



TSN Support for Quality of Service in Space

ERTS Conference - Jan. 2020

Presenter: Pierre-Julien CHAINE, PhD Student

Supervisor from ONERA: Marc BOYER

Supervisor from ONERA: Claire PAGETTI

Supervisor from AIRBUS: Franck WARTEL



The logo for Airbus, featuring the word "AIRBUS" in a bold, sans-serif font.

Introduction

Introduction

- ➔ Internal project E4S - Ethernet for Space - from Airbus Defence and Space,
- ➔ A PhD program was started in Nov. 2018 within E4S project,
- ➔ PhD is hosted at ONERA, directed by Claire PAGETTI and Marc BOYER,
- ➔ PhD is supervised on technical aspects by Franck WARTEL ,
- ➔ **Goal: Find and assess potential new technologies based on Ethernet suited for space applications.**

Outline

① Satellite Architecture Overview

- Introduction
- Current Satellite Network

② Satellite Network Foreseen Evolution

- Opportunity for an unified network
- Overview of TSN
- Which protocols for an On-Board Unified TSN Network?

③ Satisfying FDIR requirements with 802.1CB-FRER

④ Conclusion

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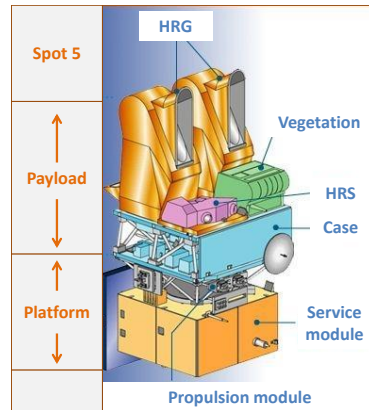
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Satellite Architecture

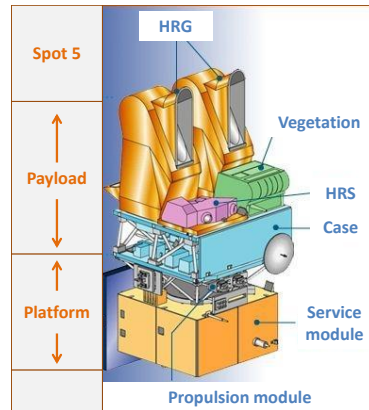
- Payload - **High Performance Domain**
It is the purpose of the satellite, what the clients pays for.



<https://earth.esa.int/web/eoportal/satellite-missions/s/spot-5>

Satellite Architecture

- Payload - **High Performance Domain**
It is the purpose of the satellite, what the clients pays for.
- Platform - **Time Critical Domain**
It is what allows the payload to achieve its mission:



<https://earth.esa.int/web/eoportal/satellite-missions/s/spot-5>

Scope of the presentation

Scope

The following presentation will only focus on the network part of the satellite architecture and especially the network **safety** properties e.g. FDIR properties for the spacecraft industry (Fault Detection, Isolation and Recovery).

Current Satellite Architecture Introduction

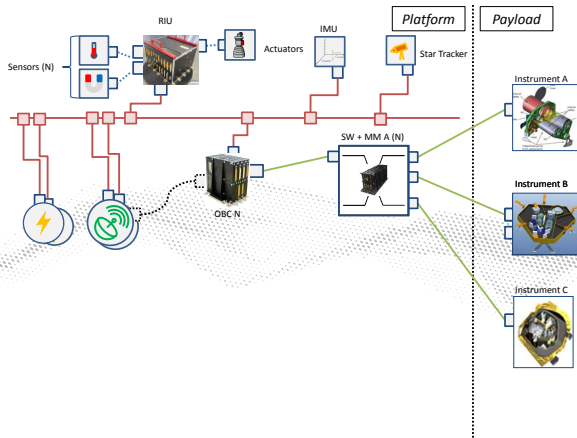
Platform

Payload

Current Satellite Architecture Introduction

Platform:

- Performances:
Low latency,
low jitter,
guarantee of
arrival
- Technologies:
1553, CAN,
SpaceWire



