Name:

Student number:

Date: Juni 26, 2020, 8:45-11.45

RTS2 examination

This exam consists of 13 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 that this exam is without supervision 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.

For multiple choice questions you need to make one and only one choice for the most probable assertion. In case there is only one assertion you have to make a binary choice, which is either true (T) or false (F). In order to avoid honoring by ad random guessing we honor good answers and punish bad ones: for n-choice: good = (n-1), wrong=-1, no answer=0. Put your choice in the little square.

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1. Given the HSDF graph in Figure 1.

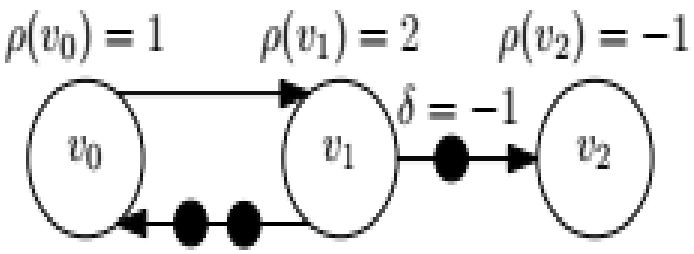


Figure 1: An HSDF graph

a) (2pnt) what is the MCR of the graph in Figure 1

b) (2 pnt) what is the condition under which the schedule of an HSDF graph is admissible?
c) (2 pnt) describe all admissible schedules of this HSDF graph with a set of inequalities.
d) (3 pnt) give an algorithm with a polynomial computational complexity that can be used to determine an admissible schedule for the HSDF graph in Figure 1
e) (3 pnt) draw the self-timed admissible schedule of this HSDF graph on gridded paper

2. Abstraction:

Consider the HSDF graph in Figure 2.1, that has 2 actors.

Figure 2.1: an HSDF graph.

a) (2 pts) under which condition is one HSDF graph an abstraction of another HSDF graph: in words + formalized?

b) (4 pts) derive the minimum value of rho such that the HSDF graph in Figure 2.2 is a valid abstraction of the HSDF graph in Figure 2.1.

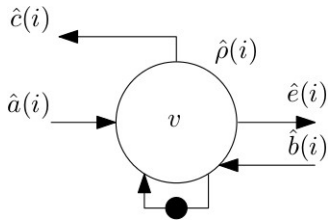


Figure 2.2: HSDF graph

c) (4 pts) give 2 practical examples when abstraction of HSDF graphs is useful.

3. Given the VRDF graph in Figure 3.

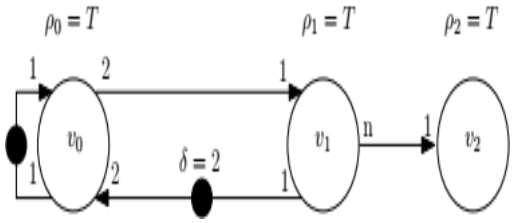


Figure 3: an VRDF graph

a) (3 pts) Derive the balance equations for the VRDF graph
b) (2 pts) Draw the corresponding HSDF graph
c) (2 pts) Indicate the critical cycle and derive the MCM
d) (2 pts) Derive the number of tokens δ needed to obtain the maximum achievable throughput

4 Given the HSDF graph in Figure 4.

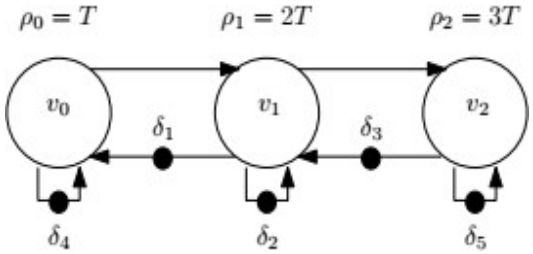
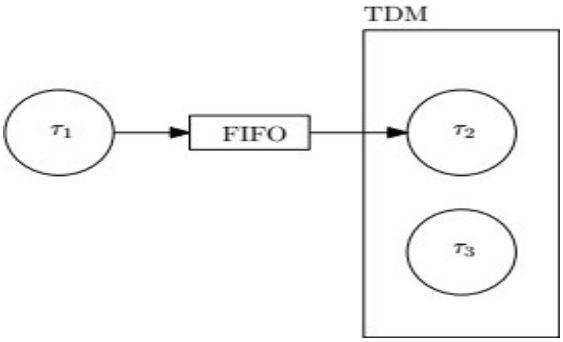


Figure 4: an HSDF graph

a) (3 pts) compute how many copies of each actor should run in parallel to achieve the maximum throughput
b) (2 pts) derived the number of initial tokens needed to obtain the maximum throughput
c) (2 pts) draw the self-timed schedule of the HSDF graph
d) (1 pts) does the number of initial tokens on the self-edge of each actor correspond with the required amount of data parallelism in the corresponding task graph to achieve the maximum throughput?

5. Given the following system in which task 2 and task 3 are scheduled by a time-division multiplex scheduler on a processor. The execution times of task 1, task 2 and task 3 are 0.5 time unit. The slice length B of each task is 1 time unit.



a) (2 pnt) given Θ=P-B and ρ=(P*x)/B, draw the corresponding HSDF graph with two actors per task, and derive the MCR of this HSDF graph

b) (2 pnt) derive the required minimum FIFO buffer capacity such that the throughput is 1 token per unit of time.

c) (2 pnt) are the results computed in c) exact or an over approximation and why is this the case?

6. (2 pnt) When is a model compositional AND motivate whether an SDF model is compositional?

7. Non-determinism

a) (2 pnt) Give two consequences of that Kahn process networks are Turing complete

8. Given the SDF graph in Figure 8.

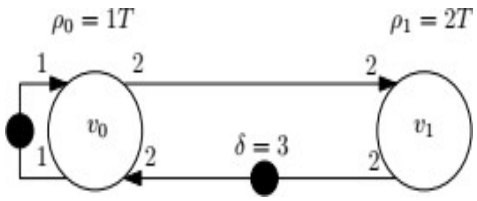


Figure 8: an SDF graph

a) (3 pts) Give the balance equations for the SDF graph
b) (2 pts) Derive the repetition vector using Gaussian elimination
c) (2 pts) Draw the corresponding HSDF graph
d) (2 pts) Indicate the critical cycle and derive the MCR
e) (2 pts) Does the topology of the corresponding HSDF graph depends on the number of initial tokens δ?
f) (2 pts) Derive the number of tokens δ needed to obtain the maximum achievable throughput

9. Give two fundamentally different ways to deal with Turing complete problems
(2 pnt)

10. (2 pnt) Give three conceptual reasons why the use of a more expressive analysis model than strictly needed is usually not preferred (2 pnt)

11. (3 pnt) Give 3 conceptually different constructs that will introduce functional non-determinism in a task graph? Give examples of cases for which functional non-determinism desirable and when is it undesirable?

12) The fixed point of a KPN is unique
True (T) or False (F)

12. ☐

13) A task graph modeled by dynamic dataflow (DDF) requires fully dynamic scheduling
True (T) or False (F)

13. ☐