



INSTITUTIONEN FÖR  
NATURVETENSKAP OCH TEKNIK

Kursens namn	Realtidsprogrammering - DT3031
Examinationsmomentets namn/provkod	0100
Datum	2015-08-25
Tid	Kl. 08:15 – 11:15

Tillåtna hjälpmedel	Miniräknare
Instruktion	Läs igenom alla frågor noga. Börja varje fråga på ett nytt svarsblad. Skriv bara på ena sidan av svarsbladet. Skriv tentamenskoden på varje svarsblad. Skriv läsligt!
Viktigt att tänka på	
Ansvarig/-a lärare (ev. telefonnummer)	Farhang Nemati Tel: 019-303264 Mobil: 0702533418
Totalt antal poäng	
Betyg (ev. ECTS)	Tentamen innehåller fem frågor. Totalt 40 poäng. 20 poäng krävs för betyg 3 (godkänd), 30 poäng för betyg 4 och 35 poäng för betyg 5
Tentamensresultat	Resultatet meddelas i Studentforum inom 15 arbetsdagar efter tentadagen.
Övrigt	

Lycka till!

## 1. (10 points)

Briefly answer the following questions (You may answer a question by an example if it makes sense):

- a) What do “Arrival Time” and “Finish Time” of task mean?
- b) When a task is preempted?
- c) What is a Mutex?
- d) What is Priority Inversion?
- e) What is the task of a scheduler in a Real-Time Operating System (RTOS)?
- f) What does it mean to say a set of real-time tasks are schedulable?
- g) Why Concurrency is used in real-time systems? You only need to mention 2 reasons.
- h) In a RTOS a task can be in different states. When is a task in WAITING state? When is it READY state?
- i) What is Synchronous and Asynchronous message passing?
- j) Mention two important timing facilities that a RTOS has to provide.

## 2. (12 points)

You are required to implement a real-time system which consist of 4 periodic tasks; task1, task2, task3, and task4. Every 5ms task1 performs puts a command into a queue. There are 2 types of commands, type 1 and type 2. task2 and task3 take the commands from the queue. If the command type is 1 the receiver (task2 or task3) writes a message on an output screen. If the command type is 2 the receiver sends the command to task4. When task4 receives a command (from task2 or task3) it performs some work and writes a message on the output screen. task2 and task3 run with periods 8 ms and 10 ms respectively. task4 runs with period 6ms. At any time only one task can write its results to the output screen (either task2, task3 or task4). The command queue can hold at most 10 commands.

- a) Implement the system using VxWorks. Show how the screen has to be protected from being used by more than one task at any time.
- b) Rewrite your program. This time use a Monitor. The monitor has to include writing on the output screen and protecting the screen from being written by more than one task at the same time. The monitor will only have one function that writes a message on the screen; *write(i)* which writes the message of task *i* on the screen.

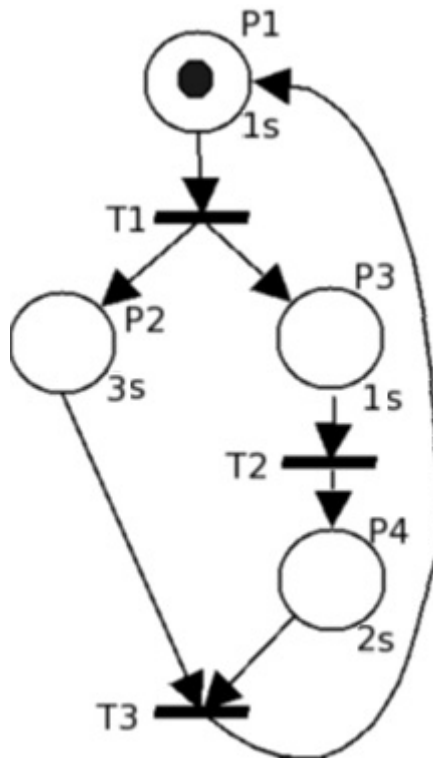
**Notice:** You can use the following function calls in your implementation:

```
void work(int i); // performs the work for task i
void writeOnScreen(int i); // writes the message of task i on the screen
int taskSpawn(char *name, int prio, 0, FUNCPTR function, int arg1, ...); // creates a task
sem = semCCreate(SEM_Q_FIFO, int initValue); // creates a semaphore
semTake(sem, WAIT_FOREVER); // takes a semaphore
semGive(sem); // gives a semaphore
q = msgQCreate(int maxQLen, int maxMsgLen, MSG_Q_FIFO); // creates a message queue
msgQSend(q, msg, int maxMsgLen, WAIT_FOREVER, MSG_PRI_NORMAL); // sends a message
msgQReceive(q, msg, int maxMsgLen, WAIT_FOREVER); // receives a message
msgType(msg); // returns 1 if the message has type 1 and returns 2 if the message has type 2
```

### 3. (6 points)

A system has been designed by the following P-timed Petri net.

- Draw the reachability graph of the P-timed Petri net
- Assuming the Petri net executes with maximum speed does the Petri net has a period (Is it repeated)? If yes what is the period of the Petri net?



#### **4. (6 points)**

- a) For a task model where tasks are periodic and preemptive and the tasks are independent, explain briefly how the following scheduling algorithms work.
  - i. Rate Monotonic Scheduling (RMS)
  - ii. Earliest Deadline First (EDF)
- b) Explain briefly:
  - i. What is a Resource Access Protocol for?
  - ii. How does Priority Inheritance Protocol (PIP) work?

## 5. (6 points)

The following independent preemptive periodic tasks are to be scheduled by Rate Monotonic Scheduling (RMS) algorithm. The deadline of each task is equal to its period.

- a) Calculate the response times for all three tasks.
- b) Is the task set schedulable by RMS?

	$e_i$ (execution time)	$p_i$ (period) = $d_i$ (deadline)
task1	1	3
task2	2	5
task3	3	13

**Notice:** The following equation is used for calculation of response times:

$$R_i = e_i + \sum_{\tau_j \in H_i} \left\lceil \frac{R_i}{p_j} \right\rceil e_j$$