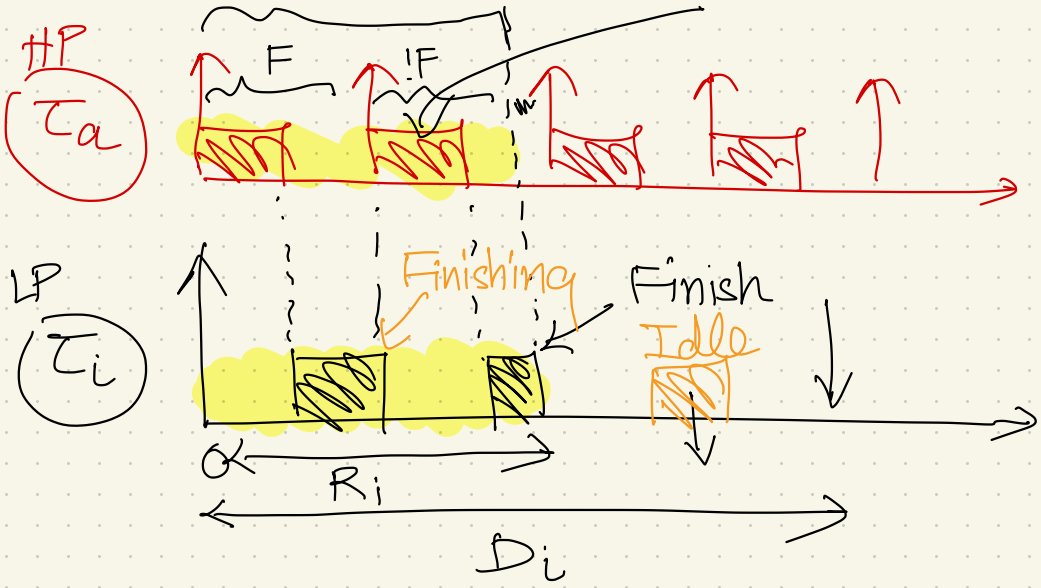
Response-Time Analysis (Any FT Scheduler)



$$C_i + \sum_{\forall a} I_i^a = R_i$$

$$C_i + \sum_{\forall a < i} I_i^a(R_i) = R_i$$

Suppose $R_i = 1$, check if $R_i = C_i + \sum_{\forall a} I_i^a(R_i)$?

Goal: Solve recurrence relation

$$R_i^{(n+1)} = C_i + \sum_{\substack{\forall a \\ < i}} \left(\left\lceil \frac{R_i^{(n)}}{T_a} \right\rceil C_a \right)$$

Smallest possible value of R_i? C_i?

Critical Instant $\Rightarrow$ $R_i \geq C_i + \sum_{a<i} C_a$

$$R_i^{(0)} = C_i + \sum_{a<i} C_a$$

Lets compute $R_i^{(1)} = C_i + \sum_{a<i} \left\lceil \frac{R_i^{(0)}}{T_a} \right\rceil C_a$

Does $R_i^{(1)} = R_i^{(0)}$? Yes $\rightarrow$ STOP

NO $\rightarrow$ $R_i^{(2)} = C_i + \sum_{a<i} \left\lceil \frac{R_i^{(1)}}{T_a} \right\rceil C_a$

Does $R_i^{(2)} = R_i^{(1)}$?

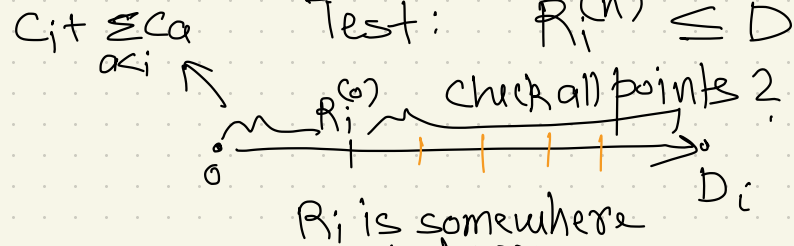
Say $T_a = 5$
From $R_i^{(1)} = 6$
to $R_i^{(1)} = 7$

Fixed point after n iterations

$$R_i^{(n+1)} = R_i^{(n)}$$

Test: $R_i^{(n)} \leq D_i$

Stop as soon as $R_i^{(n)} > D_i$



	T	D	C	
τ_1	20	18	15	
τ_2	39	30	5	
τ_3	100	90	8	RTA?

$$R_3^{(0)} = C_3 + C_1 + C_2 = 28$$

$$R_3^{(1)} = C_3 + \sum_{q<3} \left\lceil \frac{R_3^{(0)}}{T_q} \right\rceil C_q$$

$$= C_3 + \left\lceil \frac{R_3^{(0)}}{T_1} \right\rceil C_1 + \left\lceil \frac{R_3^{(0)}}{T_2} \right\rceil C_2$$

$$= 8 + \left\lceil \frac{28}{20} \right\rceil 2*15 + \left\lceil \frac{28}{39} \right\rceil 1*5$$

$$= 43$$

$$R_3^{(2)} = 8 + \left\lceil \frac{43}{20} \right\rceil 15 + \left\lceil \frac{43}{39} \right\rceil 5 = 8 + 45 + 10 = 63$$

$$R_3^{(3)} = 8 + \left\lceil \frac{63}{20} \right\rceil 15 + \left\lceil \frac{63}{39} \right\rceil 5 = 8 + 60 + 10 = 78$$

$$R_3^{(4)} = 8 + \left\lceil \frac{78}{20} \right\rceil 15 + \left\lceil \frac{78}{39} \right\rceil 5 = 8 + 60 + 10 = 78$$

$R_3^{(4)} = R_3^{(3)} \leq D_3$ YAY!

