UNIVERSITÀ
degli STUDI
di CATANIA

Department of Electrical, Electronic and Computer Engineering

MASTER'S DEGREE COURSE IN COMPUTER ENGINEERING

Final Report – Omnet++ Project

Course of Networks for Industrial Automation

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Authors:

Roggio Maria (1000037341)

Strano Giuseppe (1000027120)

Ventimiglia Andrea Paolo (1000039024)

Summary

1. Introduction

1.1. Machine Diagram

You want to implement and simulate the following scenario of a network that contains the following characteristics:

1. 2 Switch
2. 18 End-node
3. Traffico cross-domain
   a. ADAS
   b. Infotainment

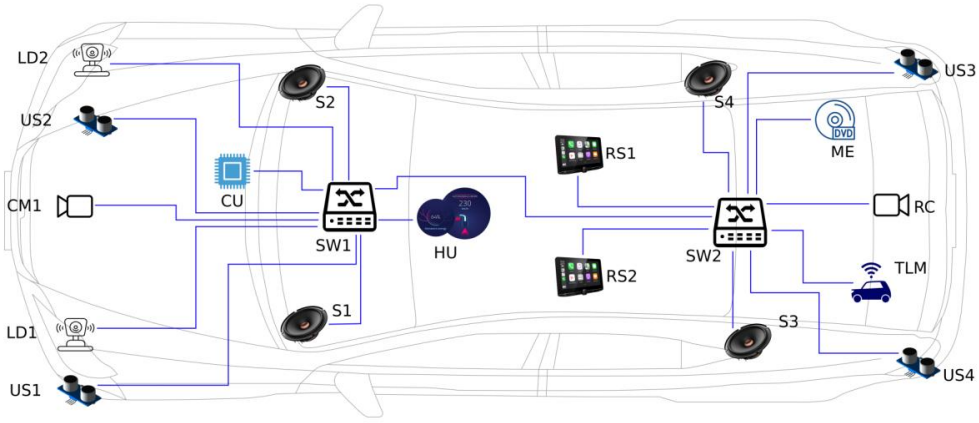


Figure 1.1 Machine Scenario

1.2. Flows

The flows that are produced by the various End-nodes are shown in the following table:

Src	Dst	Periodo	Deadline Rel.	Payload	Burst
LD1, LD2	CU	1.4 ms	1.4 ms	1300 byte	1
ME	S1, S2, S3, S4	250 us	250 us	80 byte	1
US1, US2, US3, US4	CU	100 ms	100 ms	188 byte	1
CU	HU	10ms	2 ms	1500 byte	7
CM1	HU	16.66 ms	16.66 ms	1500 byte	119
ME	RS1, RS2	33.33 ms	33.33 ms	1500 byte	119
TLM	HU, CU	625 us	625 us	600 byte	1
RC	HU	33.33 ms	33.33 ms	1500 byte	119

Table 1.1 End-Node Flows

1.3. Metrics

The metrics that are measured at the application layer are:

- End-to-end delay: $e2eDelay = RxTime - GenTime \quad per\ flusso$
- Frame Loss Ratio (FLR): $FLR = \frac{frame\_scartate}{frame\_trasmesse} \quad per\ flusso$

