② ARINC 664 - AFDX networks

We have to compute $W_1^{O_{31}}$ where O_{31} is the output port of switch n_3.

The worst case end-to-end latency of a frame f_i emitted at time t is:

$$W_{1,t}^{O_{31}} = X_{1,t} + \delta_1 + (|Path_i| - 1).sl$$

$$\delta_1 = \sum_{p \in Path_1} 1_{p,j} \cdot \max(C_j)$$

$$= \sum_{p \in Path_1} 1_{p,j} \cdot C_i$$

$$= 2.$$

$$(|Path_i| - 1)sl = 9$$

$$W_{1,t}^{O_{31}} = X_{1,t} + 11.$$

Because $hp_1 = \phi$, then:

$$X_{1,t} = \sum_{v_j \in \{v_1, v_3, v_4\}} \left(1 + \left\lfloor \frac{t + A_{1,j}}{T_j} \right\rfloor\right)^+ \cdot C_j + \underbrace{\sum_{h \in Path_i} \max_{v_j \in hp_i \cup sp_i \cup \{v_i\}} (C_j)}_{= 4} - \underset{\downarrow \atop 1}{C_i}$$

$$= 3 + \left(1 + \left\lfloor \frac{t + A_{1,1}}{T_1} \right\rfloor\right)^+ + \left(1 + \left\lfloor \frac{t + A_{1,3}}{T_3} \right\rfloor\right)^+ + \left(1 + \left\lfloor \frac{t + A_{1,4}}{T_4} \right\rfloor\right)^+$$

$$A_{1,1_?} = S^{O_{11}}_{max_1} - S^{O_{11}}_{min_1} + S^{O_{11}}_{max_1} - \Pi_1^{O_{11}}$$

$$S^{O_{11}}_{max} = S^{O_{11}}_{min_1} = \Pi_1^{O_{11}} = sl + c.$$

$$\Rightarrow A_{1,1} = 0. \quad \text{Similarly, } A_{1,4} = 0$$

$$A_{1,3} = S^{O_{31}}_{max_1} - S^{O_{31}}_{min_3} + S^{O_{31}}_{max_3} - \Pi_1^{O_{31}}$$

$$= W^{n_3}_{1,t} - (c_i + sl) + (c_i + sl) - 3.(c_i + sl)$$

$$= W^{n_3}_{1,t} - 3.(c_i + sl)$$

$$= W^{n_3}_{1,t} - 12$$

$$= X^{n_3}_{1,t} - 1$$

$$X^{O_{31}}_{1,t} = \left(1 + \left\lfloor \frac{t}{T_1} \right\rfloor\right)^+ . C_1 + \left(1 + \left\lfloor \frac{t + X^{O_{31}}_{1,t} - 1}{T_3} \right\rfloor\right)^+ C_3 + 3 + \left(1 + \left\lfloor \frac{t}{T_4} \right\rfloor\right) . C_4$$

$$BP_1 = \sum_{\substack{j \in [1,n] \\ Path_i \cap Path_j \neq \emptyset}} \left\lceil \frac{BP_1}{T_j} \right\rceil c_j = 4$$

$$X^{o_{31}}_{1,0} = 5 + \left(1 + \left\lfloor \frac{X^{o_{31}}_{1,0} - 1}{T_3} \right\rfloor\right)^+$$

$$X^{o_{31}}_{1,0}(1) = 5 + 0$$

$$X^{o_{31}}_{1,0}(2) = 5 + \left(1 + \left\lfloor \frac{5-1}{5} \right\rfloor\right)^+ = 6$$

$$X^{o_{31}}_{1,0}(3) = 5 + \left(1 + \left\lfloor \frac{6-1}{5} \right\rfloor\right)^+ = 6$$

$$W^{o_{31}}_{1,t} = X_{1,t} + 11 \longrightarrow W^{o_{31}}_{1,0} = 17. \quad \text{Latency} = 17$$

We compute $W^{o_{31}}_{1,1}$ similarly: $X^{o_{31}}_{1,1} = 7$

$W^{o_{31}}_{1,1} = 18$

Latency = 17

Remember that f_1 is emitted at time $t = 1$ here.

Finaly, after computing $W^{o_{31}}_{1,2}$ then $W^{o_{31}}_{1,3}$ and then $W^{o_{31}}_{1,4}$ we conclude that the worst case end-to-end latency of v_1 is $17 + 1 \longrightarrow \boxed{18}$

(1: C_i of the link between O_{31} and the connected end system)