Tentamen vid Institutionen för Datavetenskap, Linköpings universitet

TENTAMEN TDDD07 Realtidssystem

DATUM: 18 August 2012
TID: 14-18
PLATS: TER3
ANSVARIG JOURLÄRARE: Simin Nadjm-Tehrani (0702 282412)

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 **all** your 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, so make sure your answers are to the point. You are requested to answer the questions in English (the course language) as the majority of correcting teachers are non-Swedish speaking.

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.

Results are reported no later than September 4th.

Good luck!

Simin Nadjm-Tehrani

Q1: Scheduling

a) An electrically driven bicycle has an embedded processor that hosts several computational processes. Consider three such processes with the following parameters: A servo process for running the wheels with a period of 50ms and a maximum computation time of 4ms, a biker display unit that shows the trip statistics with an update rate of 4 times a second, each time taking a maximum computation time of 20 ms, and a brake control process that runs every100 ms and each time has a maximum computation time 30ms. Assume that only the display process can tolerate jitter.

Create a cyclic schedule for the described task set and present the major and minor cycles.

(4 points)

b) Considering the task set in 1(a):
1) Running Rate Monotonic Scheduling (RMS), use a utilization based test to illustrate whether the task set is schedulable or not.
2) Assume a fourth task is added for adjusting the gear at different road conditions, and that it has to be run every 50ms. Assume further that Earliest deadline first will be used to schedule the four task set. What is the maximum execution time for the fourth task, so it allows the new task set to be schedulable?

(2 points)

c) Provide a proof to the claim that a fixed priority scheduling algorithm when combined with immediate ceiling protocol prevents deadlocks.

(3 points)

d) How is the choice of scheduling method affected if there are precedence requirements between tasks in a system? Is it easier to accommodate precedence in a cyclic schedule or a rate-monotonic schedule?

(2 points)

e) Take a stand about the following statement (true/false) and motivate your answer!
"With a single processor as the only shared resource, when rate monotonic scheduling is used, if the WCET estimate for the lowest priority task is wrong, then the only task whose response time is affected during run-time is the highest priority task."

(2 points)

Q2: Dependability and predictability

a) What attribute of dependability was violated in the following scenario? Motivate your answer!
"In October 2011, researcher Barnaby Jack demonstrated a remote, wireless attack on an implantable insulin pump from the firm Medtronic. The attack could have enabled a remote assailant to command the pump to release a fatal dose of insulin to a diabetic."

(2 points)

b) Using clear arguments identify a potential fault-error-failure chain of events in the following scenario.

August 2nd 2012, The Register: "An algorithmic trading software bug is being blamed for a day of wild swings at the New York Stock Exchange – and has resulted in the trader placing the dodgy orders reporting a $US440 million pre-tax loss."

(3 points)

Q3: Real-time Communication

The following table describes the set of messages present in a distributed application in which the CAN bus is used as a communication bus. Given the parameters of the message set, compute the maximum response time for delivery of messages A and B. You may assume that message release jitter is negligible.

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

(4 points)

Q4: Application design & RTOS

a) Support for system dependability and predictability can be provided by methods that operate at each of the four following levels: the hardware, the system software, the application software code, and the application design model. Describe four different methods for *prevention* or *removal* of faults in each of the named levels.

(4 points)

b) Provide one argument why testing the correctness of a real-time software system on the target platform has a disadvantage compared to analysing a platform-independent model.

(1 point)

c) What is meant by interrupt latency and interrupt dispatch latency when discussing the basic requirements on real-time operating systems.

(2 points)

d) Processes in a real-time operating system may communicate using a mail box. Is that a predictable method from a timing perspective? Why/Why not?

(2 points)

Q5: Distributed systems, Quality of Service (QoS)

a) Take a stand on the following propositions (true or false) and motivate your answer!

1) Weighted fair queue scheduling allocates bandwidth based on fixed priorities.
2) In the QoS categorization of applications, all elastic applications are adaptive.

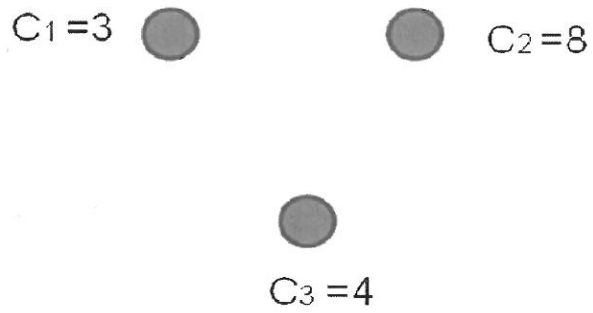
(2 points)

b) Describe the role of the two QoS enforcing mechanisms admission control and scheduling in networked applications, and explain the difference in their roles.

(4 points)

c) The figure below shows three clock values in the different nodes of a distributed system at the same point in real time. If the three nodes were to be synchronised with an internal clock synchronisation algorithm (e.g. Lamport and Mellier-Smith algorithm), what would be a suitable choice of δ (δ = maximum difference between the clocks at any point in time) to keep the current precision?

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

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

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

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

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