1.4. Scenario 3: Variant 4

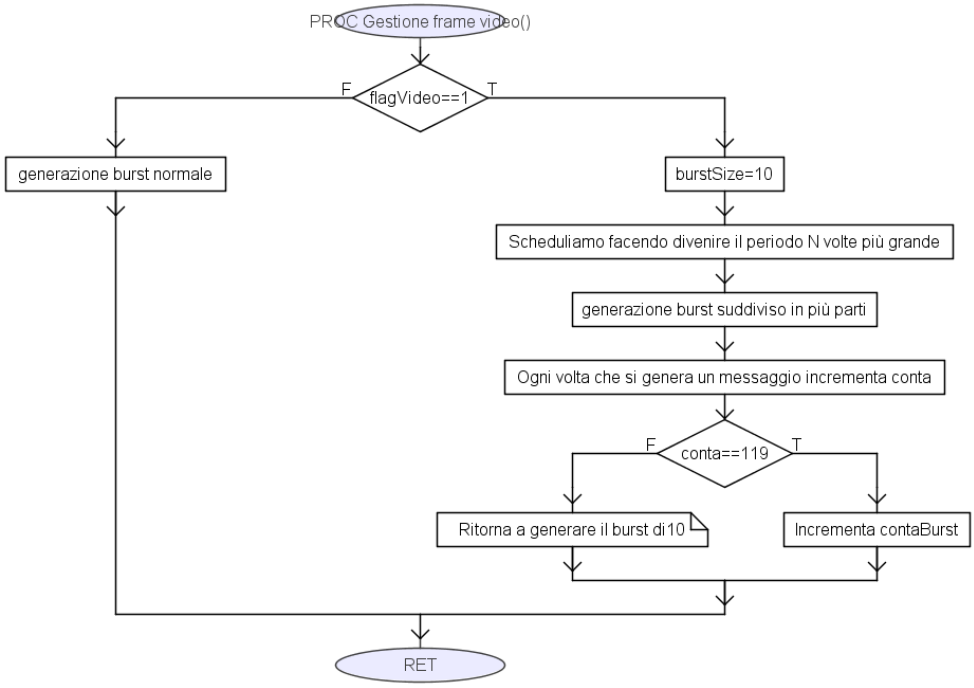
In detail, we will deal with two types of scheduling:

- one with static priority (Deadline Monotonic), in which the priority will be set by relative deadline with a maximum of 8 priorities;
- a dynamic priority (EDF), in which the priority will be set by means of an absolute deadline that will be encoded in the payload of the Ethernet frame.

The queue will be limited to 10 frames, in which video bursts should not be discarded.
In addition, e2eDelay and FLR will be calculated for each stream.

1.5. Scelte implementative

The first design choice was to create a limited queue that, when the maximum limit was reached, would discard all frames except video frames, as shown in the following figure:



The following block diagram has been implemented in the periodicBustApp.

- By means of a flag, implemented in the omnet.ini, we check if the frame belongs to a video burst or not.

- If it is not a video frame, it continues to burst without having to implement any changes. Conversely, if the frame belongs to a video burst we check if a counter, set at the beginning of the code, is equal to 119 (critical value since 109 video frames would be discarded, thus violating the design constraint) in this case we resize the burst size to 10, dividing the single burst into several bursts and increasing the period without violating the deadline.

The second design choice was to implement a dispatcher between the node and the nic, whose task is to receive the frames of the n nodes at the same time and then forward them individually to the nic because the latter, having only one port, could not receive the n frames all at once.

The other design choices are just for optimization and customization of the code.

