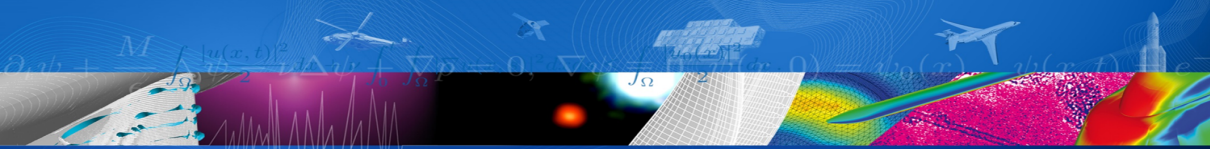


TSN Support for Quality of Service in Space

Marc BOYER, Pierre-Julien CHAINE, Claire PAGETTI, Franck WARTEL

AIRBUS

ONERA
THE FRENCH AEROSPACE LAB

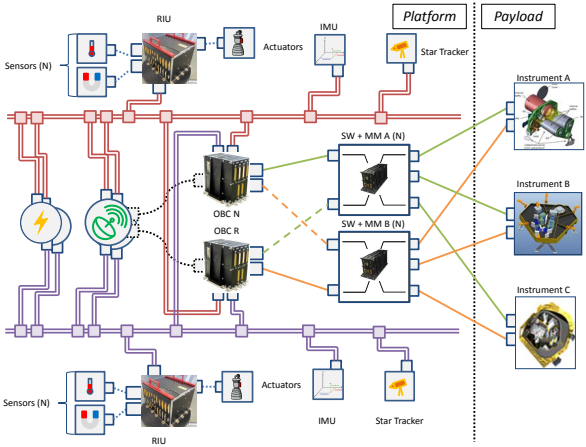
Outline

Outline

Current Satellite Architecture Introduction

Platform

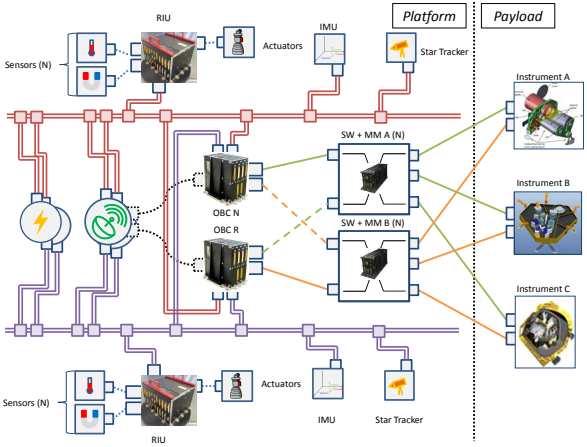
- Performances: Low latency, low jitter, guarantee of arrival
- RAMS: Link and device redundancy
- Technologies: 1553, CAN, (*SpaceWire*)



Payload

- Performances: High average throughput
- RAMS: Link and device redundancy
- Technologies: SpaceWire, HSSL, (*SpaceFibre*)

Current Satellite Architecture



Strengths

- Mature
- Suited for space environment
- Simple and reliable
- AOCS friendly

Weaknesses

- Lack of bandwidth
- Lack of flexibility
- Niche market (few customers and few users)
- Few interactions with academics or other industrials

Where to go ?

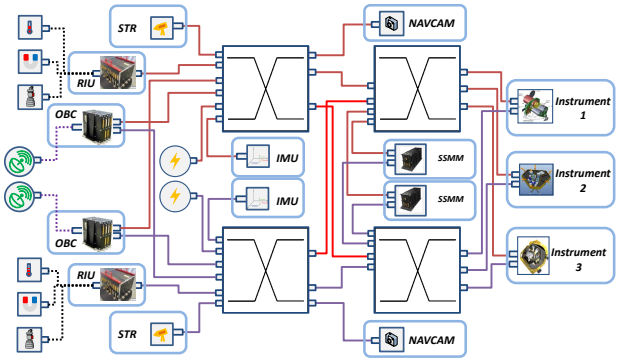
Problem Statement

Is it possible to find a unique Ethernet technology, that:

- **is able to fulfil both platform and payload needs ?**
- **has better performances ?**
- **is easy to analyse/configure ?**
- **eases development and integration ?**

Outline

Ethernet Next-Gen Satellite Functional Architecture Candidate



Opportunities

- High bandwidth with Quality of Service
- Large ecosystem with COTS
- Easier integration
- Looked at in other industry verticals

Threats

- Complex behaviour and configuration
- Most COTS not qualified for space (yet)
- Risk of redesigning "legacy" devices

Introduction of Ethernet Technologies

Ethernet

- *"Full Duplex Switched Ethernet"*
- ISO L2 based on IEEE 802.3 and 802.1Q-2008
- Network = switches + end-stations
- Ethernet frame
- Used worldwide at home and in ISP core networks

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Time Sensitive Networking

- Developed by the IEEE TSN WG
- State of the art of Ethernet
- Adds mixed QoS and fault tolerance capabilities
- Receives attention in several industry verticals

TSN: a good candidate

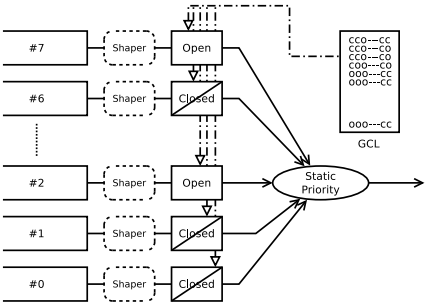
TSN faufil requirements

- high bandwidth
- fault tolerance (FRER)
- time guarantees
- low jitter with TAS