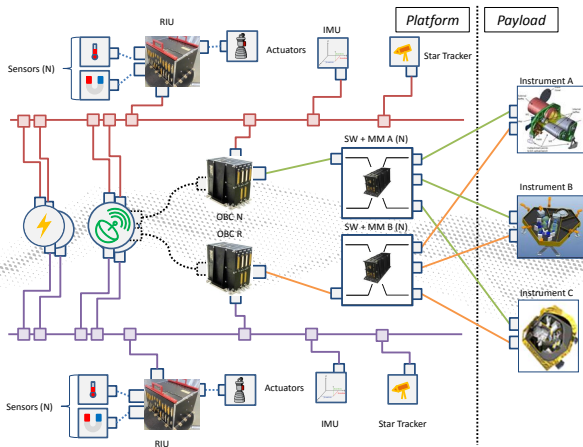
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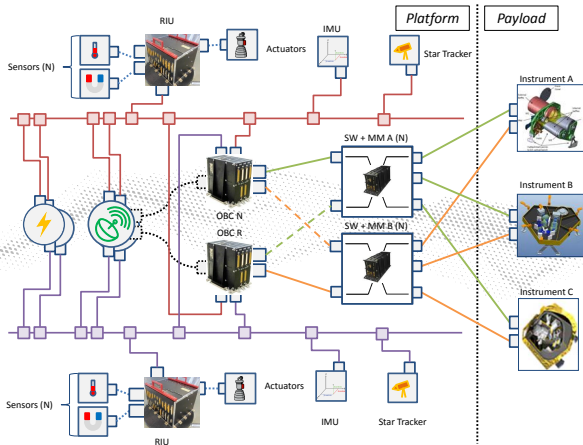
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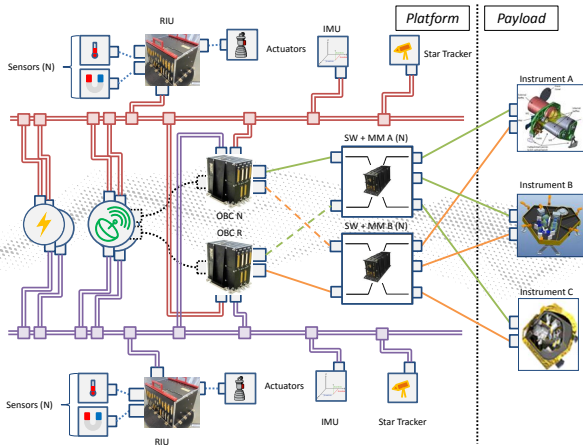
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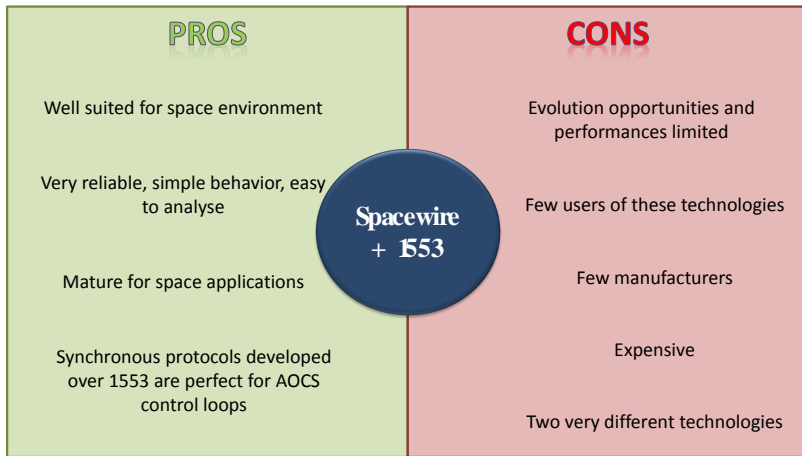
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Actual Network Pros & Cons



