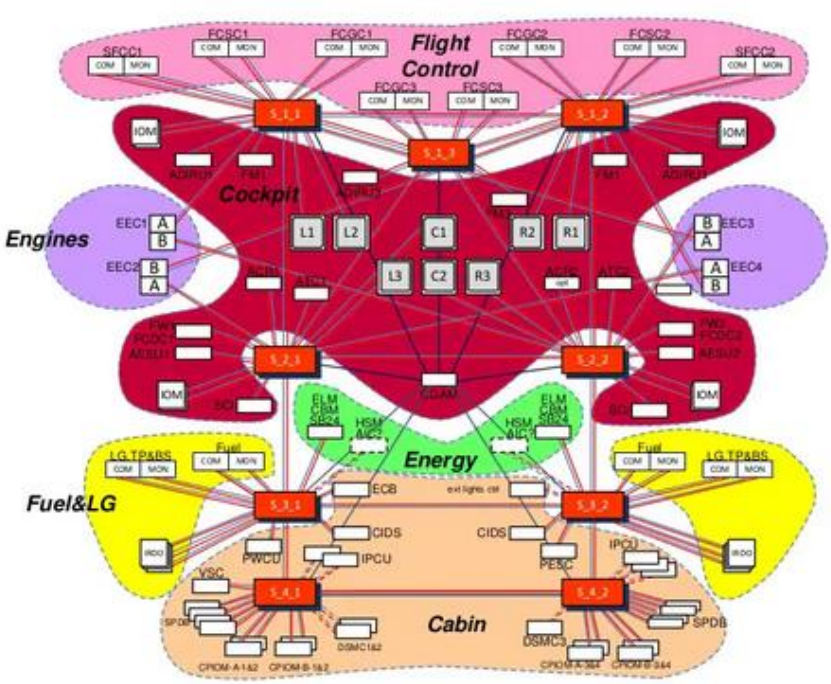
Management Report

Implementation of a Real-Time Ethernet with Quality-of-Service mechanisms

AFDX network using P4 language



P4FDX

28/04/2022

EMS 2021/2022 - *Integrated Team Project*

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I. Introduction

The main aim of the project is the implementation of a Real-time Ethernet network with quality-of-service mechanisms. For embedded systems, Real-time communications are a necessity. More specifically for avionics systems, real-time networks are the prominent form of communications due to baud rate, latency and overall system weight.

The current situation in IRIT-ENSEEIHT is that all the research related to Real-time networks, are only implemented on simulation tools (such as Mininet). Hence, the implementation of such a network in the labs of ENSEEIHT, will have a great impact on the progress of research in this field. At the end, it will serve as a base ground for future work related to Real-time networking.

This document will outline the project plan and will provide the subsidiary project management plans for the implementation of a Real-time Ethernet network with quality-of-service mechanisms.

II. Scope of project

1 – Objectives

The objectives of this project can be divided into two sub-categories (mandatory and optional):

Mandatory objectives:

- Implementation of P4 on Raspberry (using P4Pi) and on computer (using DPDK)
- Implementation of QoS using WRR and SPQ mechanisms

Optional objectives:

- Implementation of DRR QoS mechanism
- Study and implementation of Ethernet 802.1TSN mechanisms such as CBS

Given these objectives we can deduce a roadmap to be followed:

1. Test of $P4_{16}$ compilation tools to generate Mininet architecture
2. 2 parts:
    a. Implementation of real-time Ethernet architecture using P4 and T4P4S
    2 possible targets: PC, Raspberry Pi using P4Pi tools
    b. Implementation of Quality-of-Service mechanisms such as SPQ, WRR, DRR in $P4_{16}$
3. Implementation of a configuration tool that creates and configures the network architecture
4. Study and implementation of Ethernet 802.1TSN mechanisms such as CBS

Out of scope tasks:

Some extra work might be needed to validate the architecture as an aircraft capable network, so extra tests using real avionics equipment could be done for this purpose.

2 – Stakeholders

The main stakeholder of this project is the ENSEEIHT IT laboratory and, specifically, the project tutor, Jérôme Ermont, and the roles related to this stakeholder are:

- Provide the project objectives.

- List the requirements and specifications to be respected in the process.

- Provide the infrastructure needed for hardware testing.

- Provide Raspberry Pi cards and multi-network cards computer needed to validate the hardware part of the objectives.

