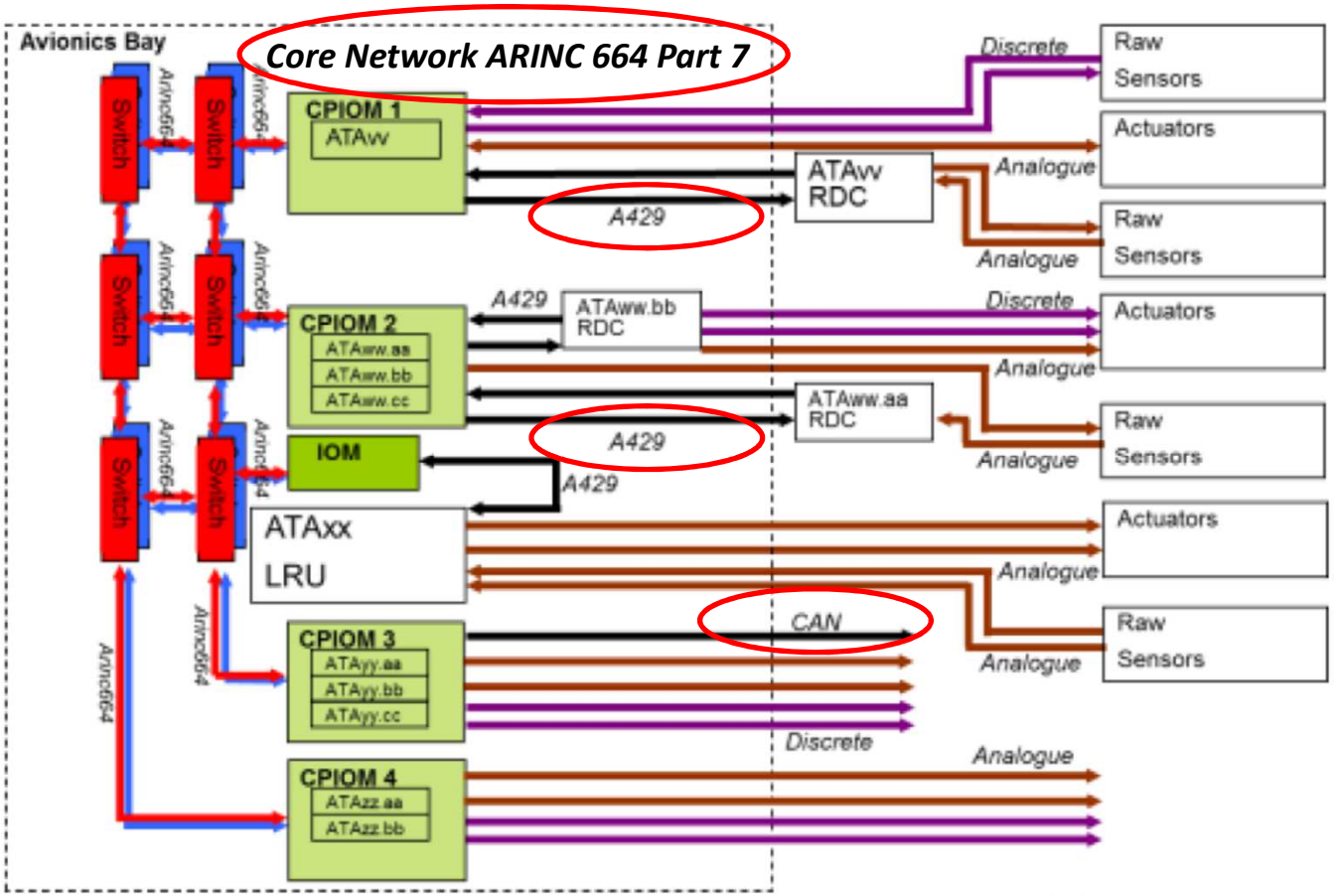
- Avionics networks
  - ARINC 664 Part 7 (AFDX)
    - Duplicated to increase the fault tolerance and ensure that data transmission even in the event of a failure or disruption in the network
  - ARINC 429
  - ARINC 629
  - ARINC 825 (CAN)
  - MIL-STD-1553
  - Commercial Ethernet
  - …

