

Date: Monday 29-06-2020, 8.45-11.45

RTS1 re-examination

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This exam consists of 10 questions.

Write your solutions/answers by hand on a paper (i.e. not typed).

Don't forget to put your name and student number on all the papers that you use

Given the new situation you have to include in your solutions an honour pledge as follows: **“I promise that I have not used unauthorized help from people or other sources for completing my exam. I created the submitted answers all by myself during the time slot that was allocated for this real-time systems 1 exam.”**

Write readable and with a **blue pen**

Upload a photo of your answers in Canvas before 11.45 today (or 45 min later if you have a card which allows 25% additional time. Add a photo copy of this card).

Please also send your answers to my mail account ([marco.bekooij@nxp.com](mailto:marco.bekooij@nxp.com)) before 11.45 today.

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1. Check whether the EDD algorithm produces a feasible schedule under non-preemptive scheduling for the following task set given synchronous arrival of the tasks

	$J_1$	$J_2$	$J_3$	$J_4$
$C_i$	4	3	3	4
$D_i$	6	15	6	12

- a) (2 pts) The modified task set ordered according to their deadlines
- b) (2 pts) Motivate whether the task set is schedulable
- c) (2 pts) Motivate whether the task set is schedulable given that preemptive scheduling is applied

2. Polling server

Using a Polling Server with  $C_S=1$ ,  $T_S=16$  as capacity and period, scheduling the following tasks according to the rate monotonic rule

Periodic tasks

	$C_i$	$T_i$
$\tau_1$	1	2
$\tau_2$	1	4

### Aperiodic tasks

	$a_i$	$C_i$
$J_1$	2	2
$J_2$	5	1

- (2 pts) Give the equations for feasibility according to the HB (Bini)
- (2 pts) Compute the feasibility according to the HB
- (2 pts) Derive an equation for the maximum utilization of the server
- (2 pts) Compute the relative deadlines for the two aperiodic tasks
- (5 pts) Verify your answer by constructing the schedule for the task set on gridded paper.

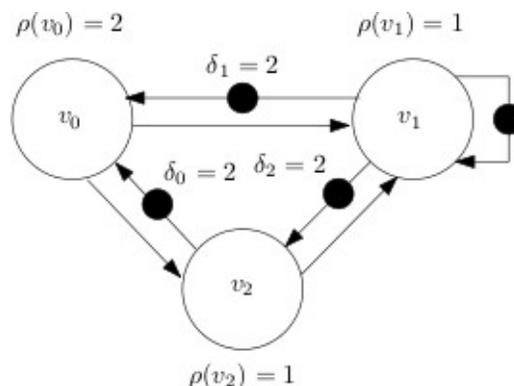
### 3. Aperiodic scheduling

Given the following precedence constraints  $J_1 \rightarrow J_3$ ,  $J_2 \rightarrow J_3$ ,  $J_3 \rightarrow J_4$  and the following task parameters:

	$r_i$	$d_i$	$C_i$
$J_1$	0	3	2
$J_2$	1	5	3
$J_3$	6	9	2
$J_4$	7	10	3

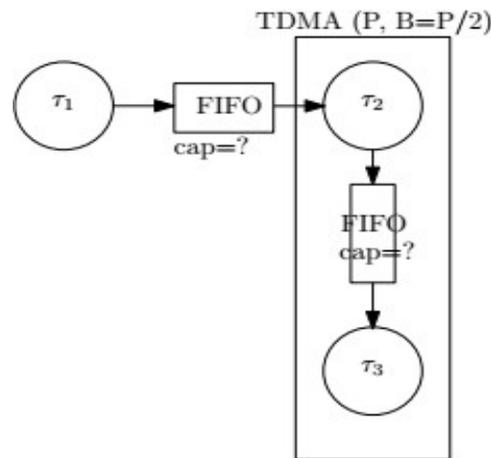
- (2 pnt) Draw the task graph
- (2 pnt) Compute the modified release-times and deadlines
- (2 pnt) Show that this task set is feasible/infeasible

### 4. Given the following HSDF graph:



- (2 pnt) Enumerate all simple cycles in the HSDF graph
- (2 pnt) Is this HSDF graph deadlock free and motivate why is this the case?
- (2 pnt) Derive the maximum throughput and the minimum throughput of this HSDF graph?
- (2 pnt) Indicate the critical cycle in the HSDF graph.
- (3 pnt) Draw the self-timed schedule of this HSDF graph on gridded paper. What is the throughput of this schedule?

5. Given the following system in which task 2 and task 3 are scheduled by a TDMA scheduler with Period  $P$  and Budget  $P/2$  on a processor. The execution times of task 1, task 2 and task 3 are 1 time unit.



- (2 pnt) draw the corresponding HSDF graph with one actor per task to compute the FIFO buffer capacities.
- (2 pnt) derive the response times of the tasks given that  $P$  is 4 time units
- (2 pnt) derive the required minimum FIFO buffer capacity such that the throughput is maximized.
- (4 pnt) Draw the HSDF graph with a 2 actor per task model and derive the maximum throughput and buffer capacities for the case that  $P=4$ . What is the reason that the 2 actor model is more accurate than the 1 actor model?
- (2 pnt) derive the response times of the tasks given that  $P=2$  time units, derive the maximum throughput and the corresponding minimum required FIFO capacities.
- (3 pnt) Draw the HSDF graph with a 2 actor per task model and derive the maximum throughput and buffer capacities for the case that  $P=2$ . What is the reason that the 2 actor model is in this case less

accurate than the 1 actor model?

6) open (2 pnt)

Give 2 limitations of the use of simulation for the analysis of real-time systems.

7) open (2 pnt)

Which characteristics have data-driven real-time systems?

8) open (3 pnt)

What is an heuristic, what are the properties of heuristics, when should you apply heuristics, give an example of an heuristic applied for real-time scheduling.

9) open (2 pnt)

What is a reactive system, and give an example of a reactive real-time system.

10) open (2 pnt)

What fundamentally complicates the analysis of real-time systems. Give 2 examples of such complications.