BITS, PILANI-DUBAI CAMPUS
KNOWLEDGE VILLAGE, DUBAI
I - SEMESTER 2006-2007

No. of Pages 2
No. of Questions 6

Course Number	:	**CS UC 444**
Course Title	:	**Real-Time Systems (Elective for IV Year CS)**
Nature of Component	:	**OPEN BOOK**
Date	:	14.12.2006 (Thursday)
Weightage	:	20%
Duration	:	50 min

Note: *1. Answer all questions. All parts of the question should be answered consecutively. Each answer should start from a fresh page.*
2. Please follow all the instructions to candidates given on the cover page of the answer book.
*3. **Text Books, Reference Books and Lecture notes are allowed.***

1. Calculate the frame size for the given task set, show the calculation of the frame size done based on the three frame size constraints. Also calculate the Hyper period for given set of tasks. The parameters of the tasks are as follows: (2 Marks)
   A= (1, 10, 10), B= (3, 10, 10), C= (2, 20, 20), and D= (8, 20, 20)
2. Construct a efficient DFD for a Billing Application, similar to one at a supermarket check-out stand, for each customer transaction, a running itemized bill is computed and the parameters for the billing applications are as follows: the input *Transaction_Control* provides the control data for the start and end of each transaction, denoted by *start_trans* and *end_trans,* respectively. At the end, the itemized bill, named bill, is read from Bill and then ouput by the print_Bill function. The *Compute_Cost* function computes the total cost of an item and sends the result to *Update_Bill* which then updates the *Bill* data. (4 Marks)
3. Construct a finite state machine for the problem definition given below:
   $M' = (Q = \{p,q,r,s,t\}, \Sigma = \{a,b\}, q0 = \{p\}, F = \{p,q,s,t\}, \delta)$ where δ is
   $\delta(p,a) = q \quad \delta(p,b) = r$
   $\delta(q,a) = s \quad \delta(q,b) = t$
   $\delta(r,a) = s \quad \delta(r,b) = p$
   $\delta(s,a) = s \quad \delta(s,b) = r$
   $\delta(t,a) = q \quad \delta(t,b) = t$
   (3 Marks)
4. Design a State Chart for the Ringing and lighting the watch alarm application described below: consider a simple digital watch with time, date, hourly chime, and alarm clock functions, and 4 buttons, ***a, b, c, & d,*** for user control. The watch alarm has two super states, one is Clock and the another is Light, the clock super state consist of two sub-super states as *Main* and Ring_alarm. The Main sub-superstate consist of three sub-states as

Normal_display, Chime_alarm_Set and Update states, The transition between Main and the ring_alarm states takes place when the triggering event (Alarm_On) of alarm ring Alarm_On $\rightarrow ct = t_{alarm}$ occurs when the condition $ct = t_{alarm}$ becomes true. The notation ***ct*** denotes current time and t_{alarm} is the time to which the alarm clock is set. Pressing any button (the ***any_button***) will cause the alarm to stop ringing; otherwise, the ringing will continue and stop after 30 seconds, denoted by *timeout* transition and go back to *Main* state. In either case, the *Main* sub-superstate is reentered at the same point where it was interrupted by the alarm (*H* entry); that is, at the default entry of one of the three states of *Main.* In the *Main* sub-superstate the transition are given as below: the start state is of *Normal_Display* state, transition takes from *Normal_Display* state to *Chime_Alarm_Set* when the ***b*** button is pressed, and to *Update* state when the *c* button is pressed. The Digital watch can come back to *Normal_Display* state from *Chime_Alarm_Set* when the *d* button is pressed and also from *Update* state when the *d* button is pressed, and also when ***a*** button is pressed the transition takes place from *Update* state to *Normal_Display* state. Show the concurrency and event broadcasting between the two super states of the statechart. The Light super state, which specifies that the light can be turned on or off with the *d* button and *d'* is the event associated with letting go of the button. The depress button event *d* is broadcast to both the Light and the clock super states. This the principal way that the machines interact and communicate directly. (6 Marks)

5. What do you mean by minor cycle and major cycle time in case of a cyclic executive program? (2 Marks)

6. Give Petri Net's design for a Model communication protocol between TWO processes. The design should consider the parameters like send message, send acknowledge, wait acknowledge, receive acknowledge, buffer between the two process in order to avoid loss of information during communication, process1 and process2 and justify your design in order to implement it in the real world of application. (3 Marks)

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BITS, PILANI-DUBAI CAMPUS
KNOWLEDGE VILLAGE, DUBAI
I - SEMESTER 2006-2007

No. of Pages : 2
No. of Questions : 6

Course Number	:	**CS UC 444**
Course Title	:	**Real-Time Systems (Elective for IV Year CS)**
Nature of Component	:	**OPEN BOOK**
Date	:	**Makeup**
Weightage	:	20%
Duration	:	50 min

Note: *1. Answer all questions. All parts of the question should be answered consecutively. Each answer should start from a fresh page.*
2. Please follow all the instructions to candidates given on the cover page of the answer book.
*3. **Text Books, Reference Books and Lecture notes are allowed.***