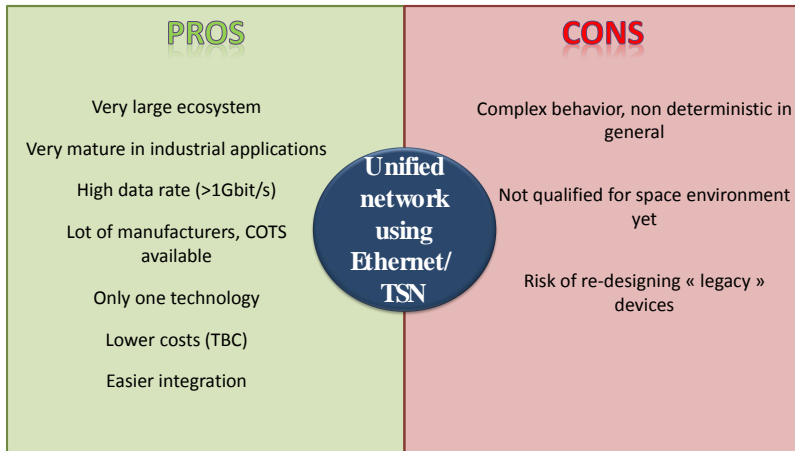
Where to go ?

Problem Statement

Is it possible to find a unique technology, that:

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

Unified Ethernet network Pros & Cons



TSN ?

Challenge

Is TSN a superset of 1553 + SpaceWire i.e. is it possible to satisfy both platform and payload requirements using the same technology in a Unified Ethernet/TSN Network ?

Organization

In order to answer that question, two aspects have to be analysed:

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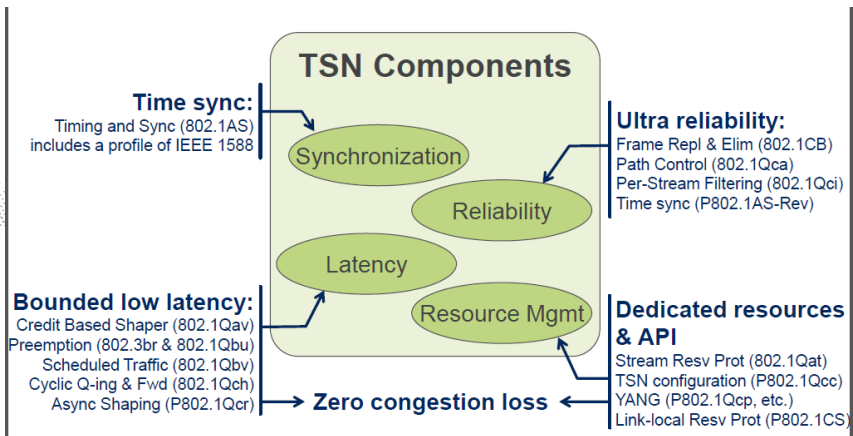
Which protocols for an On-Board Unified TSN Network ?

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Overview

(Farkas, 2018)



Which protocols for an On-Board Unified TSN Network ?

Organization

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Satisfy FDIR requirements with 802.1CB

FDIR ?

FDIR - Fault Detection Isolation and Recovery is the satellite function in charge of monitoring the satellite system by identifying when a fault has occurred, isolating it to prevent its propagation and repairing the fault or recovering from it.



Problem statement

Is TSN protocol 802.1CB-Frame Replication and Elimination for Reliability able to satisfy the network FDIR requirements ?

Requirement 1: No Single Point of Failure

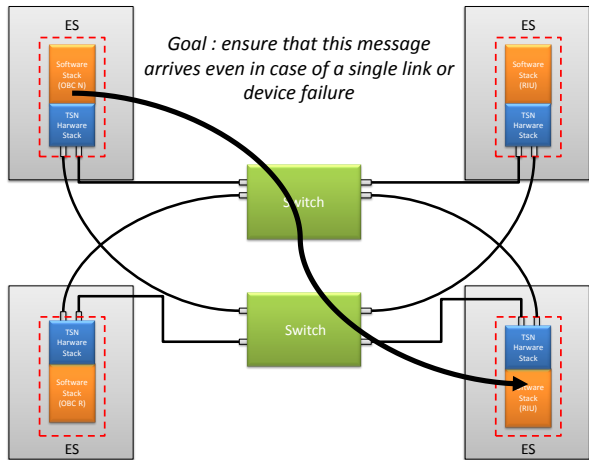
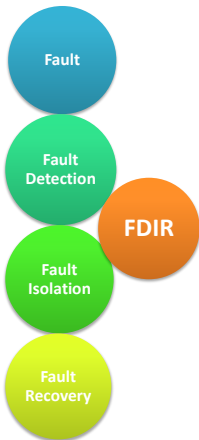
Req. 1: No Single Point of Failure