Avionics context



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

Avionics 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
  - …

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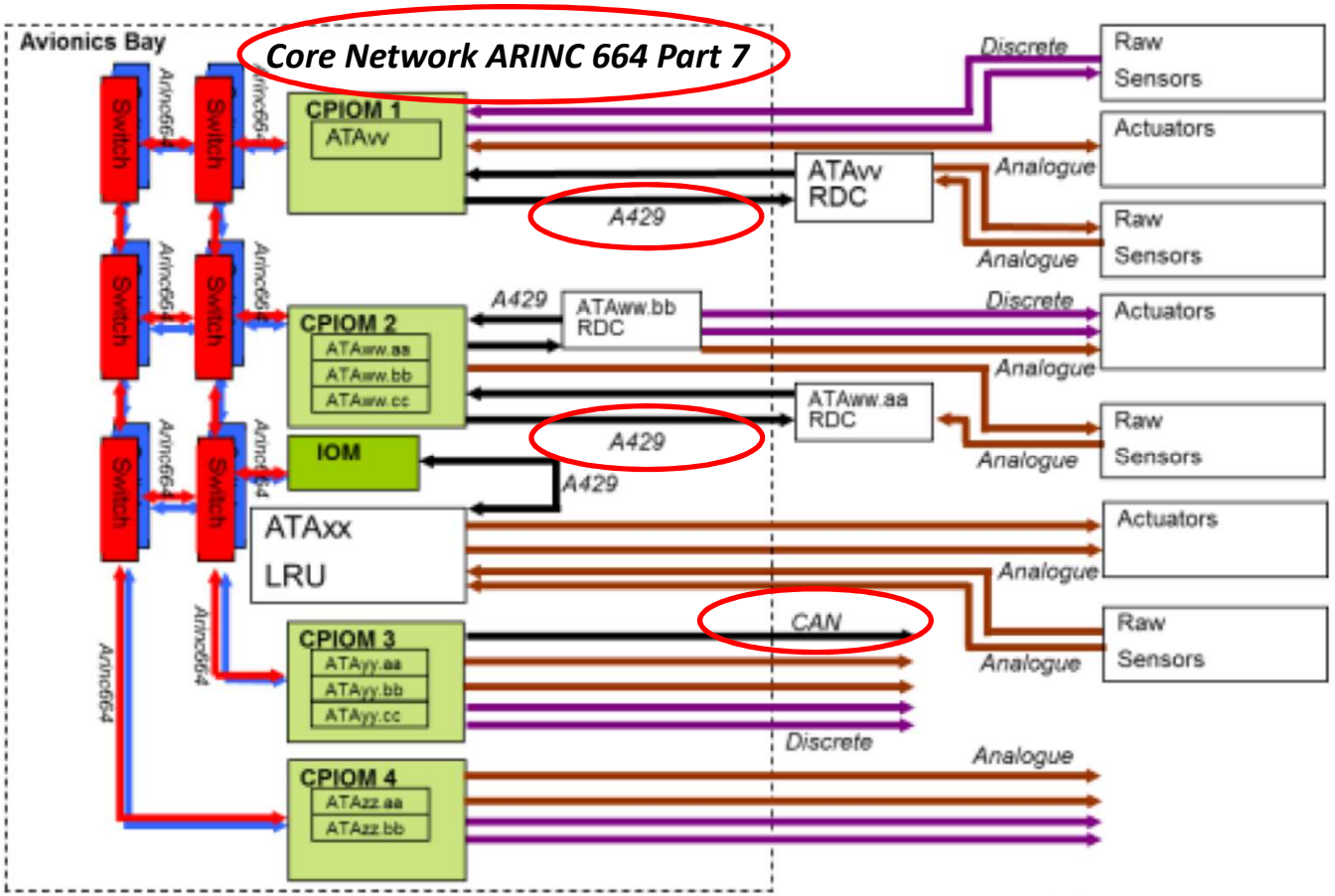
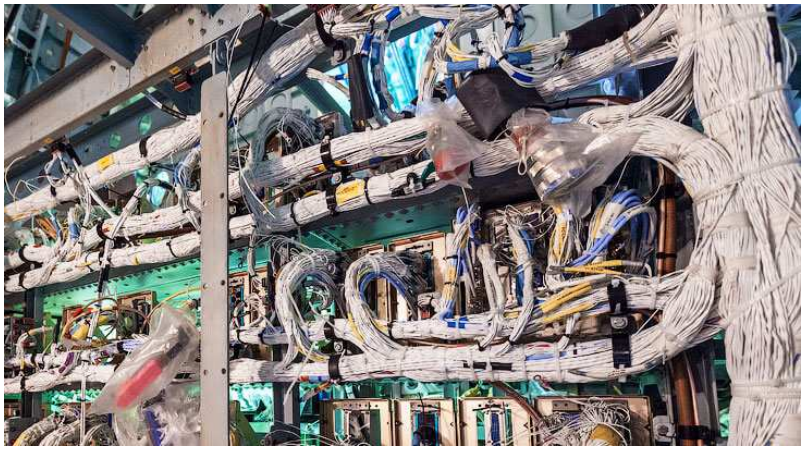
Avionics context