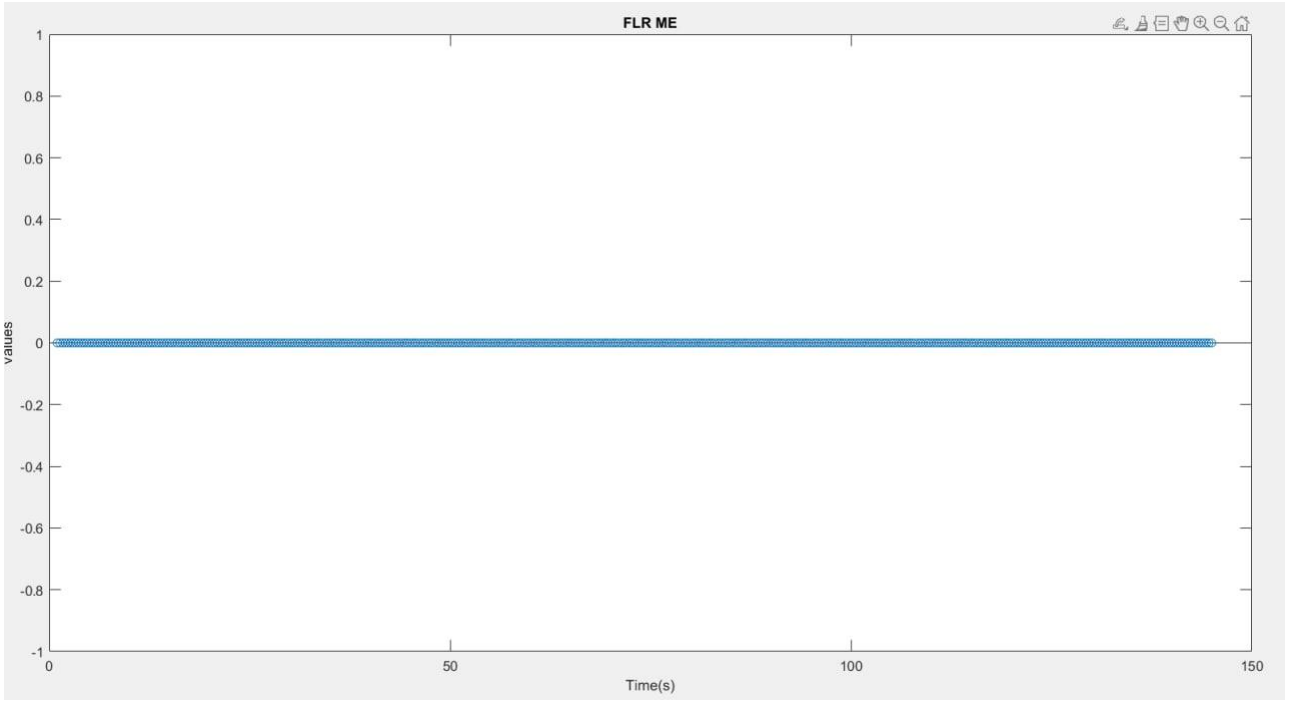
2. Static Priority

2.1. Specific

- Using Deadline Monotonic (max priority 8)
- Queue limited to 10 frames
- No video frame loss

