Lecture #12 – blackboard scribble

	Task	C_i	D_i	T_i
H	τ_1	4	6	8
L	τ_2	3	14	16
M	τ_3	2	10	32

Calculation of response times:

[τ_1 has highest priority (DM)]

$R_1 = C_1 = 4 \leq D_1 = 6 \Rightarrow$ ok!

[τ_3 has medium priority (DM)]

Note: ceiling function

$$R_3 = C_3 + \left\lceil \frac{R_3}{T_1} \right\rceil \cdot C_1$$

[Assume $R_3^0 = C_3 = 2$]

$$R_3^1 = 2 + \underbrace{\left\lceil \frac{2}{8} \right\rceil}_{1} \cdot 4 = 2 + 1 \cdot 4 = 6$$

$$R_3^2 = 2 + \underbrace{\left\lceil \frac{6}{8} \right\rceil}_{1} \cdot 4 = 2 + 1 \cdot 4 = 6$$

Convergence because $R_3^2 = R_3^1$

$\leq D_3 = 10 \Rightarrow$ ok!

Lecture #12 – blackboard scribble

Task	C_i	D_i	T_i
H τ_1	4	6	8
L τ_2	3	14	16
M τ_3	2	10	32

[τ_2 has lowest priority (DM)]

$$R_2 = C_2 + \left\lceil \frac{R_2}{T_1} \right\rceil \cdot C_1 + \left\lceil \frac{R_2}{T_3} \right\rceil \cdot C_3$$

[Assume $R_2^0 = C_2 = 3$]

$$R_2^1 = 3 + \left\lceil \frac{3}{8} \right\rceil \cdot 4 + \left\lceil \frac{3}{32} \right\rceil \cdot 2 = 3 + 1 \cdot 4 + 1 \cdot 2 = 9$$

$$R_2^2 = 3 + \left\lceil \frac{9}{8} \right\rceil \cdot 4 + \left\lceil \frac{9}{32} \right\rceil \cdot 2 = 3 + 2 \cdot 4 + 1 \cdot 2 = 13$$

$$R_2^3 = 3 + \left\lceil \frac{13}{8} \right\rceil \cdot 4 + \left\lceil \frac{13}{32} \right\rceil \cdot 2 = 3 + 2 \cdot 4 + 1 \cdot 2 = 13$$

Convergence

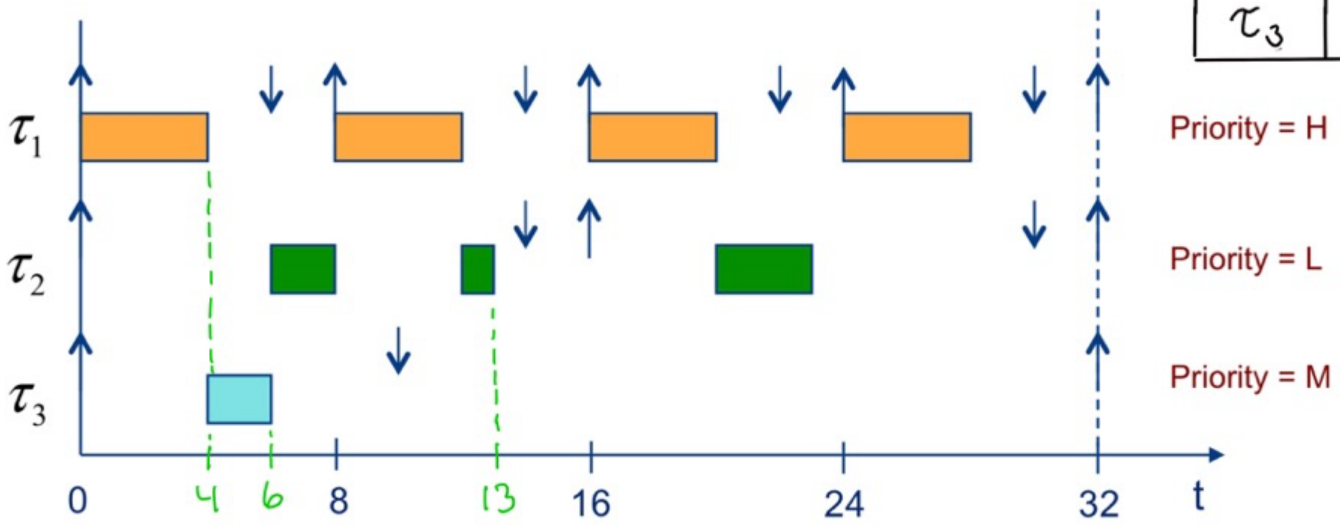
$\leq D_2 = 14 \Rightarrow$ ok !