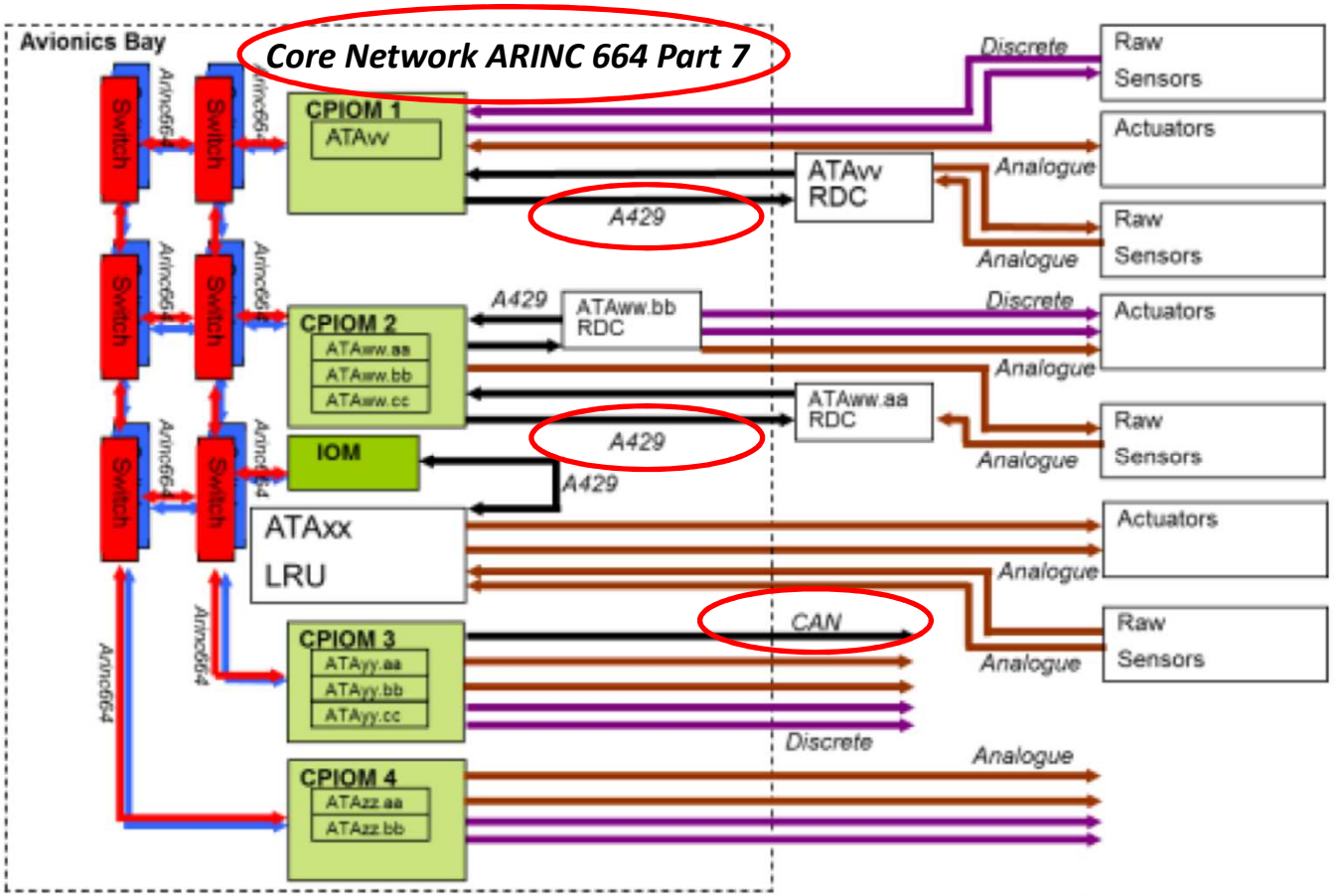


- Avionics networks
  - A380: 100,000 different wires, totaling over 530 kilometers, one of the major contributors to the aircraft weight