- *A Single of Point of Failure (SPOF) is a part of the system that, if it fails, will stop the entire system from working.*

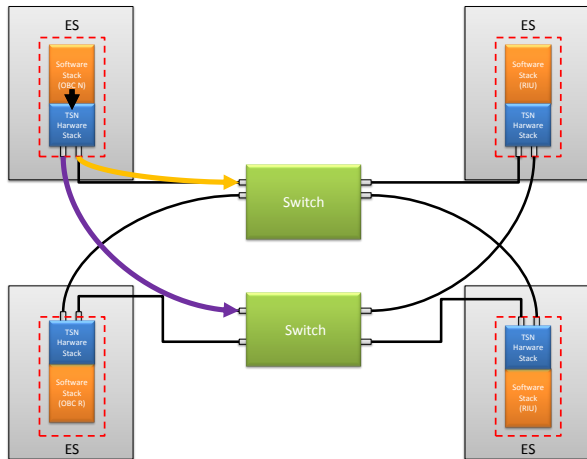
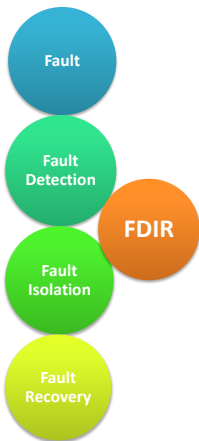
SPOFs are forbidden !

➡ At network level: even if a link or device fails, the communication shall still occur.

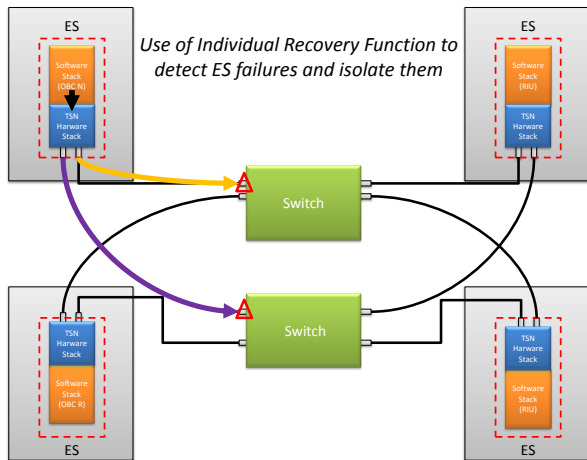
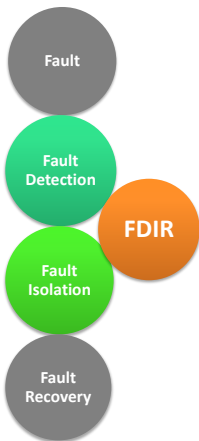
Satisfying Req. 1 with TSN feature 802.1CB-FRER