All deadlines are met !

Lecture #12 – blackboard scribble

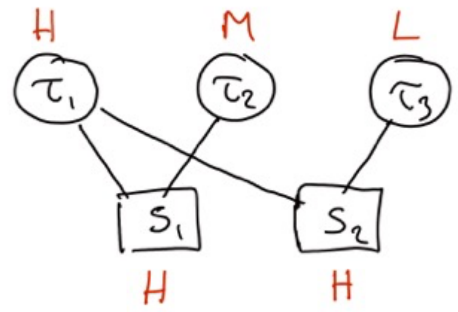
As we saw in the beginning of the lecture the resulting schedule looks like this:

Task	C_i	D_i	T_i
τ_1	4	6	8
τ_2	3	14	16
τ_3	2	10	32



Consequently, the analysis calculates worst-case response times that correspond exactly to the response times of the first instance of each task.

Lecture #12 – blackboard scribble

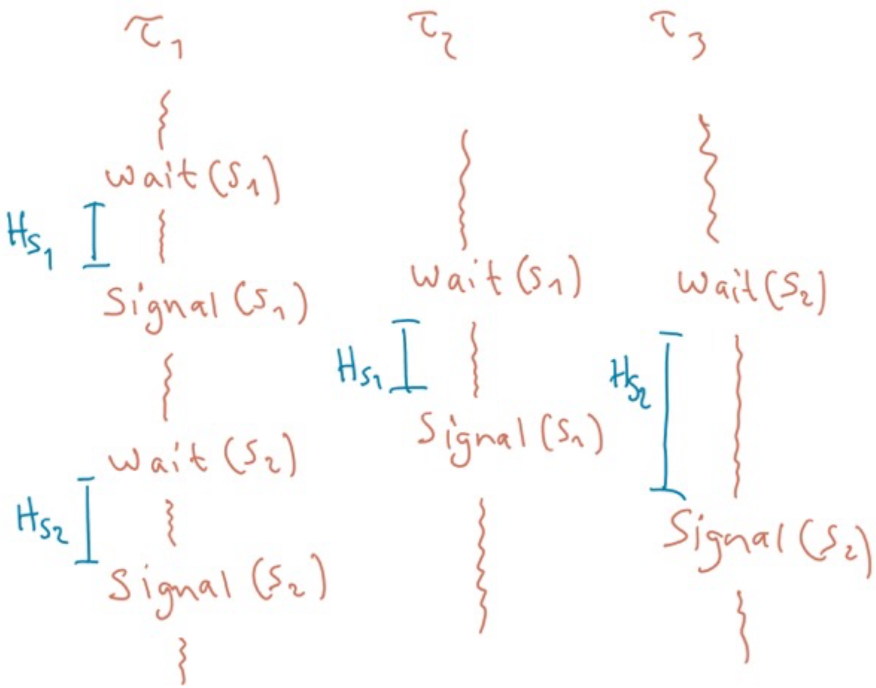


	Task	C_i	D_i	T_i	H_{S1}	H_{S2}
H	τ_1	2	4	5	1	1
M	τ_2	3	12	12	1	–
L	τ_3	8	24	25	–	2