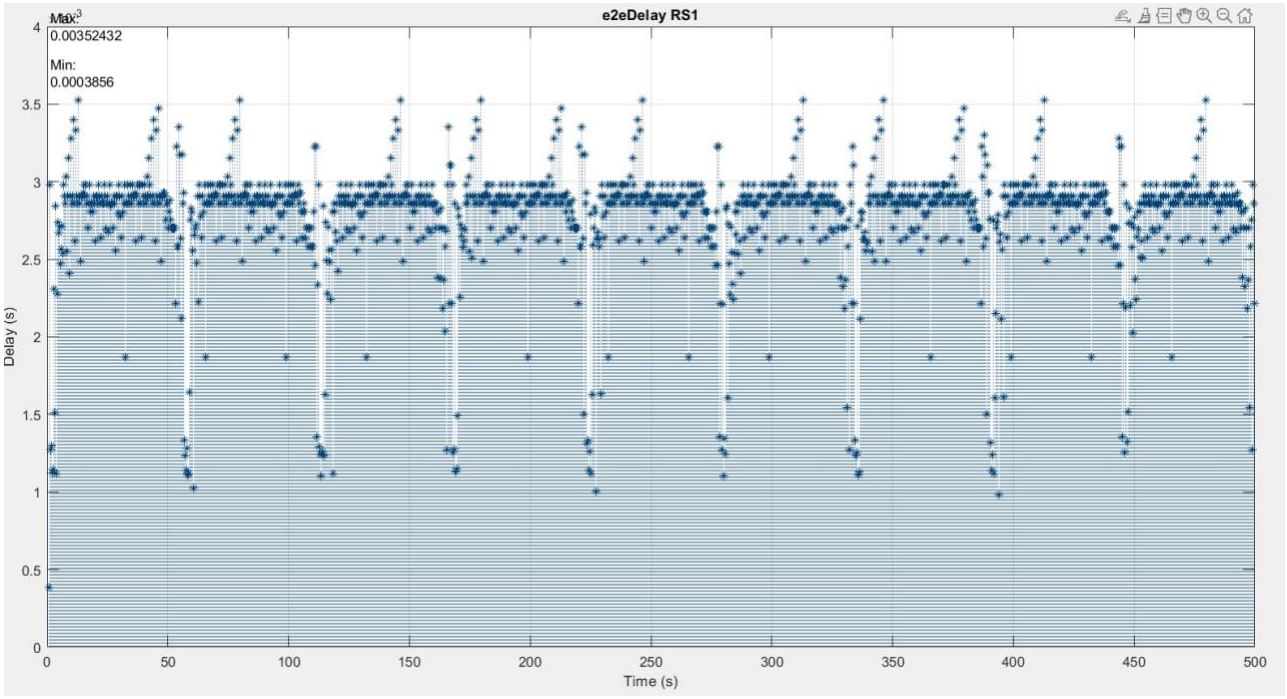
2.2. Results

The main task of the analysis to be defined is the study of the video traffic generated by the ME node. What we have noticed is that FLR (Frame Loss Ratio) is always 0, the result is what we hoped for since there should be no discarded frames:



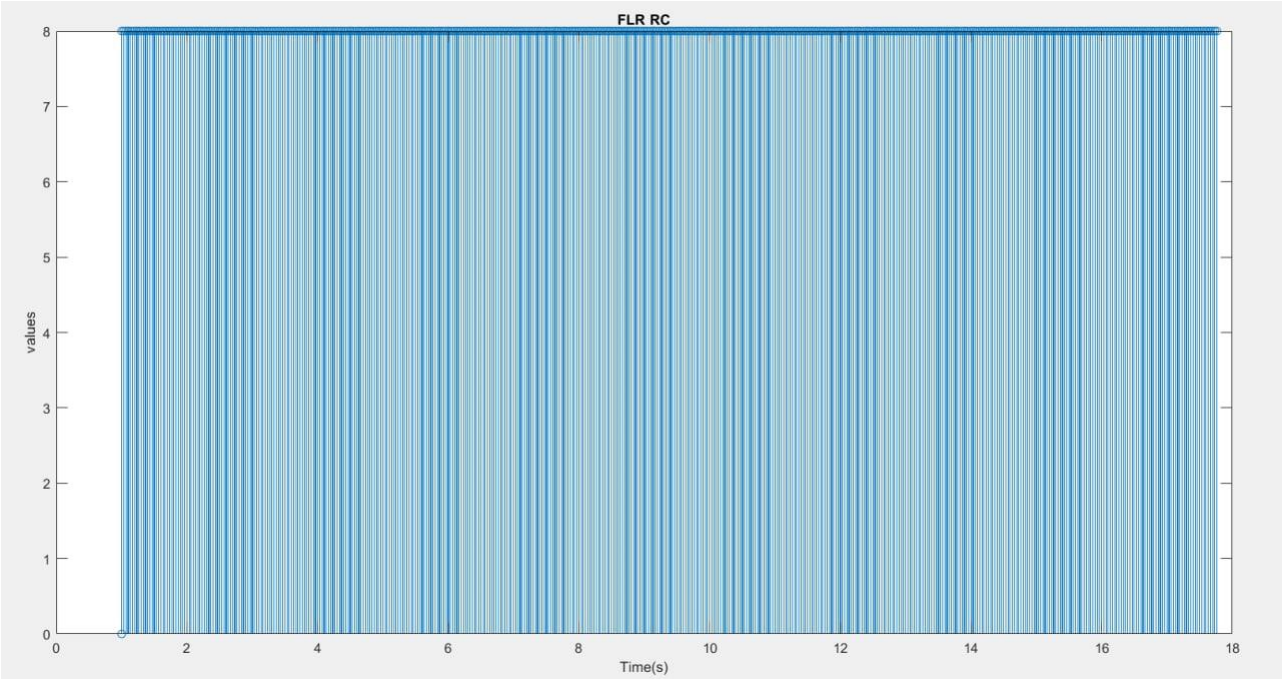
As you can see from the graph above, the FLR is always constant at 0 even if there are multiple flows.