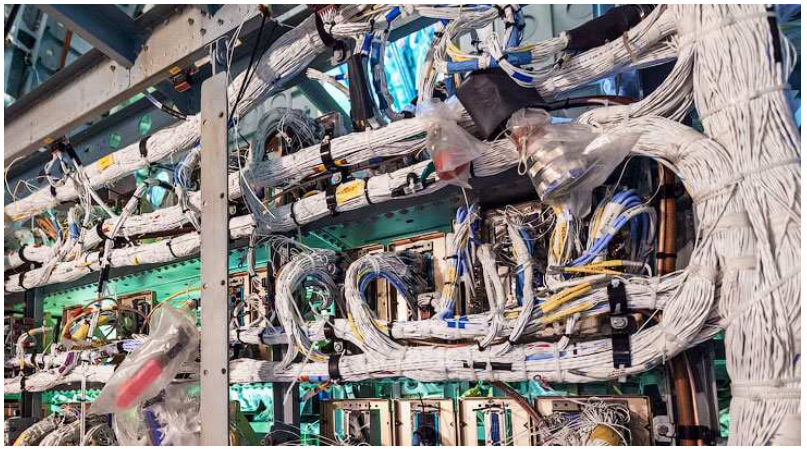


Aircraft cabling

Avionics context



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



Aircraft cabling

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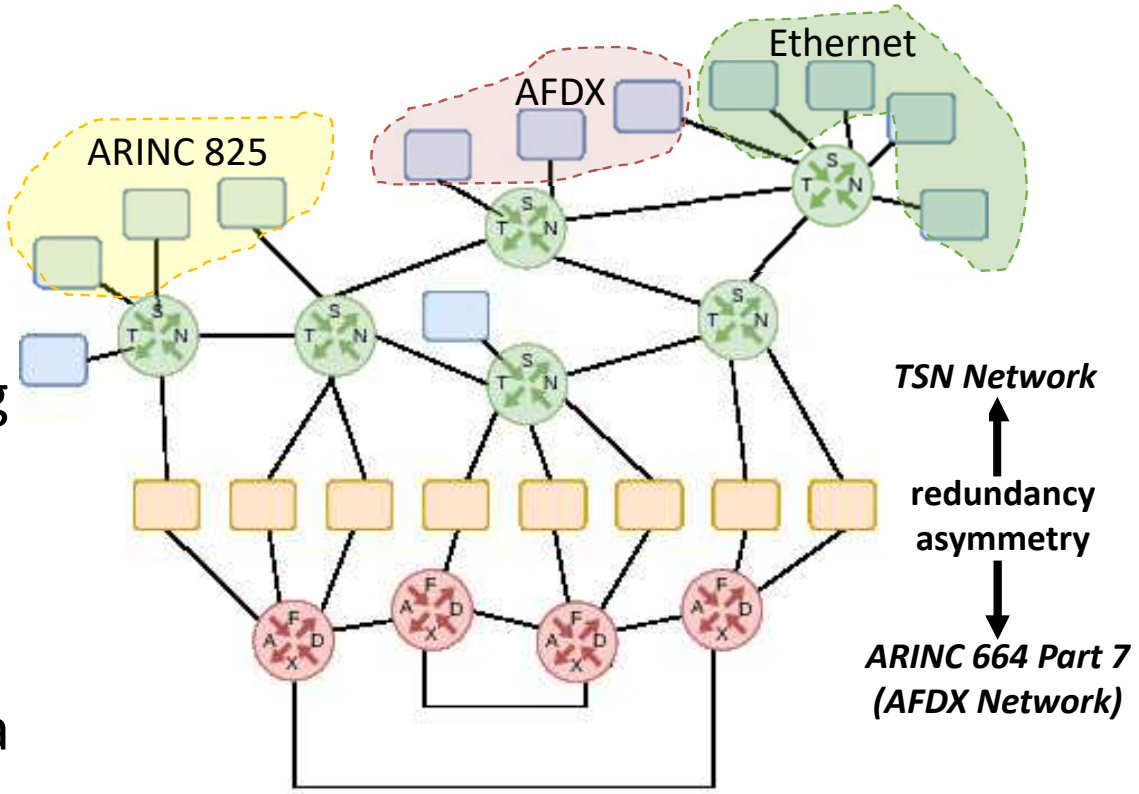
TSN in future aircrafts