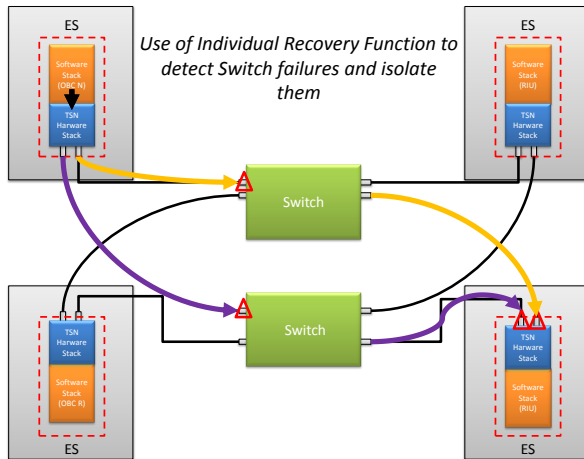
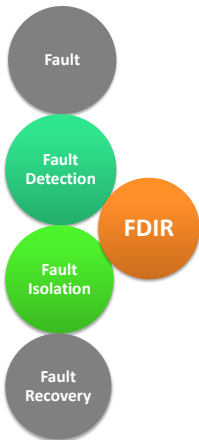
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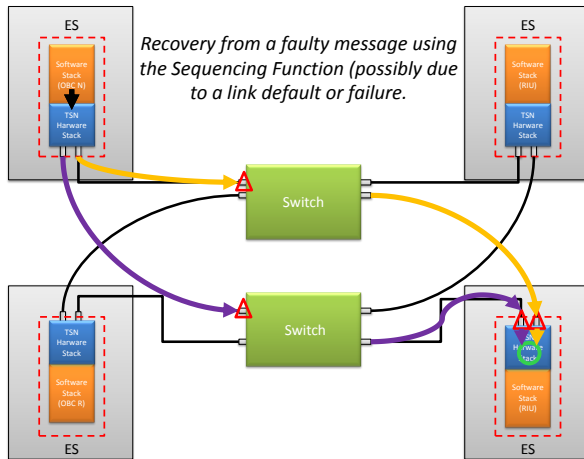
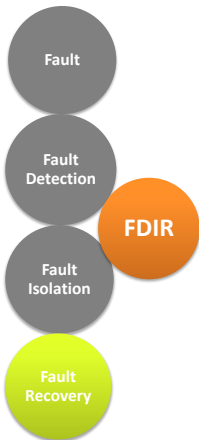
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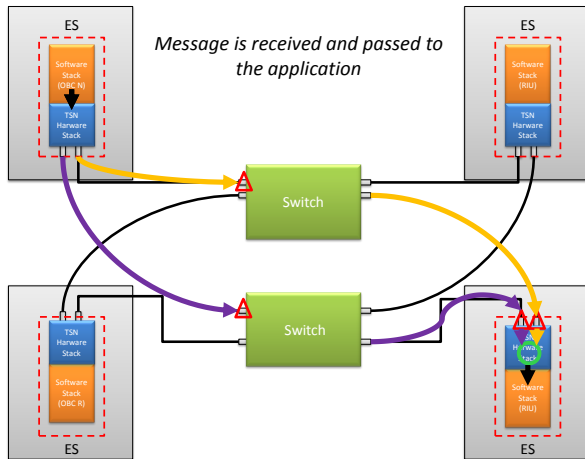
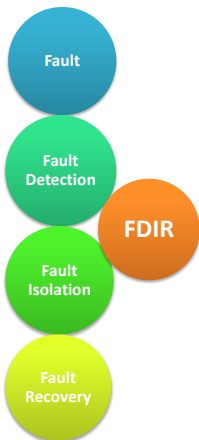
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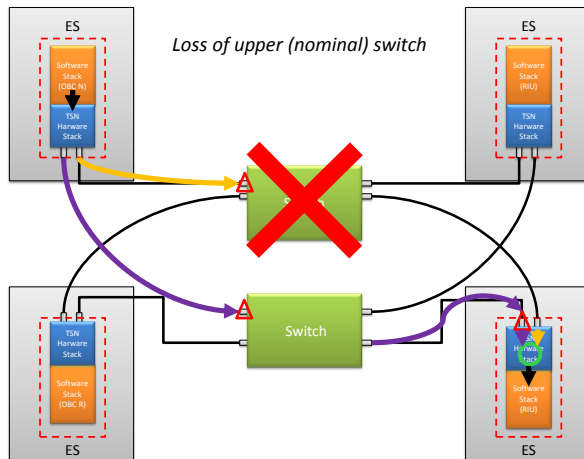
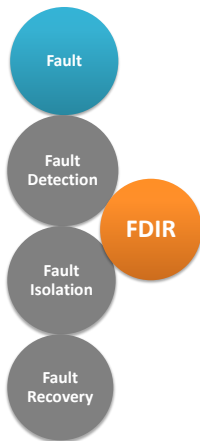
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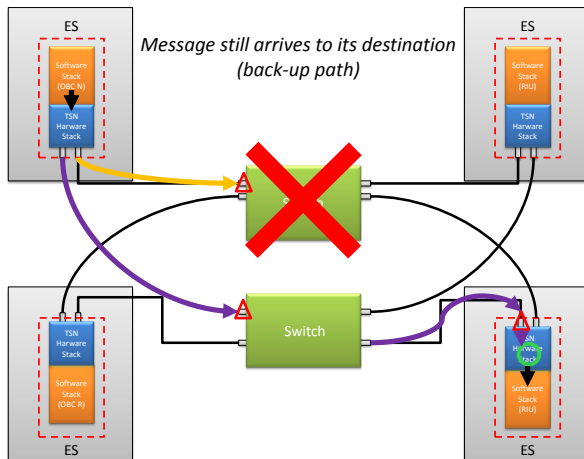
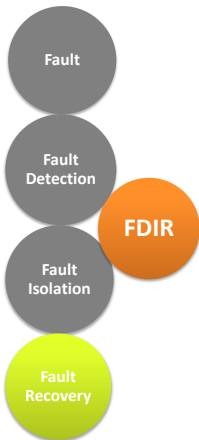
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Requirement 2: Network Monitoring