3 – Assumptions

Main project assumptions are as follows:

- P4 generation file (python base) for AFDX network
- Pseudo-code of SPQ, WRR and DRR

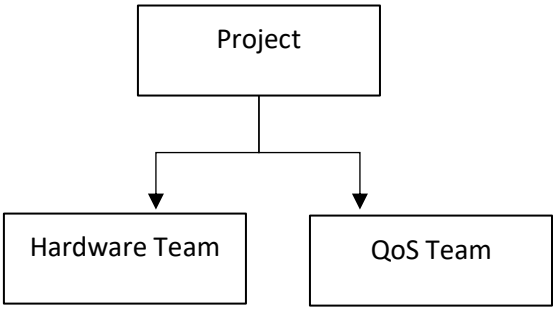
4 - List of requirements

Required skills:

- Real time networks
- Programming language such C and Python

III. ORGANISATION AND DEVELOPMENT PROCESS

1 – OBS



Hardware Team: CHAMPAIN Florian + ZEMZEM Mehdi

QoS Team: ILLI Adil + GRENIER Celestin

2 – Resources (internal / external)

Human resources:

4 embedded systems master students with different background:
- Mechanical engineer & python developer
- Avionics system maintenance & upgrade
- Cognitive engineering school
- Embedded software developer for automobile

Time:

6 weeks of full-time work:

- 1 week from 25/10/2021 to 29/10/2021
- 1 week from 21/02/2021 to 25/02/2021
- 4 weeks from 01/04/2021 to 29/04/2021

Hardware:
- Raspberry Pi
- Computer with multiple network interfaces

Software tools:
- P4 APP
- Mininet
- DPDK
- P4PI
- T4P4S
- Wireshark

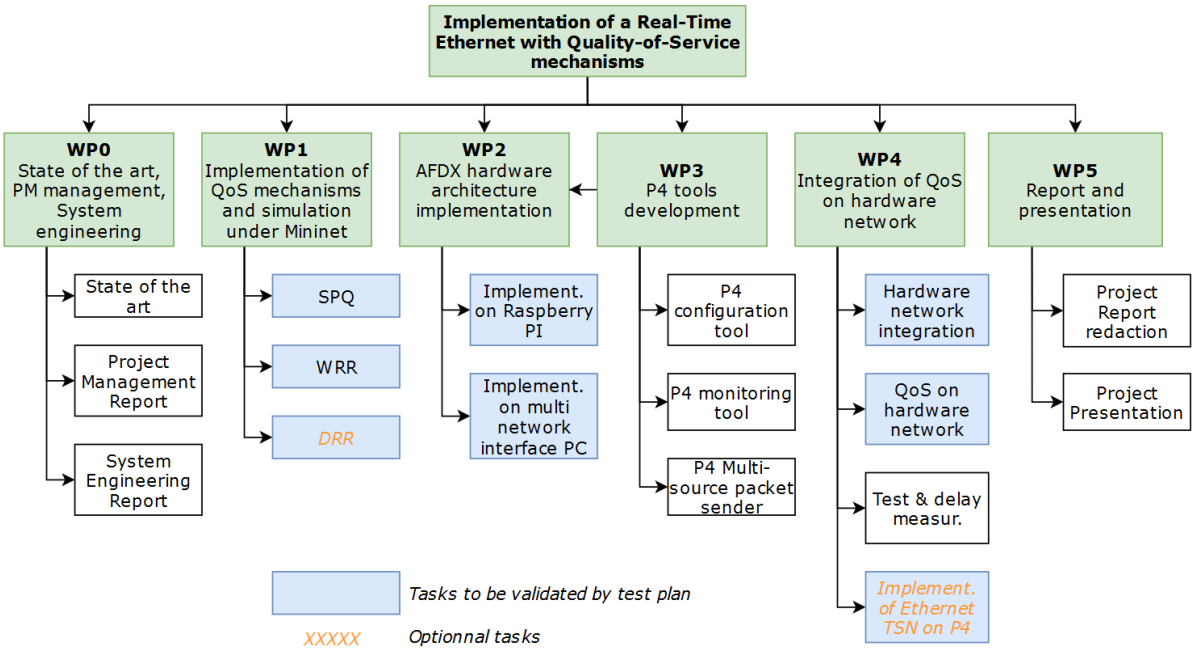
2 – Development logic / Master Schedule

The project is decomposed into 2 main phases:

- First Phase (Preliminary phase from October to January) where the following tasks are performed:
  - Kick-Off, project discovery and technical apprehension of the existing (No milestone in this phase)
  - Preparation of the Project Management Report (Draft needs to be delivered the December 11th)
  - Redaction of the MBSE report (Delivery date due the January 7th)

- Second phase (Realization Phase from February to April) with a global due date to the April 27th:
  - Technical realization
  - Redaction of final report
  - Management project update
  - Presentation preparation

3 – WBS



4 – RASCI

R – Responsible	A – Accountable	S – Supportive	C – Consulted	I – Informed

C.F	Champain Florian	*G.C*	Grenier Celestin
I.A	Illi Adil	*Z.M*	Zemzem Mehdi
J.E	Jérôme Ermont	*V.H.*	Vanderstricht Helene
J.C	Jean-Charles Chaudemar		

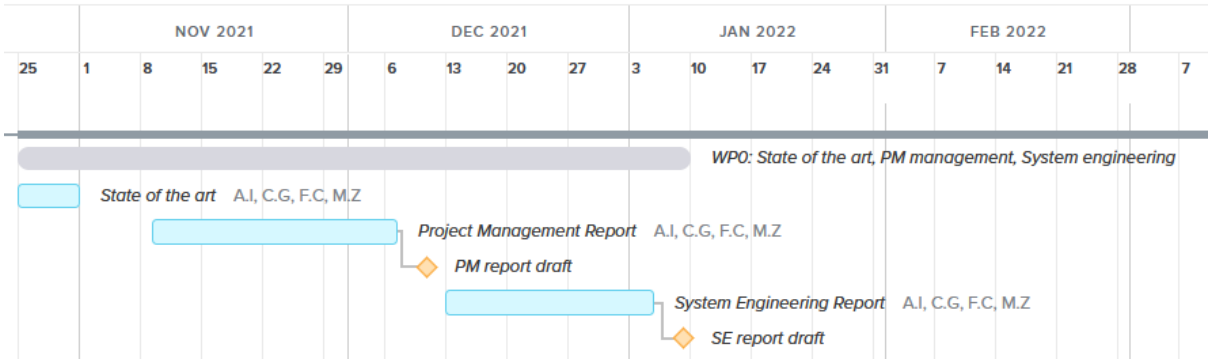
WP	Tasks	C.F	G.C	I.A	Z.M	J.E	V.H	J.C
WP0	State of the art	R	R	R	R	I		
	Project Management Report	R	R	R	R	I	C	
	System Engineering Report	R	R	R	R	I		C
WP1	SPQ		S	R		C		
	WRR		R	R		C		
	DRR		R	S		C		
WP2	Implementation on Raspberry PI	S			R	C		
	Implementation on multi network interface PC	R			S	C		
WP3	P4 configuration tool	R		S		I		
	P4 monitoring tool		S	R		I		
	P4 Multi-source packet sender		R	S		I		
WP4	Hardware network: integration	R	S	S	R	C		
	QoS on hardware network	S	R	R	S	C		
	Test & delay measurements	R	R	S	S	C		
	Implementation of Ethernet TSN on P4	S	S	R	R	C		
WP5	Project Report redaction	R	R	R	R	I		
	Project Presentation	R	R	R	R	I	C	