- TSN: the new real-time Ethernet
- Much higher bandwidth than current avionics networks
- Allows mixed criticality by hosting both
  - Critical data flows (in redundancy with legacy AFDX)
  - And non-critical data flows

➔ Candidate as future avionic data backbone



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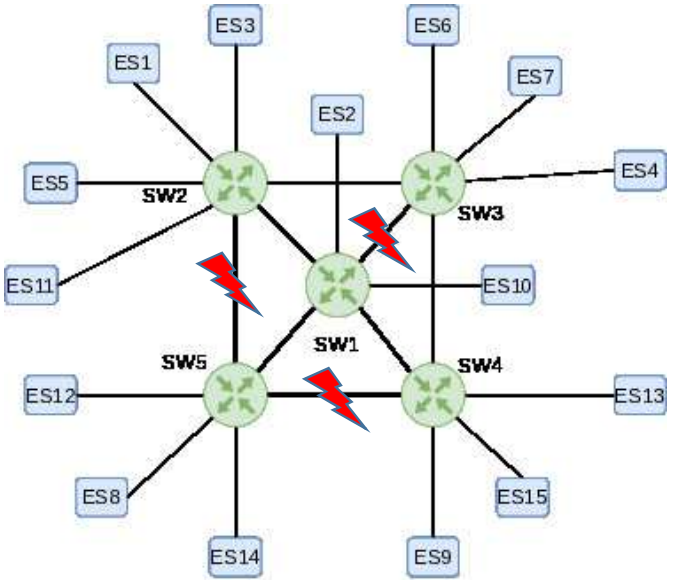
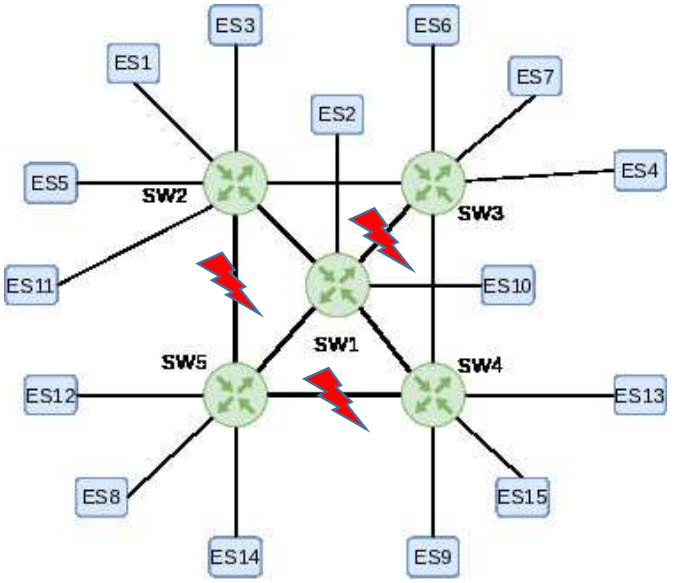
Challenge context

