CS 330 - Winter 2025
Assignment W5

Due: Wednesday, February 26, 2025 (start of class)

You should submit a physical copy of your written homework at the start of class.

[2 points] Collaboration Statement

Be sure to include a collaboration statement with your assignment, even if you worked alone.

[18 points] Problem 1 - Pi-Blocking

Create a task set of three tasks that can cause at least four time units of priority-inversion blocking for τ_1 and at least two units of priority-inversion blocking for τ_2, assuming none of the locking protocols we discussed are used, just a semaphore (with calls to `signal()` and `wait()`) to protect each resource. State $(\Phi_i, T_i, C_i, \delta_{i,A})$ for each task and draw a schedule that produces the required priority inversions.

[29 points] Problem 2 - Blocking under different protocols

Consider the task set comprised of the following four tasks which share five resources (but assume there are no nested critical sections). The maximum duration of each critical section, $\delta_{i,k}$, is given in the table below for each task τ_i and resource ℓ_k.

	A	B	C	D	E
τ_1	0	0	5	4	1
τ_2	3	0	0	0	10
τ_3	0	12	9	0	3
τ_4	1	2	0	4	0

a) What are γ_1, γ_2, γ_3, and γ_4 for this task set, assuming the NPP is used? What are B_1, B_2, B_3, and B_4?

b) What are the resource ceilings $C(\ell_A)$, $C(\ell_B)$, $C(\ell_C)$, $C(\ell_D)$, and $C(\ell_E)$?

c) What are γ_1, γ_2, γ_3, and γ_4 for this task set, assuming the PCP is used? What are B_1, B_2, B_3, and B_4?

[20 points] Problem 3 - RM with the NPP

a) Consider the task set $\tau = \{\tau_1, \tau_2\} = \{(5, 2, 1),\ (7, 4, 3)\}$ in which each task is represented as $(T_i, C_i, \delta_{i,A})$. What are γ_1 and γ_2 for this task set, assuming NPP and RM scheduling? What are B_1 and B_2 for this task set?

b) For the task set in part (a), assume that the critical section occurs first, followed by the non-resource-requiring work. Draw the schedule that is produced by these constraints for $t = 0$ to $t = 35$, clearly labeling any deadline misses.

c) Conduct the modified response-time analysis test for both tasks in the presence of blocking. Can we guarantee that this task set is schedulable by RM?

[16 points] Problem 4 - RM with the PCP

Consider the task set $\tau = \{\tau_1, \tau_2, \tau_3\} = \{(9, 4, 2, 0),\ (25, 6, 0, 2),\ (30, 5, 1, 3)\}$ in which each task is represented as $(T_i, C_i, \delta_{i,A}, \delta_{i,B})$.

a) What are the resource ceilings $C(\ell_A)$ and $C(\ell_B)$?

b) What are γ_1, γ_2, and γ_3 for this task set, assuming RM scheduling with the PCP? What are B_1, B_2, and B_3?

c) Conduct the modified RM utilization test for all tasks. Can we guarantee that this task set is schedulable by RM?

[15 points] Problem 5 - Partitioning Basics

Consider the following set of implicit-deadline tasks, where task $\tau_i = (T_i, C_i)$.

$$\tau = \{\tau_1, \tau_2, \tau_3, \tau_4, \tau_5, \tau_6, \tau_7\} = \{\ (4, 1),\ (5, 1),\ (8, 3),\ (10, 2),\ (4, 2),\ (8, 1),\ (12, 3)\ \}.$$

The total system utilization is 1.9, so we hope to schedule these tasks on a two-processor platform.

a) How many ways are there to partition these tasks between two processors?

b) What is an optimal partitioning of these tasks onto two processors, assuming each partition is scheduled using uniprocessor EDF? How do you know each partition is schedulable using EDF?

c) Perform the uniprocessor RM utilization-based test on both of your partitions from part (a). Do the tests pass?

d) Draw the schedule from $t = 0$ to $t = 12$, assuming RM scheduling for each processor. Make sure to include deadline and release arrows, as well as completion hats.

e) Given your schedule in Part (d), does the first job of each task meet its deadline? What can you conclude about the overall schedulability of this task set?

[15 points] Problem 6 (EXTRA CREDIT) - SRP and resource ceilings

Consider the task set comprised of the following three tasks which share three multi-unit resources, and that access to these resources is managed using the SRP.

	D_i	μ_A	μ_B	μ_C
τ_1	5	1	0	1
τ_2	10	2	1	2
τ_3	20	3	1	1

Assuming resources A and B each have three units available, and resource C has two units, compute the ceiling table for all resources.