5 – Milestones definition

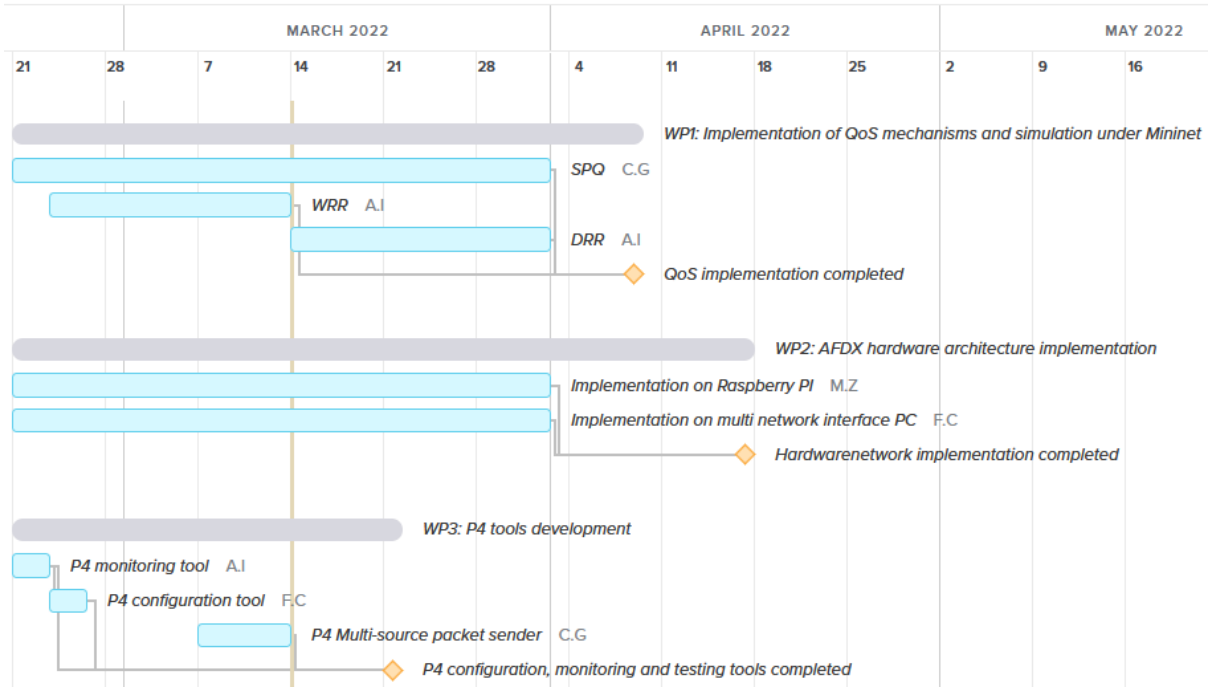
Milestone	Date
WP0 - PM report draft	09/12/2021
WP0 - SE report draft	07/01/2022
WP3 - P4 configuration, monitoring and testing tools completed	21/03/2022
WP1 - QoS implementation completed	07/04/2022
WP2 - Hardware network implementation completed	17/04/2022
WP4 - Implementation of QoS on hardware	21/04/2022
WP5 - Reports and presentation completed	27/04/2022

6 – Project schedule (Gantt chart)

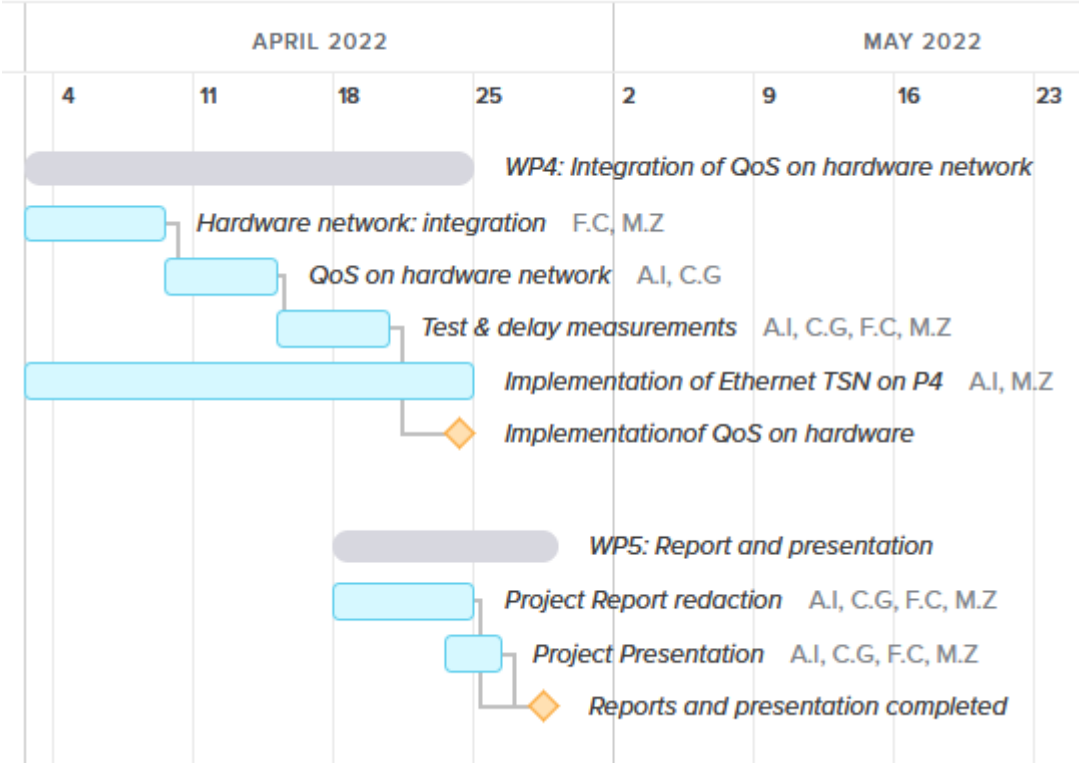
First Phase (Preliminary phase from October to January):



