Exam 08 Feb 2022; Example

Duration: 100 mins (with support of slides and notes; not electronic equipment)

Student Name: ____

Number:________________

1) Consider the following set of periodic and independent tasks.

   Task *x* (*Ci*, *Ti*) -> Task A (5, *); Task B (2, 12); Task C (4, 16)

   The tasks are scheduled with pre-emption allowed and according to the Earliest Deadline First (EDF) policy. Assume that the minimum inter-arrival time of Task A is 9, compute the worst-case response time for Task C (15%).

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2) Consider the task set above and that the period of task A is 14. Also assume also that the time for context switch (change of the task that executes on the processor) is not negligible and is at most 1 time units. Assume that the worst-case execution time for the tasks only depends on the processor speed, and that the speed of processor we use now is 25% faster. Assume the scheduling policy is based on rate monotonic and pre-emption is allowed. Analyse the schedulabilty of the task set (15%).

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3) Now consider a task set with the following characteristics:

   Task *x* (*Ci*, *Ti*, *Di*) -> Task A (2, 6, 9); Task B (3, 10, 8); Task C (4, 14, 14)

   Consider that the task set is executed under a DM (Deadline Monotonic) policy, and that pre-emption is allowed. Is the task set schedulable? Justify the answer. (15%)

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4) Consider 4 periodic tasks $\tau 1$, $\tau 2$, $\tau 3$, and $\tau 4$ (having decreasing priority) that share five resources, A, B, C, D, and E, accessed using the Priority Ceiling Protocol. Compute the maximum blocking time Bi for each task, knowing that the longest duration $\delta i,R$ for a task τi on resource R is given in the following table (there are no nested critical sections). (15%)

	A	B	C	D	E
$\tau 1$	3	6	10	0	7
$\tau 2$	0	0	8	0	0
$\tau 3$	0	4	0	8	14
$\tau 4$	7	0	9	0	11

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5) Consider two periodic tasks with computation times C1 = 1, C2 = 2 and periods T1 = 5, T2 = 8, handled by Rate Monotonic. Show the schedule produced by a Polling Server, having maximum utilization and intermediate priority, on the following aperiodic jobs (10%).

   job_i (a_i, C_i); J_1 = (2, 3); J_2 = (7, 1); J_3 = (17, 1); where a_i = arrival time of job i

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6) Consider a multiprocessor system with two processors and Global EDF (G-EDF) for scheduling the following task set:

   $\tau_i = (\phi_i, C_i, T_i)$

   $\tau_1 = (1, 4, 6)$; $\tau_2 = (2, 1.5, 5)$; $\tau_3 = (3, 1, 6)$; $\tau_4 = (0, 5, 10)$; $\tau_5 = (0, 3, 9)$

   Determine the schedule (Gantt chart) using synchronous release $\phi = 0$ and using ϕ as the offset parameter as given above. Consider the schedule until $t = 30$ time units (15%)

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7) The positioning module of an unmanned aerial vehicle (UAV, also known as "drone") employs an inertial unit and a GPS unit. Each of these two units periodically calculate three values: latitude, longitude, and altitude. On normal operation, the UAV uses the data produced by the inertial unit. However, as both systems are subject to failure, the module monitors both positions, to detect possible malfunctioning. When both positions strongly disagree, the module issues an alert, requesting the human operator to select the unit that appears more trustworthy.

The computing system supports five tasks. Their characteristics are summarised in the following table:

TASK	T	C	DESCRIPTION
T1	50 ms	15 ms	Determines the position (inertial unit).
T2	1000 ms	10 ms	Determines the position (GPS unit).
T3	3000 ms	15 ms	Monitors agreement between the two positions
T4	5000 ms	50 ms	UAV navigation (compute horizontal and vertical headings).
T5	100 ms	15 ms	Communication (telemetry e command).

Both positions – `pos_inertial` and `pos_GPS` – are stored in memory and accessed by all the tasks, according to the following table:

RESOURCE	TASKS	NOTES
pos_inercial	T1, T3, T4, T5	T1 modifies this resource.
pos_GPS	T2, T3, T4, T5	T2 modifies this resource. Tasks T4 and T5 access this resource by explicit command of the human operator, in case of a failure of the inertial unit.

Although tasks T3, T4 and T5 do not modify the values of these two resources, it is fundamental that they are coherent (i.e. are not modified) during a computation (or "job").

a) The task set is to be scheduled under the Rate Monotonic (RM) policy. Assign each task a priority according to this policy, so they can be correctly scheduled by the (POSIX) `SCHED_FIFO` scheduler.

b) The computing system provides POSIX mutexes with the priority ceiling policy for priority inversion avoidance.

Discuss the following topics, logically supporting your answer.

i) How many mutexes would you use?

ii) Which resources each mutex would synchronise the access?

iii) What should be the ceiling defined for each mutex?

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c) Consider the following sequential code (i.e. without synchronisation mechanisms) for task T3. Assume that function `diff_pos()` takes 7 ms to execute. Rewrite the code inserting synchronisation instructions and, if possible, optimise the code to reduce the blocking time caused to higher priority tasks. Discuss if such optimisation is possible or not.

```
while(1)
{
        delay_until(next_release);

        if(diff_pos(pos_inercial, pos_GPS) > MAX_DIFF)
        {
                send_alert(BAD_POSITIONING);
        }

        next_release = add_time(next_release, period);
}
```