TENTAMEN TDDD07 Realtidssystem

DATUM: 17 December 2012
TID: 14-18
PLATS: TER3, TER4
ANSVARIG JOURLÄRARE: Simin Nadjm-Tehrani (013-282411, 0702 282412)
Massimiliano Raciti (013-282416, 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.

<u>Results are reported no later than January 9th 2013.</u>

Good luck!

Simin Nadjm-Tehrani

Q1: Scheduling

a) Consider an elevator system with three processes to be run on the same processor: A servo control process that is responsible for the directional movements of the elevator cabin up and down, a passenger communication interface that receives and processes the button pressing signals arriving from various floors and queues the requests, and a soft-stop process that detects that closeness to the floor to stop at, and brings the elevator to a halt. The three processes have different parameters as follows. The movement control process has a period of 60 ms and a worst case computation time of 2ms. The communication interface is a sporadic process has shortest inter-arrival interval 25ms and worst case execution time of 15ms. The halting process has a period of 20ms and a worst case computation time of 2ms.

Create a cyclic schedule for the described task set and present the major and minor cycles. Discuss the reasons why you chose the minor cycle that you did.

(3 points)

b) Consider using a Rate Monotonic Schedule (RMS) with the task set in part (a) and compute the worst case response time for the task with lowest priority.

(1 point)

c) Assume that a fourth task is to be added to the task set under a) in order to update the digital sign outside the elevator at each floor that shows the current cabin position(floor), and assume that the maximum computation time needed for this process is 5ms. Continuing with the rate-monotonic policy , use the utilization-based test for guaranteeing schedulability of task sets in order to compute an update interval for the signs. Is this the shortest possible interval? Why/why not?

(3 points)

d) Consider the set up described with the four tasks above (parts a and c), and assume now that the movement process and the digital sign update processes need to share a common data structure that has to be used mutually exclusively. Assume that the sign is updated once a second. Can priority inversion arise in this scenario? Motivate your answer.

(3 points)

e) Describe four of the assumptions under which the utilisation-based exact analysis for earlier deadline first scheduling algorithm is valid.

(2 points)

f) Explain the notion of optimality in scheduling algorithms discussed within the course, and take a stand about the following statement (true/false), motivating your answer: “Deadline monotonic scheduling is optimal with respect to scheduling algorithms with fixed priorities.”

(2 points)

Q2: Dependability and predictability

a) The development faults in a system can be introduced by the development environment: the physical world, the human developers, the development tools, and the production/test facilities. Give two examples of timing faults introduced at the development.

(2 points)

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

There was a report in Business, on 2nd August 2012, in which the company Knight Capital was blamed for large and unexpected swings on the New York stock exchange (NYSE).

"An algorithmic trading software bug is being blamed for a day of wild swings at the NYSE – and has resulted in the trader (Knight Capital) placing the dodgy orders that resulted in a $US440 million pre-tax loss for the company.

What's been called a "mini flash crash" by *Forbes* saw 150 NYSE-traded stocks, from General Electric down to minnows, subject to wild swings before things were brought under control. Knight Capital, the firm fingered for the glitch, responded by telling its customers to use other traders. With a huge chunk of its value wiped out by the glitch. *Forbes* now says the cost of the bug is roughly equivalent to Knight Capital's entire market capitalization.

The *Reuters* report suggests that timing may have been the problem: the orders may have been intended to be filled during the trading day, but instead were filed in the opening minutes of trading. "

(3 points)

c) Describe two distinct fault types such that the TTP bus supports their detection and the CAN bus does not support their detection. Motivate your answer!

(2 points)

Q3: Real-time Communication

a) M. Klurig is an engineer at HighTech AB and currently responsible for determining whether an event-driven or a time-driven bus should be adopted by the company in its new development project. Describe two factors that may affect the decision whether to use a CAN bus compared to a TTP bus.

(2 points)

b) Assume now that the company has decided to use a CAN bus to schedule the messages in the development project. When confronted with the list of messages that would have to be scheduled on the CAN bus (see table below, where "Tx time" stands for worst case transmission time of a message on the bus), M. Klurig could *immediately* announce that the message set is not schedulable on the bus. What is the underlying reason for this?

Message	Period	Tx time
m_1	10	3
m_2	20	4
m_3	50	15
m_4	40	10

(1 point)

Q4: Application design & RTOS

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

a) Finding/removing design faults in an early stage of development is not economically justified since a real-time embedded system has to be tested in its final implementation anyway.

b) Modularity helps to deal with complexity in a design model, but in models of real-time systems it is difficult to maintain module independence if modules refer to time.

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

(6 points)

d) Describe the main benefit of using a POSIX compliant operating system as opposed to a non-POSIX-compliant version? Give one example support that the POSIX 1003.1b standard provides for real-time programming.

(2 points)

e) Consider the following two functions in a real-time operating system: interrupt handling and task synchronisation. Describe two differences between these and the same functions in an ordinary operating systems (one difference for each function).

(2 points)

Q5: Distributed systems, Quality of Service (QoS)

a) How is jitter in a flow defined as a QoS parameter in a networked application? Give two example applications that would normally have jitter-related QoS specifications.

(3 points)

b) Vector clocks can be used to capture event ordering in systems with no synchronised clocks. Using an example with three distributed nodes illustrate how vector clocks can be used to identify concurrent events.

(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:

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

Schedulability test Earliest Deadline First:

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

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

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

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

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

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