Scheduling

- Response Time Analysis
- ICPP and blocking in scheduling analysis
- Processor Demand Analysis
- Problems demonstrated during exercise: 47, 48, 51, 55, 56

Problem 47

- Consider the following task set:

Task	Period *T* [ms]	Deadline *D* [ms]	Execution time *C* [ms]
A	10	7	3
B	12	6	4

- a) Determine if the set is schedulable due to Rate Monotonic priority assignment.
- b) Determine if the set is schedulable due to Deadline Monotonic priority assignment.

Solution 47

- We will solve it in the white board.
- Answer: Using RM priority assignment this task set is not schedulable but using deadline monotonic priority assignment it is schedulable.

Assignment 48

Consider the following task set. Show that:
Assign priorities according to deadline monotonic order. Does every task meet its deadline?

Task	Period *T* [ms]	Deadline *D* [ms]	Execution time *C* [ms]
A	70	65	15
B	40	40	10
C	30	12	10

Solution 48

- We will solve it in the white board.
- Answer: We will do response time analysis and would see YES answer.

Assignment 51

- The following task set should be scheduled due to *deadline monotonic*.
- Three semaphores; S_1, S_2 and S_3 are used to synchronize the tasks.
- H_{Si} denotes the maximum locking time when a task locks semaphore *i*.
- P_A, P_B, P_C and P_D denote the tasks A,B,C and D.

Task	*T* [ms]	*D* [ms]	*C* [ms]	Priority	H_{S1} [ms]	H_{S2} [ms]	H_{S3} [ms]
A	5	4	2	1	1	-	1
B	16	12	3	2	1	2	-
C	20	16	3	3	-	3	-
D	28	28	4	4	-	-	2

Assume that ICPP (Immediate Ceiling Priority Protocol) is used to lock and unlock the semaphores. Is this task set then schedulable?

Assignment 51(cont.)

- The following task set should be scheduled due to *deadline monotonic*.
- Three semaphores; S_1, S_2 and S_3 are used to synchronize the tasks.
- H_{Si} denotes the maximum locking time when a task locks semaphore *i*.
- P_A, P_B, P_C and P_D denote the tasks A,B,C and D.

Task	*T* [ms]	*D* [ms]	*C* [ms]	Priority	H_{S1} [ms]	H_{S2} [ms]	H_{S3} [ms]
A	5	4	2	1	1	-	1
B	16	12	3	2	1	2	-
C	20	16	3	3	-	3	-
D	28	28	4	4	-	-	2

Draw the access graph to find the ceiling priority and the blocking factor.

Assume that tasks are accessing the resources one at a time.

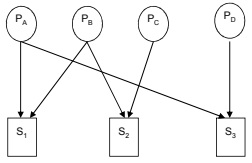
$$R_i^{n+1} = C_i + B_i + \sum_{\forall j \in hp(i)} \left\lceil \frac{R_i^n}{T_j} \right\rceil C_j$$

Assignment 51(cont.)

- The following task set should be scheduled due to *deadline monotonic*.
- Three semaphores; S_1, S_2 and S_3 are used to synchronize the tasks.
- H_{Si} denotes the maximum locking time when a task locks semaphore *i*.
- P_A, P_B, P_C and P_D denote the tasks A,B,C and D.

Task	*T* [ms]	*D* [ms]	*C* [ms]	Priority	H_{S1} [ms]	H_{S2} [ms]	H_{S3} [ms]
A	5	4	2	1	1	-	1
B	16	12	3	2	1	2	-
C	20	16	3	3	-	3	-
D	28	28	4	4	-	-	2

B_A=2 B_B=3 B_C=2 B_D=0



P_A (pri) = 1, P_B (pri) = 2, P_C (pri) = 3, P_D (pri) = 4.

Ceiling priorities:

ceil{S_1} = max {P_A (pri), P_B (pri)} = max {1,2} = 1
ceil{S_2} = max {P_B (pri), P_C (pri)} = max {2,3} = 2
ceil{S_3} = max {P_A (pri), P_D (pri)} = max {1,4} = 1

P_A can be blocked by P_B and P_D *since they use semaphores with a ceiling priority that is higher or equal to the priority of P_A*.
B_A = max { P_B uses S_1, P_D uses S_3 } =?

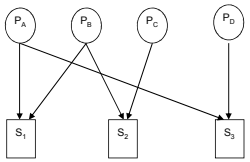
P_B can be blocked by P_C and P_D. B_B =max { P_C uses S_2, P_D uses S_3 } =?

P_C can be blocked by P_D. B_C = max { P_D uses S_3 }=?

Assignment 51(cont.)