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



The challenge itself

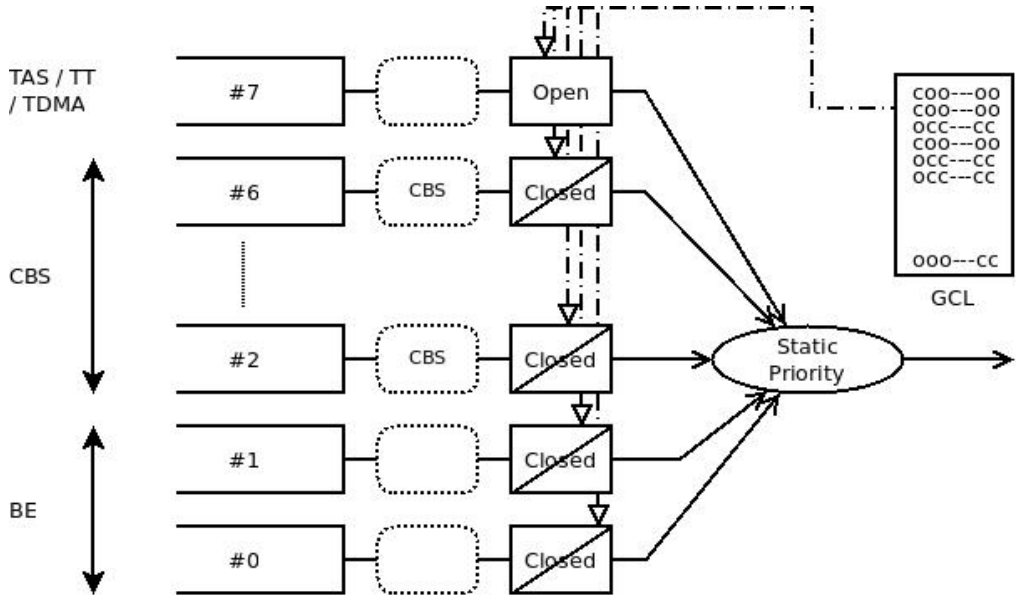
- In case of faults
  - Computing a new configuration
  - Still ensuring real-time guarantees
  - At least for most critical flows
    - Notion of flow utility/criticality
  - In short amount of time
  - Using embedded resources
  - While maintaining service



The challenge limits

A subset of TSN

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



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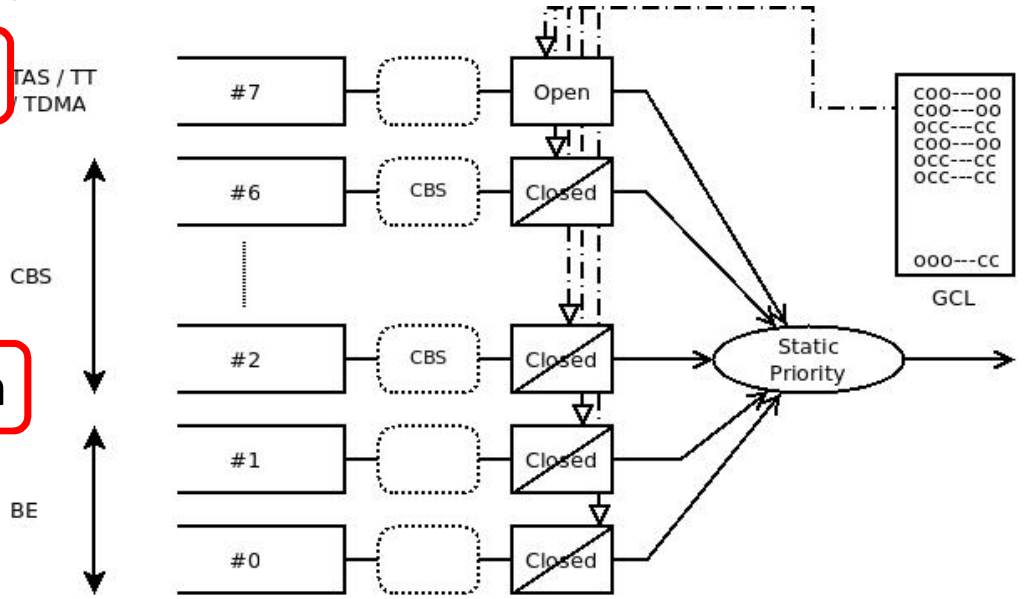
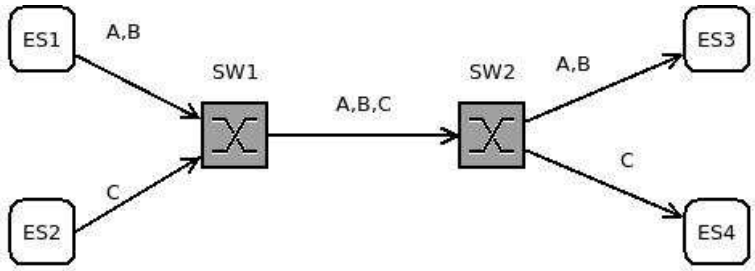
Is it really a challenge?