Outline

802.1Qbv: Time Aware Shaper – TAS

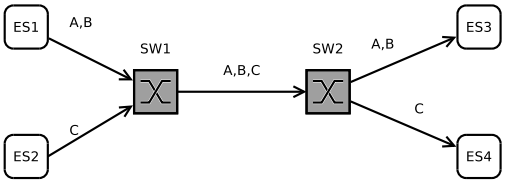
- "Enhancements for Scheduled Traffic"
- A gate is associated to each queue
- The gate is either open or closed
- A global cyclic schedule (Gate Control List – GCL), w.r.t local clock
- Building schedule is out of standard
- "Exclusive gating" $\approx$ one gate opened at a time
- Integration with GCL: update of credit evolution rules
- End-to-end TT schedule requires
  - global build of local schedules
  - synchronisation of local clocks (eg. 802.1AS)



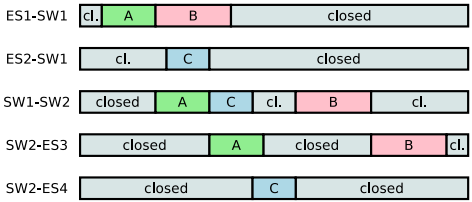
TAS: a Time-Triggered implementation

Principles

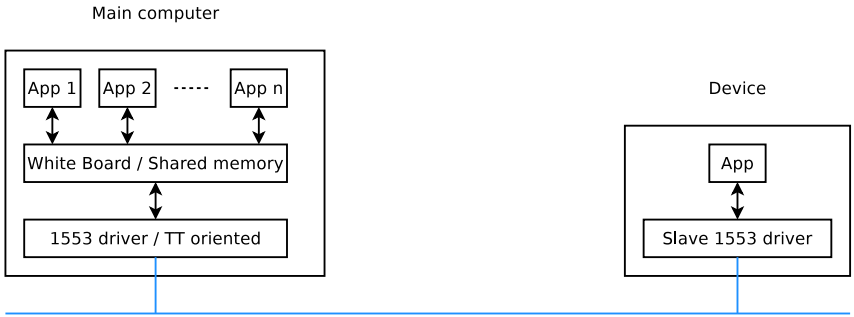
- one TT queue
- exclusive access
- gate opening built in a “smart” way



Nominal case

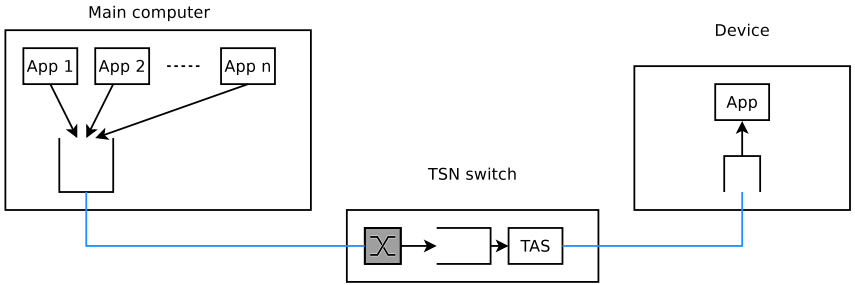


Low jitter with 1553



- The 1553 master is sheduled based on Time-Triggered table
- The slaves have very low reaction time (from 4μs to 12μs)
- Each app must write data before time slot

Low jitter with TSN



- TSN TAS is based on queues

$\Longrightarrow$ require ordering at emission

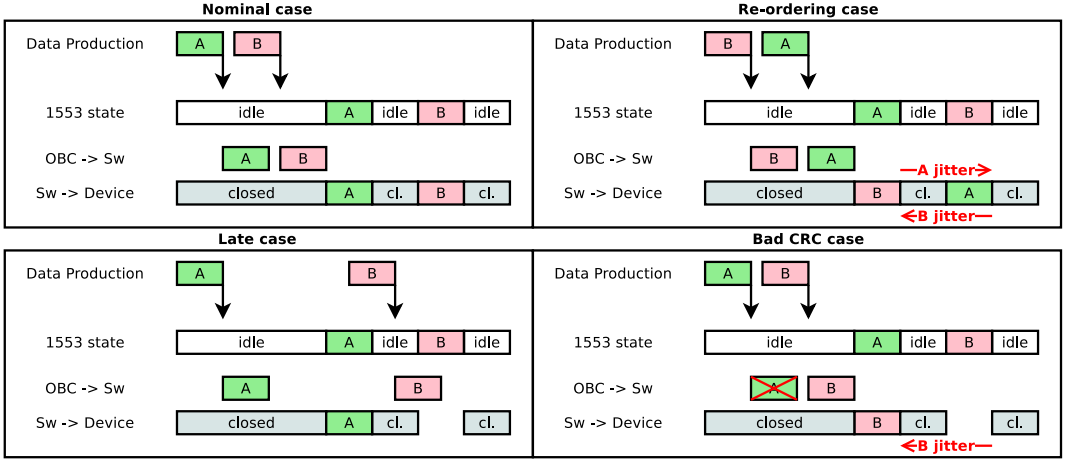
$\Longrightarrow$ A buffer app? Synch. between Apps?

- Frames may be lost

$\Longrightarrow$ next frame in queue is send

$\Longrightarrow$ out of schedule frame

1553 vs TAS schedule



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- current work: evaluating several solutions
  - publication under submission soon

References I


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