Another result obtained is related to the end-to-end delay of the RS1 node receiving from ME. The end-to-end delay usually fluctuates no more than 0.5 seconds. This is a great result since frames don't wait long to be transmitted:

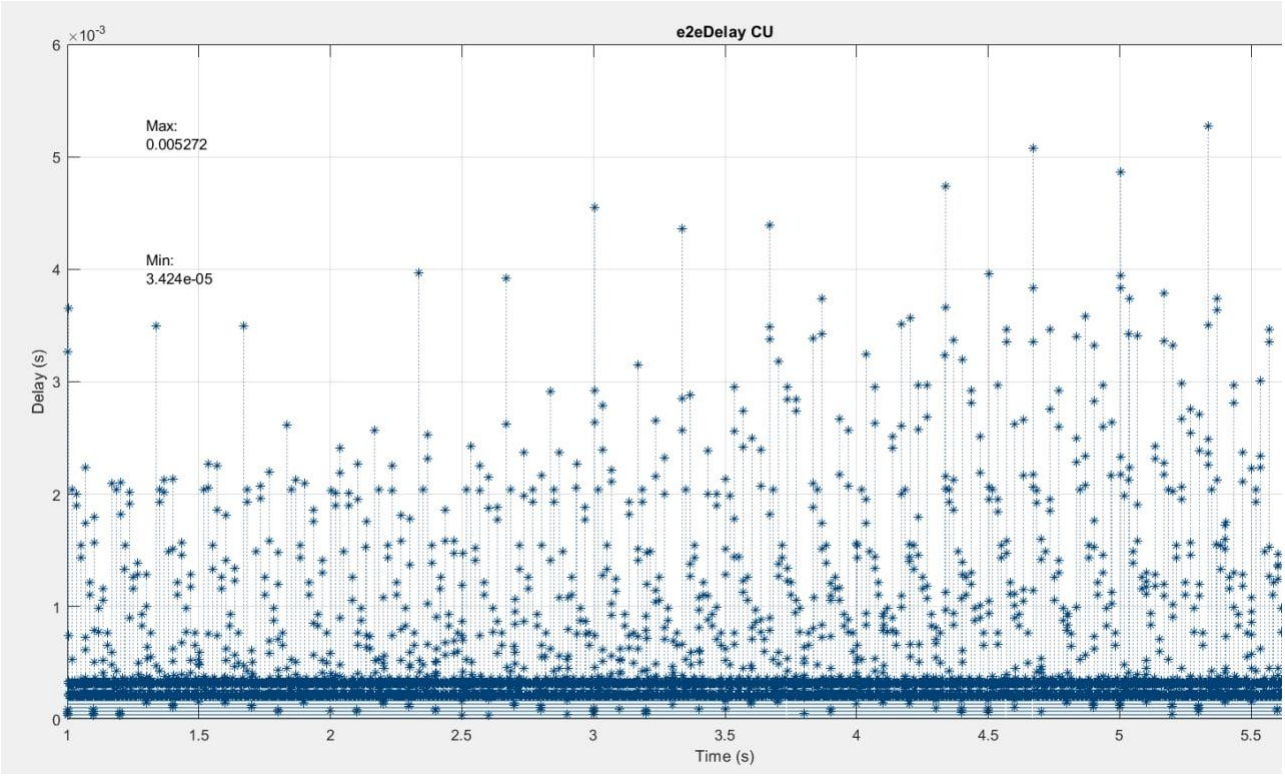


2.3. Valori end-to-end delay e FLR

The results obtained in the previous paragraph, inherent to the ME node, were obtained by not having discarded frames and therefore not losing packets. This consideration cannot be made for the other nodes in the network, since no mechanism has been implemented for them to safeguard and avoid frame loss. In fact, the FLR turns out to be non-zero as can be seen from the graph below concerning the trend of the RC node:



For the sake of completeness, we also report the graph of the end-to-end delay of the CU node:



