

Date: 17-04-2020, 8.45-11.45

RTS1 examination

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) before 11.45 today.

1. Precedence graph

Given seven tasks, A,B,C,D,E, and F. The tasks have an arrive time of 1,3,3,4,4,5, respectively. These tasks have a worst-case computation time of 2,3,3,5,1, and 2, respectively. Furthermore, all tasks have a best-case execution time of 1 and a deadline $D=15$.

a) (2 pts) construct the precedence graph given the following precedence constraints:

$A \rightarrow C$, $B \rightarrow C$, $C \rightarrow E$, $D \rightarrow F$, $B \rightarrow D$, $C \rightarrow F$, $D \rightarrow E$

b) (5 pts) modify their arrival times and deadlines to schedule them by EDF.

task	arrival	deadline
A		
B		
C		
D		
E		
F		
G		

c) (3 pts) motivate whether this set of tasks satisfies its deadline.

2. Polling server

A Polling server with $C_S=2$, $T_S=5$ as capacity and period is used for scheduling of the following tasks

Periodic tasks

	C_i	T_i
τ_1	1	4
τ_2	2	6

Aperiodic tasks

	a_i	C_i
J_1	2	2
J_2	5	1
J_3	10	2

a) (2 pts) Determine whether this task set is feasible?

b) (5 pts) Verify your answer by constructing the schedule for the task set on paper.

c) (2 pts) Compute whether the task set is feasible according to LL (Liu & Layland) and HB (Bini)

d) (5 pts) Verify your answer by constructing the schedule for the task set on paper.

3. Static periodic scheduling

Periodic tasks

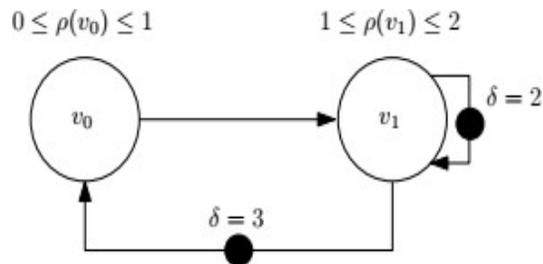
	C_i	T_i
τ_1	1	2
τ_2	3	8

a) (2 pts) Compute the feasibility according to LL (Liu & Layland) and HB (Bini)

b) (4 pts) Draw the schedule for this task set on gridded paper. Is this task set schedulable?

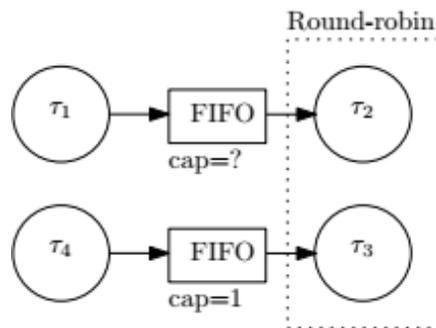
c) (4 pts) Verify the schedulability of this task set with another approach

4. Given the following HSDF graph:



- (2 pnt) Is this HSDF graph deadlock free and motivate why is this the case?
- (2 pnt) Derive the minimum and maximum throughput of this HSDF graph using the MCR equation?
- (3 pnt) Draw the worst-case self-timed schedule of this HSDF graph. What is the throughput of this schedule?

5. Given the following system in which task 2 and task 3 are scheduled by a round-robin scheduler on a processor. The worst-case execution times of task 1, task 2, task 3, task 4 are 0.5 time unit.



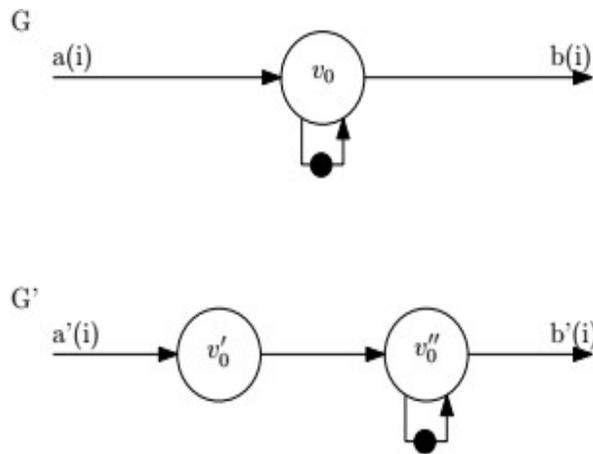
- (2 pnt) draw the corresponding HSDF graph to compute the required FIFO buffer capacity.
- (2 pnt) derive the required minimum FIFO buffer capacity such that the throughput is 1 token per unit of time.
- (3 pnt) derive the maximum guaranteed throughput that can be achieved for tasks 1 and the corresponding minimum FIFO buffer capacity.

6. (2 pnt) Why are most real-time systems **not** time-triggered?

7. (2 pt) Give an example of an NP-hard scheduling problem.

8. (3 pt) Give an example of a task set that is not schedulable despite that the processor utilization is only 50%.

9. Given a task with a WCET= T scheduled on a processor using a TDM scheduler with Period $P=T$ and budget $B=T/2$.



a) (1 pt) derive the firing duration for the case that the task is modeled with one actor as shown in graph G.

b) (1 pt) derive the firing durations for the case that the task is modeled with two actors per task as shown in G'

c) (4 pt) prove that G' refines G and explain why this should be the case?

10. (2 pt) What is non-determinism **and** why does the use of wait and signal calls for accessing a share resource introduce non-determinism whereas FIFO communication using acquire and release calls is deterministic?