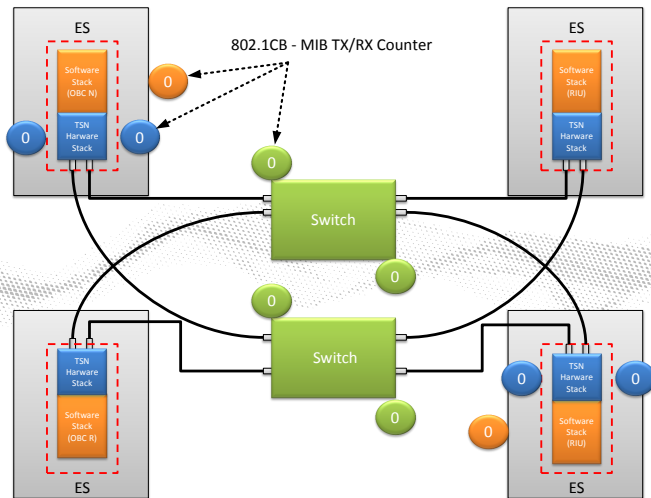
Req. 2: Network Monitoring

- *"Network Monitoring (NM) is the on-board function in charge of collecting indicators on the good or bad health of the satellite system."*

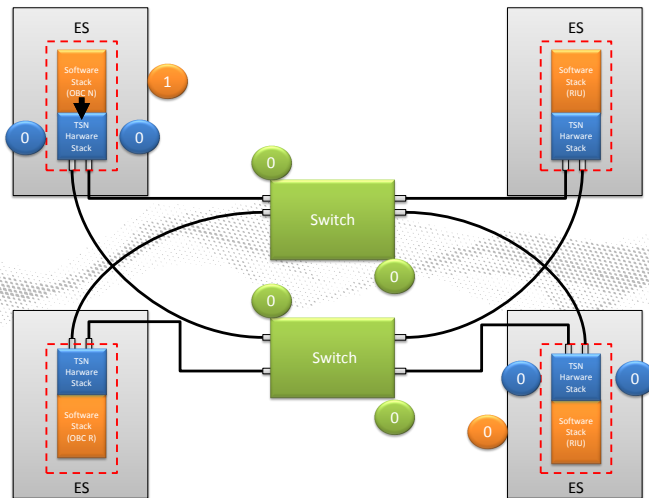
NM is mandatory !

- At network level: observations to diagnose communication links and devices health status.

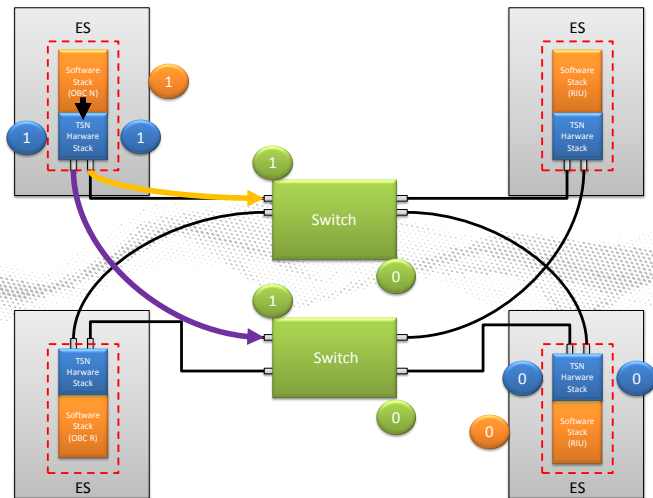
Satisfying Req. 2 with TSN feature 802.1CB-FRER



