universidade de aveiro
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# 42081 - SISTEMAS OPERATIVOS E DE TEMPO-REAL

2021-2022

Exam, Regular Period — Duration: 2h00m

#MEC: _____ Name: _____

**Note 1:** all answers should be properly justified. Just answering Yes/No or writing numerical results without indicating the equations and values used implies that the corresponding answer will not be considered.

**Note 2:** the weight of each question is placed at the beginning, between square brackets. E.g. "[0.5]".

**Note 3:** several answers have a limited size. In such cases the maximum number of lines that can be used is indicated at the end of the question. E.g. "[5 lines]" means that up to 5 lines of text can be used for the answer. Diagrams/figures are not size-limited. Just the text.

## Part I – Short Questions (6/20 points)

1. [1.0] Consider the following statement: "All Real-Time tasks must have an associated deadline". Do you agree? Justify! [6 lines]

2. [1.0] Identify three factors that can contribute to the variation of the Worst-Case Execution Time of a task. [8 lines]

3. [1.0] Consider a set of three tasks with periods 25, 30 and 50 t.u., scheduled in a tick-based OS. Compute the optimum value for the tick value, providing a brief justification. [6 lines]

4. [1.0] Consider a task set composed of independent periodic tasks, scheduled with preemption. If this task set is schedulable with Rate-Monotonic, then it can be assumed that is also schedulable with EDF? Why? [4 lines]

5. [1.0] One of the code optimization techniques is called "cycle expansion". Explain briefly how this technique is applied in practice (you can use an example, if you wish) and indicate one potential benefit and one potential drawback. [6 lines]

6. [1.0] Regarding cache, multi-core systems have additional problems with respect to single-core ones? If so, which ones? [6 lines]

## Part II – Development Questions (14/20 points)

1. [7.0] An industrial milling machine with numerical control has 3 orthogonal axes, each equipped with closed-loop position control and range-limit sensors for their protection, and also two milling cutter pressure sensors to detect jam situations. **The global control is performed by a CPU that executes six tasks concurrently. It is used an EDF scheduler, tasks are preemptible and deadlines are set to the period/mit**. The tasks are characterized as follows:

   - $\tau_1$ - reads instructions from a control program written in a high-level language, one at each iteration, and transforms them into simple movements used by task $\tau_2$. It is fired whenever the execution of an instruction ends.
     - Sporadic, $C_1$=1 ms, $mit_1$=50 ms
   - $\tau_2$ - interprets the movements generated by task $\tau_1$ and generates the set-points appropriate for each of the axes.
     - Periodic – $C_2$=5 ms, $T_2$=20 ms
   - $\tau_3$ to $\tau_5$ - perform the closed loop control of each axis.
     - Periodic – $C_{3\text{-}5}$=1 ms, $T_{3\text{-}5}$=5 ms
   - $\tau_6$ - is activated by triggering any of the protection sensors and stops the machine in safe conditions.
     - Aperiodic, $C_6$=1 ms, $R_6$ =10 ms, R = maximum allowable response time for a single event

a) [1.0] Determine, justifying, if it is possible to guarantee the scalability of the set of tasks $\tau_1$ to $\tau_5$, by using a criteria based on utilization rate.

b) [4.0] Admitting now that the relative deadlines of tasks $\tau_3$ to $\tau_5$ are $D_{3\text{-}5}$=4 ms, determine **analytically** if the task set is schedulable.

c) [2.0] It is intended to use a server to handle task $\tau_6$. Select a suitable server and determine the parameters that allow to comply with the task's response time constraint. Justify clearly your reasoning.

2. [7.0] Consider the task set described below, where $R_1$, $R_2$ and $R_3$ are shared resources that require mutual exclusion and $E_i(R_i)$ stands for the worst-case time that task $\tau_i$ spends on $R_j$. $E_i(R_j) = 0$ means that task $\tau_i$ does not use $R_j$. The system is scheduled with RM and nested shared resource access is not allowed.

| | $C_i$ | $T_i=D_i$ | $E_i(R_1)$ | $E_i(R_2)$ | $E_i(R_3)$ |
|---|---|---|---|---|---|
| $\tau_1$ | 2 | 5 | 1 | 0 | 1 |
| $\tau_2$ | 2 | 10 | 0 | 1 | 0 |
| $\tau_3$ | 5 | 20 | 2 | 4 | 1 |

a) [1.0] Is preemption disabling a suitable method for handling shared resources in this case? If not, provide an example. [Diagram + 4 lines]

b) [2.0] Assume that it is used PCP. Compute the blocking times for each task.

c) [4.0] Determine **analytically** if the system is schedulable with PCP.