

TENTAMEN TDDD07 Realtidssystem

DATUM: 27 April 2011

TID: 14-18

PLATS: KÅRA, T1, T2

ANSVARIG JOURLÄRARE: Examinator Simin Nadjm-Tehrani (Tel: 013-282411, 0702 282412), Massimiliano Raciti (013-282416).

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 your answers are 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 in Swedish or English as you prefer.

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. A correct answer that is embedded in errors may give reduction in points, so make sure your answers are to the point.

Results are reported no later than May 12th.

Good luck!

Simin Nadjm-Tehrani

Q1: Scheduling

In modern train systems many safety systems are implemented in software. For example, functions for maintaining a given speed and a system to avoid passing a red light signal. Also in order to stop the wheels from skidding there are regulators for each pair of wheels so that their speed is kept under control separately. Consider the set of three processes that implement the named functions:

- The cruise controller to keep a given a speed, running with a period of 10 ms and a maximal execution time of 3ms.
- The group of wheel-pair regulators all having a period of 5 ms and collectively take a maximum of 1ms to run.
- The monitoring of stop light signal and automatic braking will have a maximum running time of 1 ms.

a) How often should the monitoring process be scheduled if the processor utilisation is desired to be at most 70%?

(2 points)

b) Assume that a new process for controlling the power usage by the wheel motors is added. This process will need to run with a period of 30 ms and takes a maximum of 2ms to run. Assume further that the requirement of 70% utilisation is dropped, but the jitter for the cruise control process is to be minimised. Let the minimum inter-arrival time for activating the monitoring/stopping process be 5 ms. Construct a cyclic schedule for the four processes, including its major/minor cycles.

(4 points)

c) The following three processes share two resources R and S with the given worst case locking times:

Process	Shared Resource	Worst case locking for shared resource	Priority (highest is 4)
P1	R	0.5 ms	2
P2	R	1.0 ms	3
P2	S	2.0ms	3
P3	S	1.0ms	1
P4	-	-	4

Assume that the processes are to be analysed for their response time according to rate monotonic scheduling and using the immediate ceiling protocol. Find the blocking term for each process.

(4 points)

d) Take a stand on the following statement (true/false) and motivate your answer!
 “If a task set includes a task that is neither periodic nor sporadic, then the task set cannot be analysed for schedulability in the rate-monotonic context .”

(3 points)

Q2: Dependability and predictability

a) Explain the notion of dependability, and provide one example attribute for a system that is supposed to be dependable.

(2 points)

- b) Identify the causal chain of fault-error-failure in the following scenario.

The University College London Hospitals Trust (a consortium of hospitals in London) was on 22nd February 2011 forced to halt a number of services, including the cancellation of 50 per cent of its operations, due to a faulty network switch. The faulty switch left computers across the connected London hospitals unable to access various systems such as the trust's patient administration system and its patient records software CareCast.

(3 points)

- c) Many real-time applications are built on top of small proprietary kernels that are adaptations of well-known time sharing operating systems, e.g. through adding preemptive priority-based scheduling. Describe three other adaptations needed in a real-time kernel that makes the kernel operations predictable in a real-time setting.

(3 points)

Q3: Design

- a) Consider a collision avoidance component in a flight control system. Decide which of the following properties is a functional property and which is an extra-functional property (also sometime called a non-functional property):

- 1) When another aircraft is within X meters of own aircraft on the same altitude, the marking on both pilot display screens should change colour within Y milliseconds.
- 2) For two aircrafts on the same altitude if own aircraft is instructed to rise, the other aircraft has agreed to descend (go down).
- 3) If the altitude measurement delivered by the altitude-metering system is inaccurate then the collision avoidance system should switch to an alternative source for altitude value.

(3 points)

- b) Name two types of languages that can be used to describe a system at a higher level of abstraction than the platform-dependent programming language. For each language describe one benefit that the language brings to the system development process.

(4 points)

Q4: Real-Time Communication

a) The following 3 messages are being sent on a CAN bus that has 0 as a dominant bit:

Message	ID
m1	10011111000
m2	00000000001
m3	10100000111

Assign priority high/medium/low to each message on the bus. Motivate your answer!
(2 points)

b) The timely operation of the TTP bus is dependent on two functions implemented in the Communication Network Interface (CNI):

- At the CNIs within the nodes, the relevant state variables are periodically updated by the real-time communication system to establish temporally accurate real-time images.
- After each computation at the node, the outputs of the host are stored in the CNI and transported by the TT communication system to the CNIs of other nodes at *a priori*-determined instants.

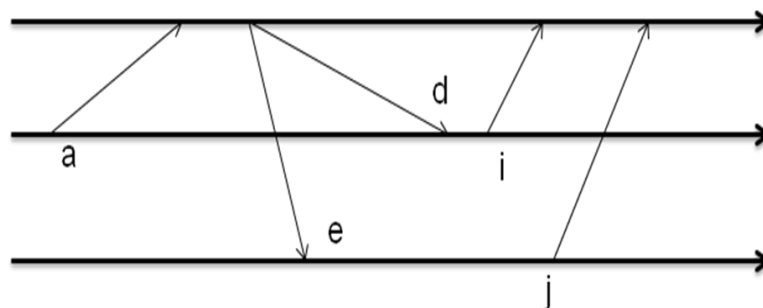
How does the CNI know which data has to be transported and at which time?
(2 points)

Q5: Distributed systems, QoS

a) Consider the following two terms used in quality of service (QoS) requirements descriptions, and identify for each term whether it is an application level description or an enforcement level indication: loss ratio, video quality.
(2 points)

b) Illustrate why one cannot detect that n clocks being synchronized with an internal synchronization algorithm (e.g. Lamport & Melliar-Smith algorithm) are out of synch if t of the clocks ($3t \geq n$) are two-face clocks.
(3 points)

c) Consider the following occurrence of events in three concurrent processes, where the horizontal arrows denote the local timelines of the three processes respectively. Give three pairs of concurrent events recognisable using vector clocks.
(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 messages with lower priority than m .

$hp(m)$ = set of messages with higher priority than m .

$hep(m)$ = set of messages with higher or equal priority than m .

n = number of bytes in message (data field)

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

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

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

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

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

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

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

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