Task	*T* [ms]	*D* [ms]	*C* [ms]	Priority	H_{S1} [ms]	H_{S2} [ms]	H_{S3} [ms]
A	5	4	2	1	1	-	1
B	16	12	3	2	1	2	-
C	20	16	3	3	-	3	-
D	28	28	4	4	-	-	2

B_A=2 B_B=3 B_C=2 B_D=0



$$R_i^{n+1} = C_i + B_i + \sum_{\forall j \in hp(i)} \left\lceil \frac{R_i^n}{T_j} \right\rceil C_j$$

We solve it in Whiteboard and see …
(SCHEDULABLE)

EDF SCHEDULING
(Processor Demand Analysis)

Assignment 55 (Exercise # 6)

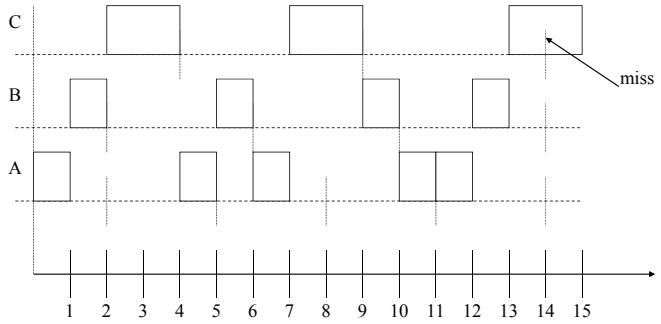
The following task set should be scheduled due to *earliest deadline first* (EDF).

Task	*T* [ms]	*D* [ms]	*C* [ms]
A	3	2	1
B	4	2	1
C	5	4	2

a) Calculate processor utilization factor.
b) Draw a timing diagram showing the possible scenarios for execution order. (“simulation”).

Assignment 55 (cont)

- (a) U=59/60. But we can not give any scheduling guarantee. Why?



Processor Demand Analysis (From Jan's Lecture #15)

Processor-demand analysis:

- We can express N_i^L as

$$N_i^L = \left\lfloor \frac{L - D_i}{T_i} \right\rfloor + 1$$

- The total processor demand is thus

$$C_p(0, L) = \sum_{i=1}^{n} \left(\left\lfloor \frac{L - D_i}{T_i} \right\rfloor + 1 \right) C_i$$

A sufficient and necessary condition for earliest-deadline-first scheduling, for which $D_i \le T_i$, is

$$\forall L : C_p(0, L) \le L$$

where $C_p(0, L)$ is the total processor demand in $[0, L]$.

Only the following points(absolute deadlines) need to be checked

$$\forall L \in K : C_p(0, L) \le L$$

$$K = \left\{ D_i^k \mid D_i^k = kT_i + D_i, D_i^k \le \mathrm{LCM}\{T_1, \ldots, T_n\}, 1 \le i \le n, k \ge 0 \right\}$$

Assignment 56

A real-time system with three periodic tasks is scheduled due to EDF. The run-time system executes all tasks with preemption and due to task priorities. The following table details periods (T), deadlines (D) and worst case execution times (C). All tasks arrives at $t = 0$.

Task	T [ms]	D [ms]	C [ms]
A	4	4	3
B	10	4	1
C	20	16	3

a) Show that Liu & Layland's simple utilization based test is inapplicable in this case.
b) Use *processor demand analysis* to determine whether the task set is schedulable or not

Assignment 56

LCM{A,B,C} = LCM{4,10,20} = 20.
Checkpoints ***K***:
K = { 4,8,12,14,16,20}

L	$N^L_A * C_A$	$N^L_B * C_B$	$N^L_C * C_C$	C_P (0, L)	C_P (0, L) ≤ L
4	(⌊(4-4) / 4⌋)+1)*3 = 3	(⌊(4-4) / 10⌋)+1)*1 = 1	(⌊(4-16) / 20⌋)+1)*3 = 0	4	OK
8	(⌊(8-4) / 4⌋)+1)*3 = 6	(⌊(8-4) / 10⌋)+1)*1 = 1	(⌊(8-16) / 20⌋)+1)*3 = 0	7	OK
12	(⌊(12-4) / 4⌋)+1)*3 = 9	(⌊(12-4) / 10⌋)+1)*1 = 1	(⌊(12-16) / 20⌋)+1)*3 = 0	10	OK
14	(⌊(14-4) / 4⌋)+1)*3 = 9	(⌊(14-4) / 10⌋)+1)*1 = 2	(⌊(14-16) / 20⌋)+1)*3 = 0	11	OK
16	**(⌊(16-4) / 4⌋)+1)*3 = 12**	**(⌊(16-4) / 10⌋)+1)*1 = 2**	**(⌊(16-16) / 20⌋)+1)*3 = 3**	**17**	**NOT OK!**
20	(⌊(20-4) / 4⌋)+1)*3 = 15	(⌊(20-4) / 10⌋)+1)*1 = 2	(⌊(20-16) / 20⌋)+1)*3 = 3	20	OK

I.e. NOT schedulable since $C_P(0, 16) = 17$ exceeds length of the interval

Good Luck with Exam!!