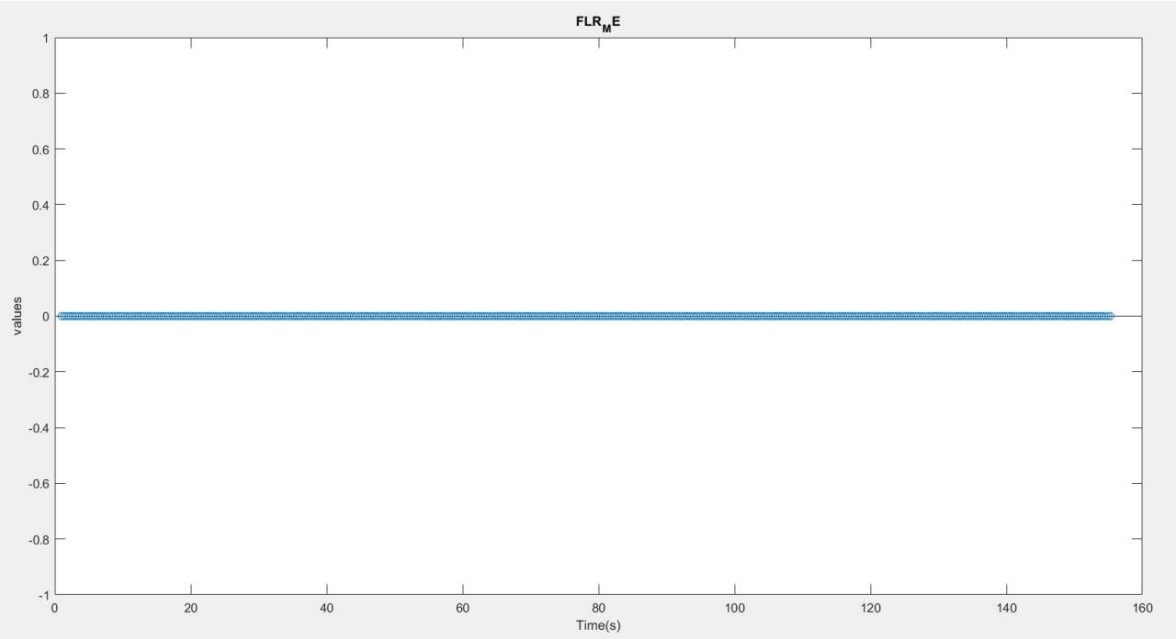
3. Dynamic Priority

3.1. Specific

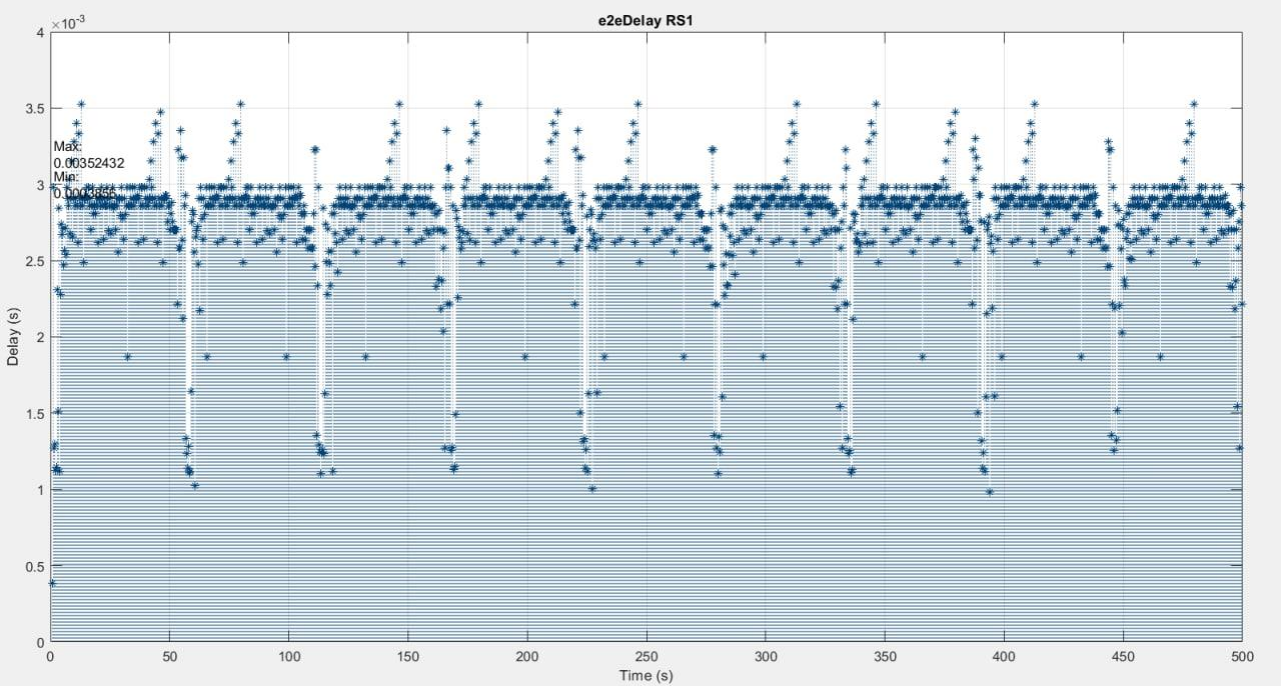
- Using Erliest Deadline First-EDF
- Queue limited to 10 frames
- No video frame loss
- Absolute deadlines encoded in the Ethernet frame payload

