Försättsblad till skriftlig tentamen vid Linköpings universitet

	(fylls i av ansvarig)
Datum för tentamen	2013-08-24
Sal	TER2
Tid	14-18
Kurskod	TDDD07
Provkod	TEN1
Kursnamn/benämning	Realtidssyem (Real-time Systems)
Institution	*IDA*
Antal uppgifter som ingår i tentamen	5
Antal sidor på tentamen (inkl. försättsbladet)	7
Jour/Kursansvarig	Massimiliano Raciti
Telefon under skrivtid	0762 388815
Besöker salen ca kl.	15.15
Kursadministratör (namn + tfnnr + mailadress)	Liselott Lundberg 073-270 24 30 liselotte.lundberg@liu.se
Tillåtna hjälpmedel	miniräknare
Övrigt (exempel när resultat kan ses på webben, betygsgränser, visning, övriga salar tentan går i m.m.)	
Vilken typ av papper ska användas, rutigt eller linjerat	Rutigt
Antal exemplar i påsen	

Tentamen vid Institutionen för Datavetenskap, Linköpings universitet

TENTAMEN TDDD07 Realtidssystem

DATUM: 24 August 2013
TID: 14-18
PLATS: TER2
ANSVARIG JOURLÄRARE: Massimiliano Raciti (0762 388815)

Material: English-Swedish-English dictionary
Calculator

No of assignments: 5

Total no. of points: 40

Preliminary grade limits for grades: 3, 4 and 5

3:	20 - 26 p
4:	27 - 33 p
5:	34 - 40 p

INSTRUCTIONS:
Please write your anonymous ID on each sheet of paper that you hand in. Further, pages should only contain answer to **one question per page** (answers to sub-questions can be on the same page). You are asked to only write on one side of each paper. Please **sort** all the sheets that you hand in, in the order of the question number.

Make sure that **all** answers are **motivated** and supported by **clear** explanations. Figures or charts can be used to provide a clearer explanation but should be accompanied by a **textual description**. Points will not be given to answers for which the reasoning cannot be followed or that cannot be read due to bad handwriting. Wrong answers/reasoning which is embedded in partially correct ones will lead to deduction of points. You may answer the questions in English (the course language) or Swedish.

Hints: Try to dispose of your time on each question in proportion of the assignment points. In any case where you are in doubt about the question, write down your interpretation and assumptions, and answer the question based on the interpretation. Make sure your answer is to the point and relevant for the question asked, by reading the question carefully.

Results are reported no later than September 10th 2013.

Good luck!

Simin Nadjm-Tehrani

Q1: Scheduling

A modern smart TV can be considered as an enhanced data acquisition, processing, and visualisation unit not only interacting with TV operator networks but also with external devices and sensors in a home.

a) Consider the four basic tasks of visualisation, user interaction (through the remote controller), data access/storage, and data processing that can be used to integrate a smart TV into a smart home environment. Assume that the user interaction is allowed to take place with a minimum interarrival time 50ms, the data access/storage task is run every 30 ms, which is also the rate at which the data processing task is run. Assume further that the visualisation task runs every 100ms, and that it takes a maximum computation time of 30 ms to complete the task. Given the following WCET for the three remaining tasks, access/storage: 5 ms, processing: 1 ms, and interaction: 10ms, create a cyclic schedule in which jitter for the visualisation task is not allowed. Provide your minor and major cycles.

(3 points)

b) Consider the addition of a new (independent) task to the existing set whereby the built-in camera is used to capture images from the room, to enable tracking the movements in the vicinity at regular intervals. Assume that the image capturing process has a worst case execution time of 8ms. In order to keep the code development for the image capturing task isolated, the code that runs for that process cannot be split into several tasks. How often can image capturing process be run so that the major and minor cycles in the existing cyclic schedule (constructed under part a) above) remain unchanged?

(1 point)

c) Let's now drop the independence assumption. Consider the memory of the smart TV as a resource shared between the data access/storage task and the image capturing tasks. If the task set were to be run using rate-monotonic scheduling, what information in addition to the parameters in part a and b above would you need to be able to analyse the schedulability of the task set? (Note: you are not asked to perform a schedulability analysis.)

(1 point)

d) When deciding on a scheduling approach for processes one can use static information about processes or dynamic information. Compare the two approaches with respect to testability of schedules, and extensibility of schedules (i.e. what is the effect of workload changes?). Give one example method for each scheduling approach.

(4 points)

e) Explain the notion of *starvation* in the context of real-time systems. How can one argue that immediate ceiling protocols combined with fixed priority scheduling can prevent starvation?

