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Example: scheduling using DM

Problem: Assume a system with tasks according to the figure below. The timing properties of the tasks are given in the table.

a) Calculate the task response times.

b) Show that the tasks are schedulable using DM

c) What is the outcome of Liu & Layland's feasibility test for RM?

Task	C_i	D_i	T_i
τ_1	12	52	52
τ_2	10	40	40
τ_3	10	30	30

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Example: scheduling using DM

a) Calculation of response times:

(Also see solution in Tindell pp. 22-23)

$R_3 = C_3 = 10$ [τ_3 has the highest priority w r t DM]

$R_2 = C_2 + \left\lceil \frac{R_2}{T_3} \right\rceil C_3$ [Assume $R_2^0 = C_2 + C_3 = 10 + 10 = 20$]

$R_2^1 = 10 + \left\lceil \frac{20}{30} \right\rceil \cdot 10 = 10 + 1 \cdot 10 = 20$ [Convergence because $R_2^1 = R_2^0$]

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Example: scheduling using DM

$R_1 = C_1 + \left\lceil \frac{R_1}{T_2} \right\rceil C_2 + \left\lceil \frac{R_1}{T_3} \right\rceil C_3$ [Assume $R_1^0 = C_1 + C_2 + C_3 = 12 + 10 + 10 = 32$]

$R_1^1 = 12 + \left\lceil \frac{32}{40} \right\rceil \cdot 10 + \left\lceil \frac{32}{30} \right\rceil \cdot 10 = 12 + 1 \cdot 10 + 2 \cdot 10 = 42$

$R_1^2 = 12 + \left\lceil \frac{42}{40} \right\rceil \cdot 10 + \left\lceil \frac{42}{30} \right\rceil \cdot 10 = 12 + 2 \cdot 10 + 2 \cdot 10 = 52$

$R_1^3 = 12 + \left\lceil \frac{52}{40} \right\rceil \cdot 10 + \left\lceil \frac{52}{30} \right\rceil \cdot 10 = 12 + 2 \cdot 10 + 2 \cdot 10 = 52$

[Convergence because $R_1^3 = R_1^2$]

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b) Compare response times with corresponding deadline:

Task	R_i	D_i	Result
τ_1	52	52	OK
τ_2	20	40	OK
τ_3	10	30	OK

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c) The utilization U in the system is

$$U = \sum_{i=1}^{n} \frac{C_i}{T_i} = \frac{12}{52} + \frac{10}{40} + \frac{10}{30} \approx 0.81$$

The least upper bound U_{lub} for the test is

$$U_{lub} = n\left(2^{1/n} - 1\right) = 3\left(2^{1/3} - 1\right) \approx 0.780$$

Since $U > U_{lub}$ and the test is only a sufficient one, we cannot decide whether the task are schedulable or not.

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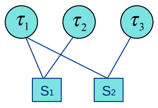
Example: scheduling using DM

Problem: Assume a system with tasks according to the figure below.
The timing properties of the tasks are given in the table.
Two semaphores S1 and S2 are used for synchronizing the tasks.
The parameters H_{S1} and H_{S2} represent the longest time a task may lock semaphore S1 and S2, respectively.



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

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Example: scheduling using DM

Problem: (cont'd)

Examine the schedulability of the tasks when ICPP (Immediate Ceiling Priority Protocol) is used.

a) Derive the ceiling priorities of the semaphores.

b) Derive the blocking factors for the tasks.

c) Show whether the tasks are schedulable or not.

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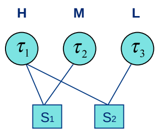
Example: scheduling using DM

a) Ceiling priorities for the semaphores:



$$S_1 = \max\{H, M\} = H$$
$$S_2 = \max\{H, L\} = H$$

b) Since both semaphores have highest ceiling priority (H), tasks τ_1 och τ_2 may always be blocked by another task with lower priority regardless of which semaphore it uses.

$B_1 = \max\{1,2\} = 2$ — τ_2 and τ_3 may use semaphores S1 and S2

$B_2 = \max\{2\} = 2$ — τ_3 may use semaphore S2

$B_3 = 0$

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c) Calculate response times:

$R_1 = C_1 + B_1 = 2 + 2 = 4 \quad \leq D_1 = 4 \quad \Rightarrow \text{OK!}$

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

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

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

$R_2^3 = 3 + 2 + \left\lceil \frac{9}{5} \right\rceil \cdot 2 = 3 + 2 + 2 \cdot 2 = 9 \quad \leq D_2 = 12 \quad \Rightarrow \text{OK!}$

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$R_3 = C_3 + \left\lceil \frac{R_3}{T_2} \right\rceil C_2 + \left\lceil \frac{R_3}{T_1} \right\rceil C_1$ Assume $R_3^0 = C_3 = 8$

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

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

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

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

$R_3^5 = 8 + \left\lceil \frac{24}{12} \right\rceil \cdot 3 + \left\lceil \frac{24}{5} \right\rceil \cdot 2 = 8 + 2 \cdot 3 + 5 \cdot 2 = 24 \quad \leq D_3 = 24 \quad \Rightarrow \text{OK!}$