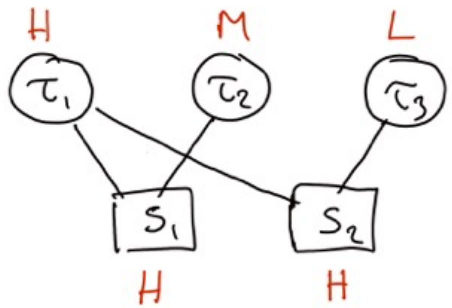
a) Ceiling priorities

$S_1: \max\{H, M\} = H$

$S_2: \max\{H, L\} = H$



Lecture #12 – blackboard scribble



Task	C_i	D_i	T_i	H_{S1}	H_{S2}
τ_1	2	4	5	1	1
τ_2	3	12	12	1	–
τ_3	8	24	25	–	2

b) Blocking factors:

Since both semaphores have highest priority ceiling (H) task τ_1 and τ_2 may be blocked by a task with lower priority regardless of which semaphore that lower-priority task uses.

$B_1 = \max\{1, 2\} = 2$ { τ_2 may use semaphore S_1 or τ_3 may use semaphore S_2

$B_2 = 2$ { τ_3 may use semaphore S_2. NOTE: τ_2 may be blocked although it does not use S_2

$B_3 = 0$ ← NOTE: lowest-priority task can never be blocked

Lecture #12 – blackboard scribble

Task	C_i	D_i	T_i	H_{S1}	H_{S2}
τ_1	2	4	5	1	1
τ_2	3	12	12	1	–
τ_3	8	24	25	–	2

c) Calculate response times!

[τ_1 has highest DM priority]

$R_1 = C_1 + B_1 = 2 + 2 = 4 \leq D_1 = 4$ $\Rightarrow$ ok! (but barely)

[τ_2 has medium DM priority]

$R_2 = C_2 + B_2 + \left\lceil \frac{R_2}{T_1} \right\rceil \cdot C_1$ [Assume $R_2^0 = C_2 = 3$]

$R_2^1 = 3 + 2 + \left\lceil \frac{3}{5} \right\rceil \cdot 2 = 3 + 2 + 1 \cdot 2 = 7$

$R_2^2 = 3 + 2 + \left\lceil \frac{7}{5} \right\rceil \cdot 2 = 3 + 2 + 2 \cdot 2 = 9$

$R_2^3 = 3 + 2 + \left\lceil \frac{9}{5} \right\rceil \cdot 2 = 3 + 2 + 2 \cdot 2 = 9$

Convergence $\leq D_2 = 12$ $\Rightarrow$ ok!

Lecture #12 – blackboard scribble

[τ_3 has lowest priority]

Task	C_i	D_i	T_i	H_{S1}	H_{S2}
τ_1	2	4	5	1	1
τ_2	3	12	12	1	–
τ_3	8	24	25	–	2

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

[Assume $R_3^0 = C_3 = 8$]

$$R_3^1 = 8 + \left\lceil \frac{8}{12} \right\rceil \cdot 3 + \left\lceil \frac{8}{5} \right\rceil \cdot 2 = 8 + 1 \cdot 3 + 2 \cdot 2 = 15$$

$$R_3^2 = 8 + \left\lceil \frac{15}{12} \right\rceil \cdot 3 + \left\lceil \frac{15}{5} \right\rceil \cdot 2 = 8 + 2 \cdot 3 + 3 \cdot 2 = 20$$

$$R_3^3 = 8 + \left\lceil \frac{20}{12} \right\rceil \cdot 3 + \left\lceil \frac{20}{5} \right\rceil \cdot 2 = 8 + 2 \cdot 3 + 4 \cdot 2 = 22$$

$$R_3^4 = 8 + \left\lceil \frac{22}{12} \right\rceil \cdot 3 + \left\lceil \frac{22}{5} \right\rceil \cdot 2 = 8 + 2 \cdot 3 + 5 \cdot 2 = 24$$

$$R_3^5 = 8 + \left\lceil \frac{24}{12} \right\rceil \cdot 3 + \left\lceil \frac{24}{5} \right\rceil \cdot 2 = 8 + 2 \cdot 3 + 5 \cdot 2 = 24$$

Convergence

$\leq D_3 = 24 \Rightarrow$ ok!

(but barely)

All deadlines are met!