(3 points)

Q2: Dependability and predictability

a) The following headlines appeared in the news in the past week:

- "Failing electronic circuit caused a total stop at Arlanda airport for several hours"
- "Google suffered a brief and rare outage on Friday when all of its services became inaccessible for up to five minutes".

In both cases the commentators have speculated about a *single point of failure* which is a fault source that is alone capable of leading to a (total) service outage. Explain a fault tolerance strategy that helps to avoid a system outage due to one single fault.

(2 points)

b) Explain the distinction between "fault removal" and "fault tolerance" and use examples in the following contexts to make the distinctions clear:
   - dealing with faults that are foreseeable and those that are unforeseen
   - dealing with faults that appear in the system and those that appear in the external operating environment (not under the designer's control)
   - dealing with permanent and transient faults.

(5 points)

Q3: Real-time Communication

a) Give one service supported by a TTP bus that the CAN bus does not provide, and provide a concrete example application that needs that service.

(2 points)

b) A set of messages are intended to be sent over a CAN network. Assume that the transition time per bit is negligible, and jitter can be reduced to zero. Construct the argument for schedulability (or lack thereof) for the message set below.

Message	*Priority*	*Period*	*Max Tx. time*	*Deadline*
A	medium	8	2	10
B	high	12	3	15
C	low	20	4	20

(4 points)

Q4: Application design & RTOS

Take a stand on the following statements (true/false) and motivate your answer!

a) Creating an implementation by automatic generation of code from a design model avoids errors due to human factors.

b) Platform-independent design models make analysing outcomes of simulation runs unambiguous.

c) A system that interacts with a physical environment can only be tested in the real environment.

(6 points)

d) What are the different requirements on an operating system for an embedded system or an air-traffic control system respectively?

(2 points)

e) What is meant by *predictable synchronisation* in a real-time operating system context?

(2 points)

Q5: Distributed systems, Quality of Service (QoS)

a) In a networked real-time system jitter can be defined as the difference between the inter-departure times and inter-arrival times of the i^{th} and $(i+1)^{th}$ data unit in a given flow. Give an example application in which minimization of jitter is important. Motivate your answer!

(2 points)

b) What is the fault type that creates the worst case drift in clocks synchronised by the Lamport/Melliar-Smith internal clock synchronisation algorithm? If the algorithm assumes that there are n clocks and a maximum of t ($t < n$) clocks can be faulty, what is the constraint so that the system remains synchronised? Motivate your answer!

(3 points)

Notation for Processes

C = Worst-case execution time
B = Worst-case blocking time
D = Relative deadline
n = Number of processes
T = Period
R = Worst-case response time
J = Release jitter

Schedulability test for Rate Monotonic:

$$\sum_{i=1}^{n}\left(\frac{C_i}{T_i}\right) \leq n(2^{1/n} - 1)$$

Schedulability test Earliest Deadline First:

$$\sum_{i=1}^{n}\left(\frac{C_i}{T_i}\right) \leq 1$$

RMS Response time analysis

$$w_i = C_i + B_i + \sum_{\forall P_j \in hp(P_i)} \left\lceil \frac{w_i + J_j}{T_j} \right\rceil C_j$$

$$R_i = w_i + J_i$$

$hp(P_i)$ is the set of processes with a higher priority than process P_i.

Timing Analysis of CSMA/CR

B = blocking time
C = transmission time of entire frame
T = period
τ_{bit} = transmission time of one bit
w = response time for the first bit of a frame to be sent
R = total response time
J = Jitter
t = Longest busy interval
$lp(m)$ = set of frames with lower priority than m.
$hp(m)$ = set of frames with higher priority than m.
$hep(m)$ = set of frames with higher or equal priority than m.
n = number of bytes in message (data field)

$$R_m = \max_{q=0..Q_m-1}(R_m(q))$$

$$R_m(q) = J_m + w_m(q) - q \cdot T_m + C_m$$

$$w_m(q) = B_m + q \cdot C_m + \sum_{\forall j \in hp(m)} \left\lceil \frac{w_m(q) + J_j + \tau_{bit}}{T_j} \right\rceil \cdot C_j$$

(with $w_m^{\;0}(q) = B_m + C_m q$)

$$Q_m = \left\lceil \frac{t_m + J_m}{T_m} \right\rceil$$

$$t_m = B_m + \sum_{j \in hep(m)} \left\lceil \frac{t_m + J_j}{T_j} \right\rceil \cdot C_j \qquad \text{(with } t_m^{\;0} = C_m \text{)}$$

$$C_m = \left(8n + 47 + \left\lfloor \frac{34 + 8n - 1}{4} \right\rfloor \right) \tau_{bit}$$

$$B_m = \max_{j \in lp(m)}(C_j)$$