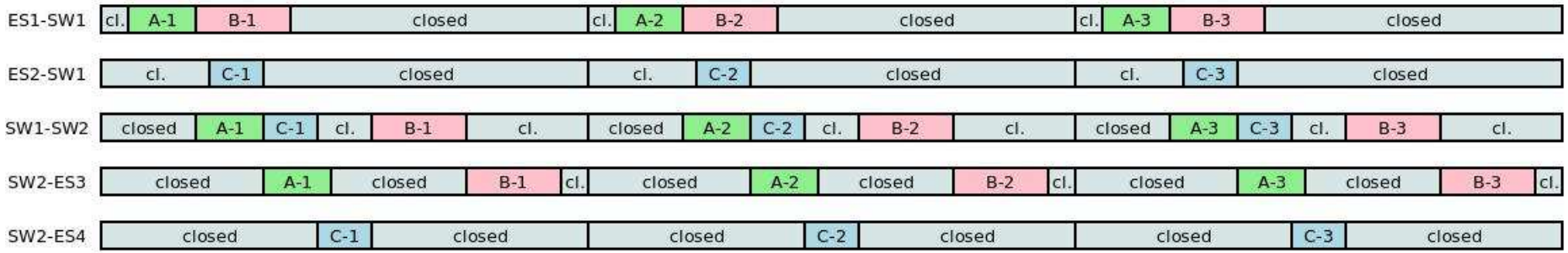
TAS configuration challenge

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

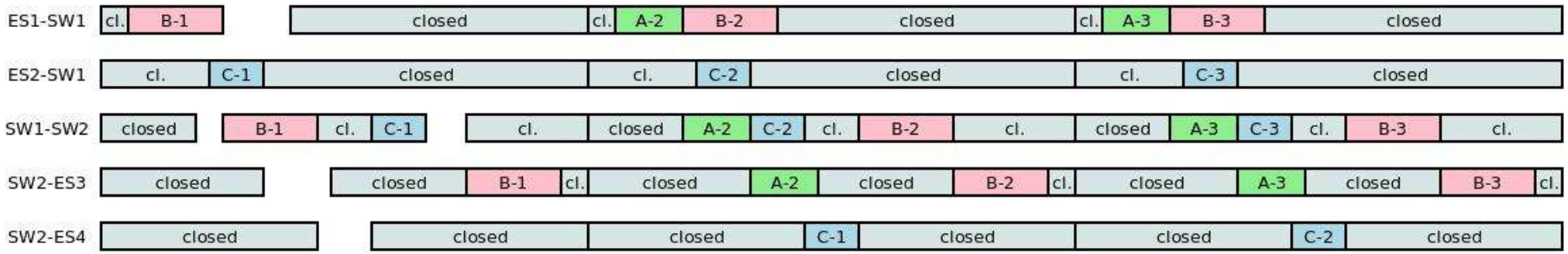




Nominal TAS behavior



Loss impact



TAS re-configuration challenge

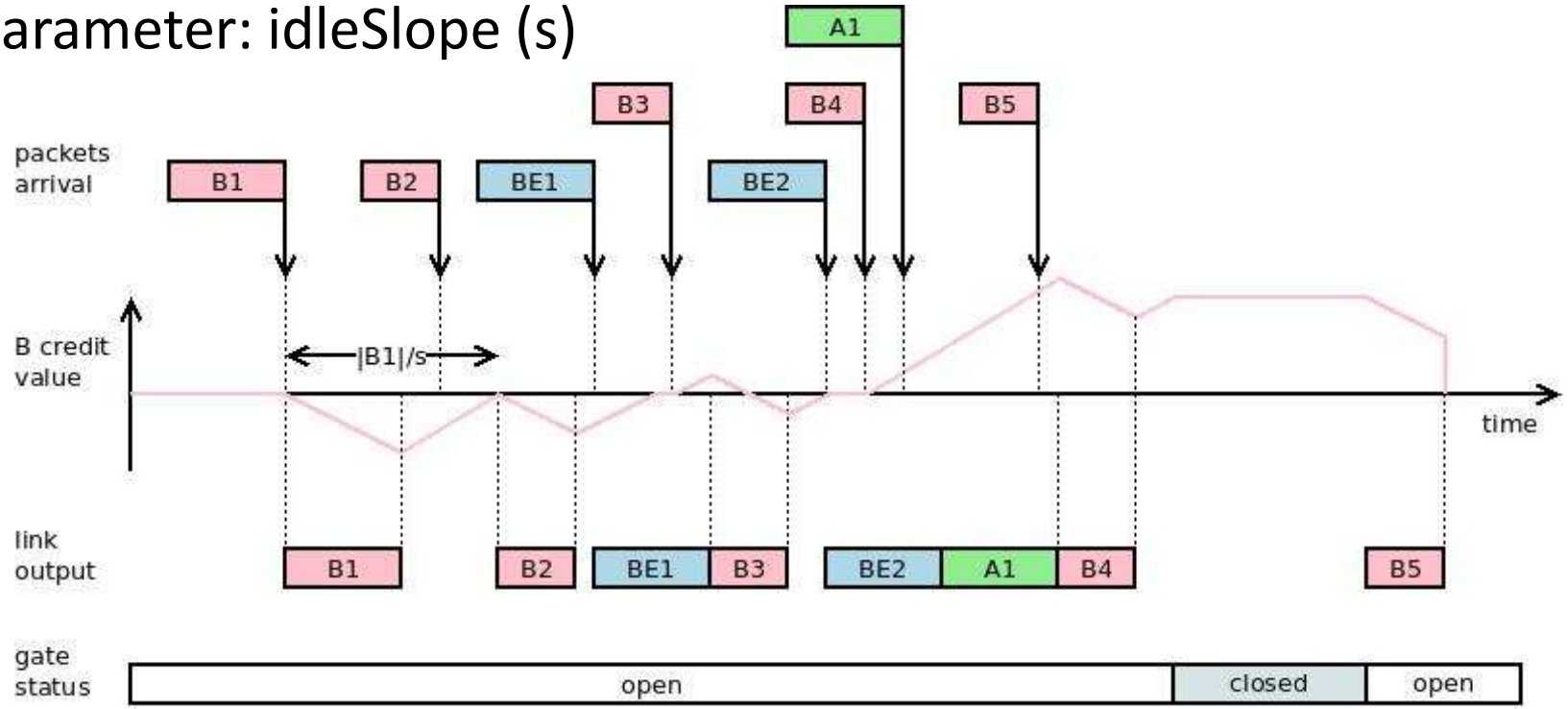
- Short configuration time (s – mn)
- Incremental schedule (keep existing windows, as much as possible)
- But re-schedule based on utility
  - Ex: route of flow *f* is broken
  - No (route,schedule) is found
  - Some lower utility flows can be removed: which ones? How many?