3.2. Results

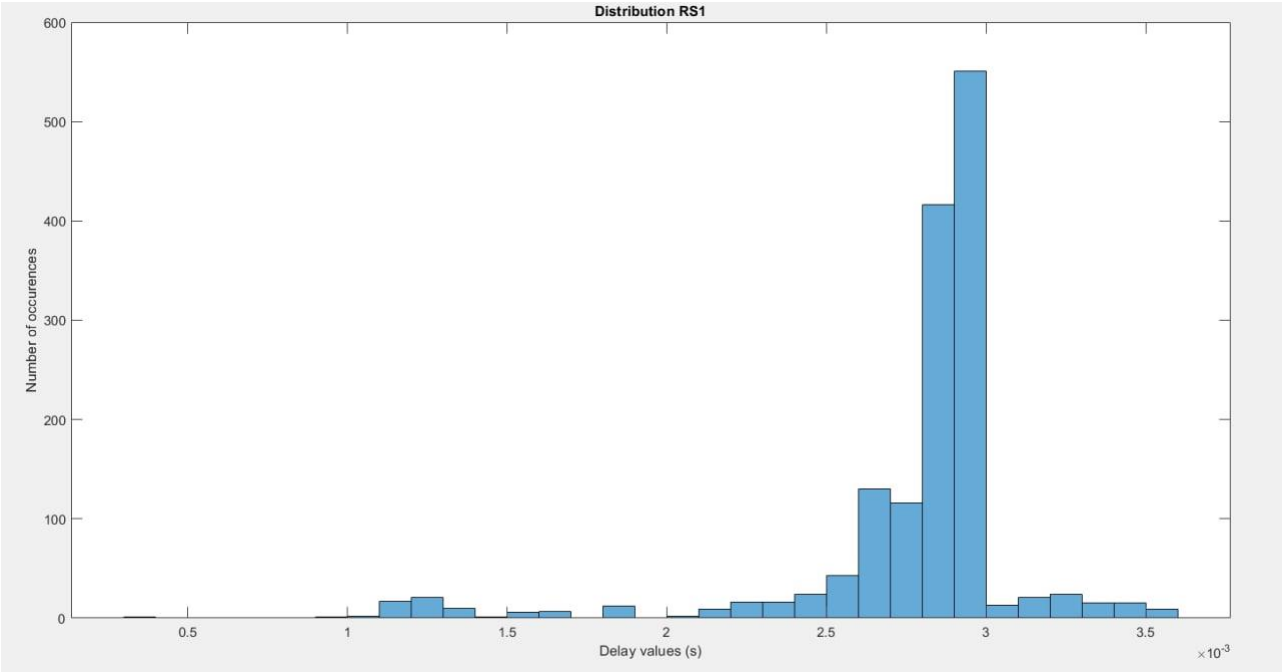
Compared to the previous case, where the priority is static, with the dynamic priority it could be seen that the FLR has remained unchanged, since the previously adopted mechanism does not need to be changed as it does not depend on the priority. We can see this from the following graph:



Another node taken into consideration, in addition to the ME, is RS1. The values of the end-to-end delay and its distribution relative to the previously mentioned node are shown below:



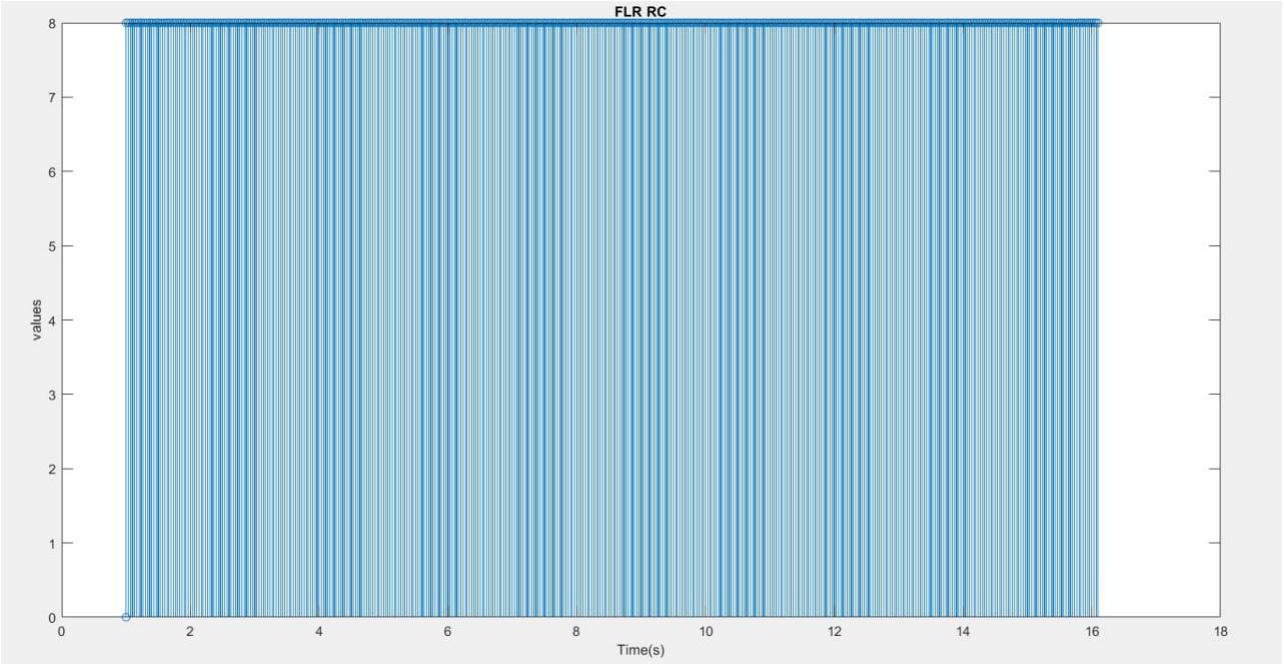
As shown in the upper left of the figure, there are the minimum and maximum points.



3.3. Valori end-to-end delay e FLR

The results obtained in the previous paragraph, inherent to the ME node, were obtained by not having discarded frames and therefore not losing packets. This consideration cannot be made for the other nodes in the network, since no mechanism has been implemented for them to safeguard and avoid

frame loss. In fact, the FLR turns out to be non-zero as can be seen from the graph below concerning the trend of the RC node:



As you can see from the graph, the RC node periodically loses a certain number of frames that cause the FLR to increase dramatically.

For the sake of completeness, we also report the graph of the end-to-end delay of another node of the HU network as a comparison between its values and those of the ME