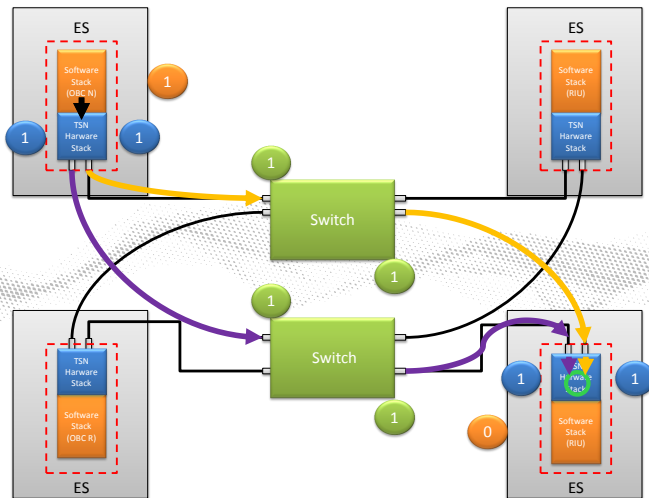
Satisfying Req. 2 with TSN feature 802.1CB-FRER



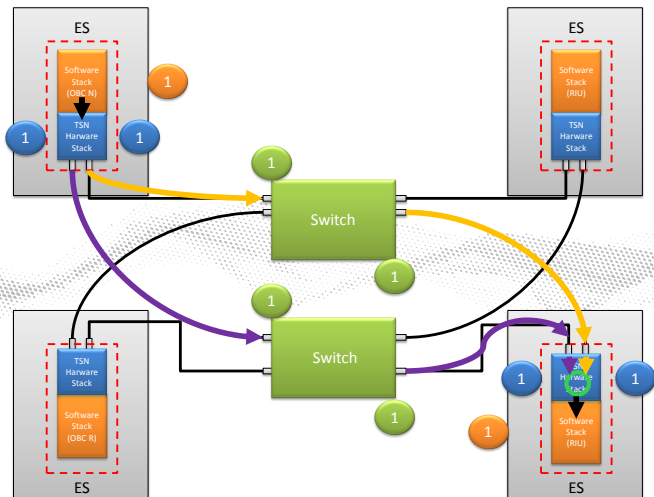
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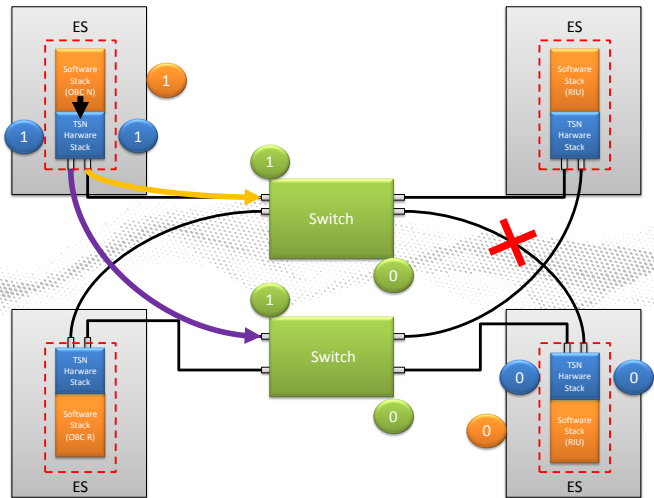
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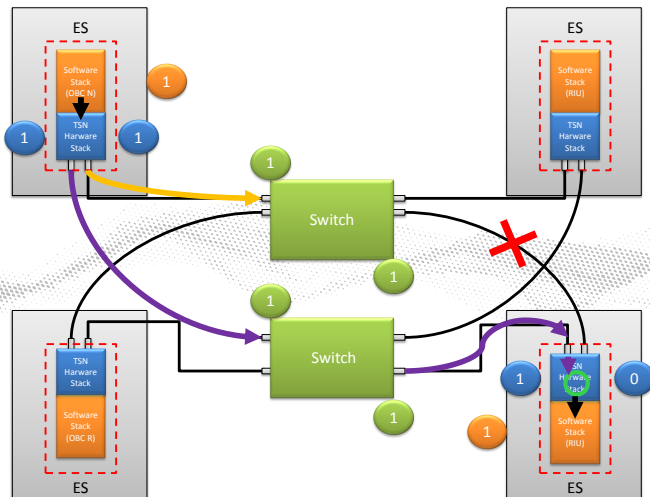
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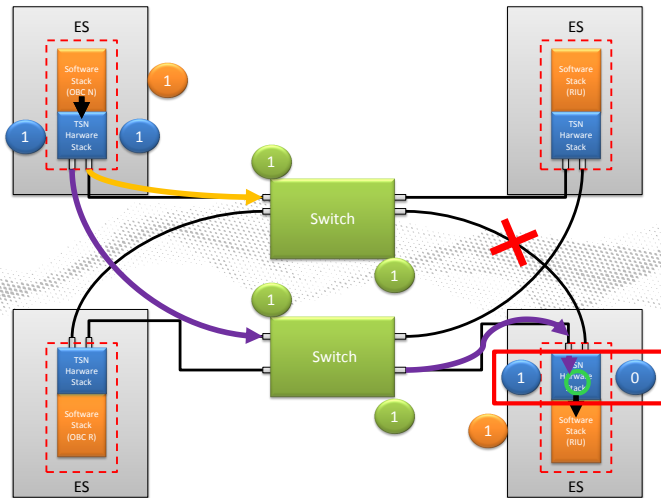
Satisfying Req. 2 with TSN feature 802.1CB-FRER



