TENTAMEN TDDD07 Realtidssystem

DATUM: 18 April 2017
TID: 14-18
PLATS: KÅRA
ANSVARIG JOURLÄRARE: Simin Nadjm-Tehrani (0702 282412)

Material: English-Swedish-English dictionary
Calculator

No of assignments: 6

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. 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 question numbers.

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.

Hints: Read the question carefully to find the focus of the question. Make sure your answer is to the point and relevant for the question asked. Take the opportunity of asking questions about unclear issues during the exam session. Otherwise, whenever in doubt about the question, write down your interpretation and assumptions, and answer the question based on that interpretation. Try to dispose of your time on each question in proportion of the assignment points.

Results are reported no later than 5th May 2017.

Good luck!

Simin Nadjm-Tehrani

Q1: Scheduling

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.

Assume that the three processes have the following periods and worst case execution times (WCET) respectively:

	Period (ms)	WCET (ms)
Servo control	15	3
Passenger communication interface	10	2
Soft stop	30	12

a) Assume that there are no constraints on minimizing the utilization of the CPU. Construct a cyclic schedule for the three processes and provide the minor and major cycles. Describe all your additional assumptions and how they affect the scheduling problem.

(4 points)

b) Use the relevant utilization based test for rate-monotonic scheduling and present the outcome, i.e. can the test provide an answer to whether the process set in part a) above is schedulable or not?

(2 points)

c) Consider now that a fourth process is added to update the display inside the elevator. The display process shares data structures with the passenger communication interface, mapped on to memory storing the data about which floor has been chosen and which floor is the next stop. Assume that the fourth process is run every 20ms, and that the access time to memory for each of the processes takes max 1ms. Given that the rate-monotonic scheduling is going to be combined with immediate ceiling protocol, compute the maximum blocking time for all four processes - processes in part a) above and the display process. Motivate your answer!

(4 points)

d) Next assume the operating system operations (scheduling, queuing, dequeuing, context switch) are expected to have a maximum utilisation of 5%. What should be the WCET of the display process so that the process set passes the schedulability test when the utilization-based test for earlier-deadline-first scheduling is applied?

(2 points)

e) Present a proof that using immediate ceiling protocol with a fixed priority scheduling algorithms entails that a process is blocked max once.

(3 points)

f) Describe how industry/business applications benefit from the scheduling knowledge that you obtained during this course by exemplifying 3 such applications, where at least one application considers a resource other than CPU-utilisation. Relate each application to a specific part of the knowledge acquired.

(3 points)

Q2: Dependability and predictability

Use the terminology of IFIP Working Group 10.4 (from the course literature) to answer the following questions.

a) After months of reviewing information, the US Federal Drugs Administration (FDA) confirmed there are "vulnerabilities" that if exploited could allow an unauthorized user to "remotely access a patient's RF-enabled implanted cardiac device by altering the Merlin@home Transmitter."

The FDA said there has been no reports of patient harm related to the cybersecurity vulnerabilities but that if hacked, the "transmitter could be used to modify programming commands to the implanted device, which could result in rapid battery depletion and/or administration of inappropriate shocks."

Relate the notion of vulnerability to the notion of fault. Use the above example to clarify why the term fault is not used in the above scenario.

(4 points)

b) When a service fails by affecting both information and timing, there are two such categories of failure: halting and erratic failures. Present an example for each type.

(2 points)

Q3: Real-time Communication

a) We have studied two alternative approaches to communication (TTP or CAN). Both can be used to guarantee that a set of generated messages are delivered within their deadlines. Explain the differences between the approaches in terms of supporting detection of faults in the following scenario: One of the communication controller units among the N nodes on the bus is affected by a Byzantine fault so that instead of sending one value to the other N-1 nodes it sends different values. Explain the difference between the two bus types in treating this scenario.

(2 points)

b) The following set of messages are to be scheduled on a CAN bus with the given message transmission times (Tx). Determine whether message m_3 meets its timeliness constraints, stating any assumptions that you need to make.

Message	Priority	Period (ms)	Tx time (ms)
m_1	Very High	50	4
m_2	High	15	2
m_3	Medium	30	1
m_4	Low	10	2

(3 points)

Q4: Application design & RTOS

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

(1) Security in industrial control systems running critical infrastructures is more important than the real-time properties.

(2) If a system developer does not consider fault models for a system, the evidence for dependability is not possible to provide.

(3) OSEK is a time-triggered operating system widely deployed in one industrial sector.

(4) MARTE is a language for documenting a chosen platform at design stage.

(4 points)

b) How is the application developer expected to estimate the scheduler's overhead in a real-time OS so that utilization-based approaches to analyzing schedulability can be applied with a margin for the overhead?

(2 points)

Q5: Distributed systems, Quality of Service (QoS)

a) List three metrics for measuring Quality of Service (QoS) in Internet-based applications and provide three techniques for QoS enforcement such that each method uses one of the listed metrics for evaluation.

(3 points)

b) In order to manage the VM loads and adapt to the dynamic changes in arriving tasks the Xiao et al. 2013 paper proposes two methods for predicting the future load on physical machines. Present one of the prediction approaches

(2 points)

Q6: Bonus points

a) In this question you state if you have any bonus points allocated to your attempts at bonus exercises 1, 2, and 3 during the course. Please sum up all three (if any) of your attempted exercises and write the total attained points here.

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

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

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

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

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