- The coherence problem ….

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: deployement of new configuration along all paths

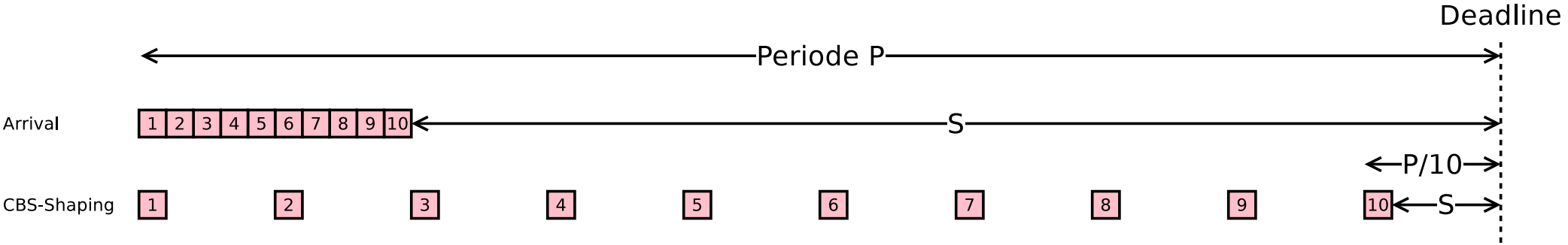
CBS configuration challenge

- 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 $s(p) \quad = \sum_{i \in F(p)} r_i$
- 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

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How to contribute ?

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

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Thank you !
Any questions ?