Preemption → Non-preemptive

CARS = Bus Protocol

CAN Controller Area Network

$$R_i^{(n+1)} = C_i + \sum_{\forall a < i} \left\lceil \frac{R_i^{(n)}}{T_a} \right\rceil C_a$$

$+ I_{from\ b>i}$ ↓ $\max_{\forall b>i} C_b$

Hint: Interference

$$R_i^{(n+1)} = \left(\max_{b>i} C_b \right) + C_i + \sum_{\forall a < i} \text{---11---}$$

Task	Priority	Time Period	Deadline	Exec
A	1	~~2~~ 5 10	~~2~~ 5 10	~~1~~ 4
B	2	~~3~~ 5 14	~~3~~ 25 13	~~1~~ 4
C	3	~~3~~ 5 14	~~3~~ 25 13	~~1~~ 4

$$R_A^{(1)} = \max(C_B, C_C) + C_A$$
$$= \max(1,1) + 1$$
$$= 2$$

$$R_A^{(1)} = \max(4,4) + 4$$
$$= 8$$

$$R_B^{(1)} = \max(C_C) + C_B + \left\lceil \frac{R_B^{(0)}}{T_A} \right\rceil C_A$$

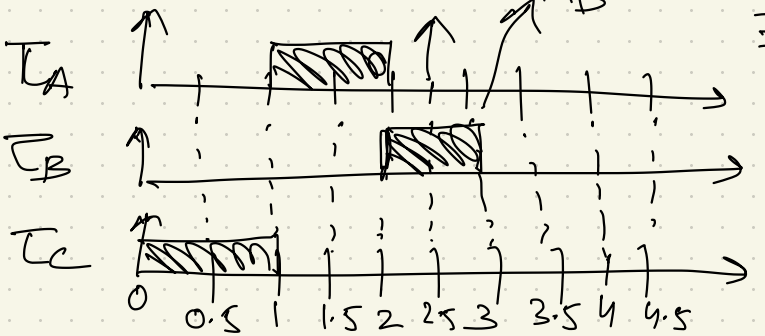
$$= 1 + 1 + \left\lceil \frac{R_B^{(0)}}{2.5} \right\rceil 1 \qquad R_B^{(0)} = 1+1 = 2$$

$$= 2 + 1 = 3$$

$$R_B^{(2)} = 1 + 1 + \left\lceil \frac{3}{2.5} \right\rceil 1 = 2 + 2 = 4$$

$$R_B^{(3)} = 1 + 1 + \left\lceil \frac{4}{2.5} \right\rceil 1 = 2 + 2 = 4$$

$R_B = 3ms$



$$R_B^{(1)} = 4 + 4 + \left\lceil \frac{R_B^{(0)}}{10} \right\rceil 4 \qquad R_B^{(0)} = 8$$

$$= 4 + 4 + \lceil 8/10 \rceil 4 = 8 + 4 = 12$$

$$R_B^{(2)} = 4 + 4 + \lceil 12/10 \rceil 4 = 8 + 8 = 16$$

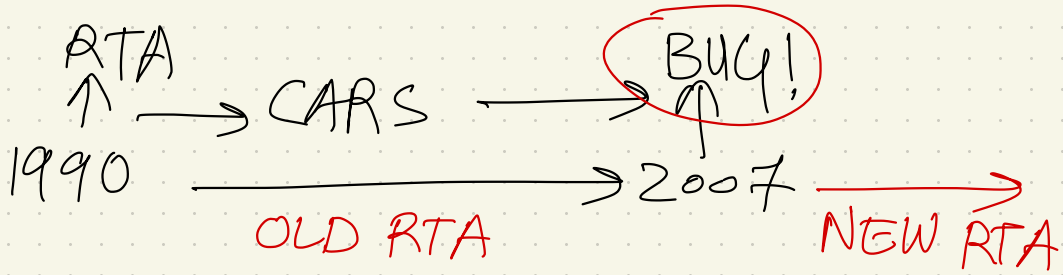
$$R_B^{(3)} = 4 + 4 + \lceil 16/10 \rceil 4 = 8 + 8 = 16$$

CAN Transmission $\approx$ NP FP Uniprocessor Sched.

CAN msgs have priority = FP

Bus = CPU

Time to transmit = C_i



4.6 HW: EDF for constrained deadline