Second phase (Pre-Production Phase from February to March):



Third Phase (Production and finalization phase in April:



IV – DETAILLED PROJECT DEFINITION

1 - Work Packages (tasks) description

The project can be segmented into 6 main packages:

- WP0: State of the art, PM management, System engineering
- WP1: Implementation of QoS mechanisms and simulation under Mininet
- WP2: AFDX hardware architecture implementation
- WP3: P4 tools development
- WP4: Integration of QoS on hardware network
- WP5: Report and presentation

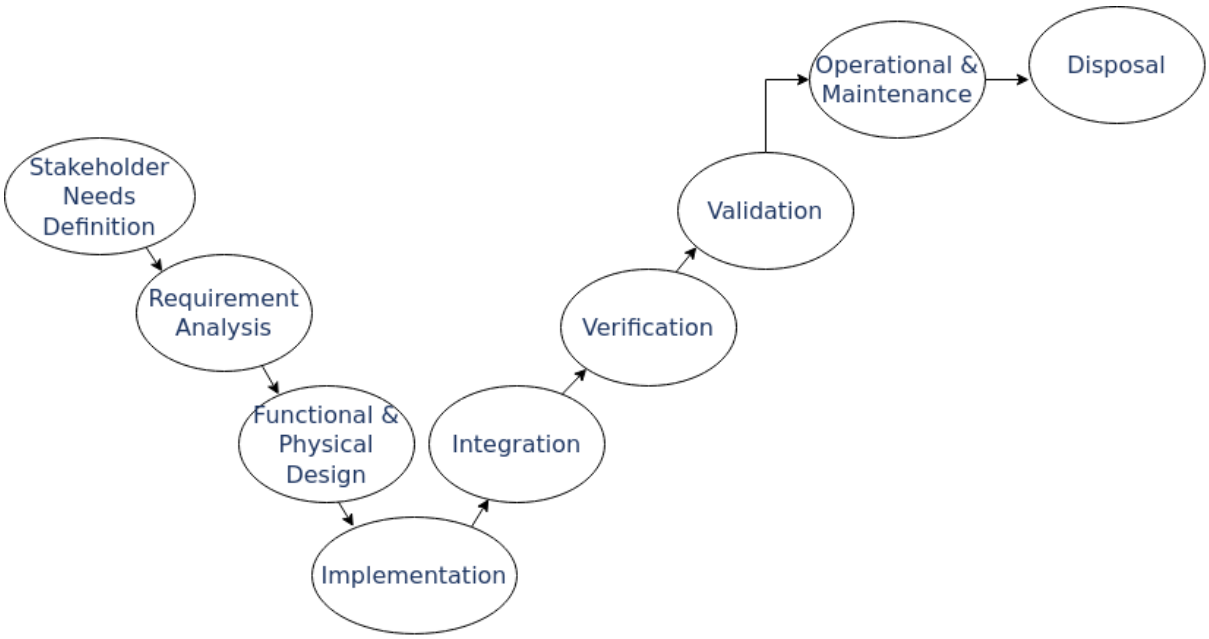
See §III-3 and §III-4 for tasks details for each work package.

2 - Project costs assessment

The project costs are estimated in number of hours:

4 students with 6 total work weeks, with 5 days per week and 8 hours per day: 960 hours

3 - Life cycle



V - PROJECT'S DELIVERABLES

1 - List of deliverables to customer (end products)

- Hardware network architecture with implementation tools
- Quality of service (SPQ and WRR) P4 codes
- Project report

2 - List of intermediate deliverables (enabling products)

The only intermediate deliverable is a draft of the management report (present document) in order to be discussed with the project tutor, along with a system engineering report.

VI - RISK ASSESSMENT

The main risks can be listed, as follows:

- The technical complexity and the lack of documentation on Internet can be time consuming
    - Criticality: High
    - Probability: Medium
    - This risk can be mitigated with the technical support of the project tutor.

- Difficulty to access to ENSEEIHT labs, due to covid situation
    - Criticality: Medium
    - Probability: Low
    - A substantial part of the study can be done in working from home