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Other requirements

Other requirements

There are other safety requirements such as:

- Seamless redundancy at application level
- Network protection against babbling idiot end-stations
- etc.

⇒ They will be addressed in future works.

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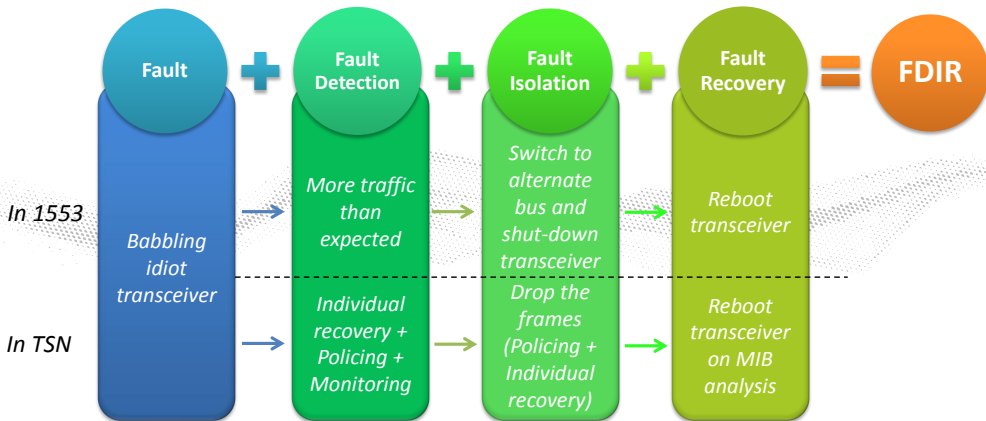
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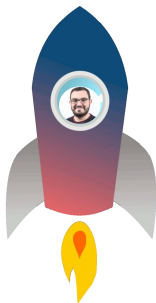
Summary

- ➔ Existing satellite network technologies used in space are specific and have limited performances and high cost,
- ➔ Change opportunity: using an Unified Ethernet TSN Network, shared with other industries such as aeronautic, automotive, industrial automation, . . .
- ➔ TSN is interesting but wide and its complexity can increase quickly,
- ➔ **Challenge:** Which configuration for TSN protocol 802.1CB-FRER?
- ➔ **Challenge:** What is the minimum subset of TSN to satisfy the network requirements and the FDIR requirements while minimizing complexity, having a minor impact on legacy equipments at lower cost possible ?

Pro for TSN: Babbling Idiot Example



TSN Profile for Aerospace

**Mandatory:**

- IEEE 802.1AS & 802.1AS-rev
- IEEE 802.1Qci
- IEEE 802.1CB
- IEEE 802.1Qbv
- IEEE 802.1Qav
- IEEE 802.1 Qcc (static configuration)

Optional

- IEEE 802.1Qbu & 802.3br
- IEEE 802.1Qch

Not requested:

- IEEE 802.1Qat
- IEEE 802.1Qcc (dynamic)
- IEEE 802.1Qca

TSN AEROSPACE PROFILE ?

Références I

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