1. A system contains the following periodic tasks: T1 = (5,1), T2 = (7, 1, 9), T3 = (10,3) and T4 = (35, 7).
   a) If the frame size constraint (5.1) is ignored, what are the possible frame sizes?
   b) Give the cyclic static schedule for the given set of tasks using the frame sizes from part (a). (4 Marks)
2. If H denotes the hyperperiod of the periodic tasks, give the formula to calculate the maximum number of jobs in each hyperperiod. (2 Marks)
3. Give the state chart for the Traffic Light Controller system and the state chart should have at least two superstates, one for normal processing (N) and another for ambulance processing (A). (4 Marks)
4. Show the Moore Finite State Automata for a system that scans for the bit sequence 01111110 in a string of bits (the sequence is allowed to appear anywhere in a bit string). This bit sequence is standardly used to denote packets boundaries in serial communications. (3 Marks)
5. Give Petri Net's design for a Model communication protocol between TWO processes. The design should consider the parameters like send message, send acknowledge, wait acknowledge, receive acknowledge, buffer between the two process in order to avoid loss of information during

communication, process 1 and process 2 and justify your design in order to implement it in the real world of application. (4Marks)

6. For the formal definition of machine M given below construct the non-deterministic finite state machine.

   State = {Start, Deposited, Removed, Violated}, input I = {D, R}, initial state = Start, F= {Deposited, Removed}, and the transition equation is :

   f (Start, D) = Deposited, f(Start, R) = Violated, f(Deposited, D) = Deposited,

   f(Deposited, R) = Removed, f(Removed, D) = Deposited, f(Removed, R) = Violated,

   f(Violated, x) = Violated for x in I. (3 Marks)

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BITS, Pilani – Dubai Campus
Knowledge Village, Dubai
First Semester 2006 – 07

Nos. of Questions:	**11**
Nos. of Pages :	**4**

Course Number & Title	:	**CS UC444 – Real-Time Systems (IV Year CS Elective)**
Component Name	**:**	**Comprehensive Examination (Closed Book)**
Weightage	:	40 %
Duration	:	3 hours
Date & Day	:	27-12-2006, Wednesday
Max. Marks	:	40 Marks

Note:-1. Answer all questions.
2. Answer all questions sequentially; questions answered out of sequence will **not be evaluated.**
3. Read the instructions from the cover page of the main answer book.

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1. Briefly mention the tasks faced by the real-time designer while designing and implementing the real-time systems? (3 marks)
2. Which of the following computer systems are real-time systems? Justify your answer in terms of the characteristics described in the text book. (2 ½ Marks)
   a) An automatic teller machine that dispenses cash to credit card and bank customers.
   b) An elevator system that responds to patron request inside and outside an elevator, controlling the elevator and door operations.
   c) A payroll system that produces employee paychecks every two weeks.
   d) A sports system that register, maintains, and displays scores during sporting events, such as baseball games or track and field.
   e) A system that monitors and controls the environment (heat, lighting, air quality, security, etc.) of a large building.
3. Give a partial design for the Air Traffic Control software, considering the following events are the major functions of the ATC processing. Identify the periodic and sporadic processes in the proposed design based on the major functions defined. The major function s of each process are: (4 ½ Marks)

Tracker	:	Maintains the Track file, controls radar output, and processes radar hits.
Background search	:	Searches airspace for unknown objects
Command Processor	:	Receives and interprets operator input, and directs it to the appropriate internal process.
Display Manager	:	Displays airspace contents, the response to operator commands, and any other output of interest to the operator.
Radar Input and Output	:	Controls and handles message IO for the communications subsystem.

4. State whether the statement follows is correct or wrong, "The major cycle time is the minimum time required to execute through a major schedule and a major schedule is divided into a sequence of minor cycles". Justify your answer if the answer is neither correct nor wrong. (2 Marks)

5. Suppose there are three processes, specified by the triples (1, 14, 14), (2, 20, 20), and (3,22,22). Find the Major Cycle Time and Minor Cycle Time if it schedule on a static cyclic schedule. (2 Marks)

6. Consider a selective herbicide spraying problem in precision production. Vehicle is needed to detect weed conditions in the field and then spray herbicide based on the weed conditions. In this system, images of the field are obtained periodically by a camera mounted on the vehicle, and the images are processed to decide the weed density, then a command is sent to the sprayer. Weed detection and command transfer can be treated as real-time task. In weed area, the vehicle has to go slowly because the calculation detecting weed conditions take longer time. Thus, the weed distribution introduces load uncertainty in the system, and each task is associated a deadline. The total time taken to finish spraying of the whole field has to be minimized. Cast this problem as a feedback control real-time system problem by identifying the relevant parameters. (5 Marks)

7. Consider 3 periodic tasks, in the increasing order of priority, T1, T2, and T3 and let there be two resources S1 and S2. Let the resource access pattern of the tasks be as follows:
   - T_1 : *Lock*(S_2), *Lock*(S_1), *Unlock*(S_1), *Unlock*(S_2)
   - T_2 : *Lock*(S_1), *Unlock*(S_1)
   - T_3 : *Lock*(S_2), *Unlock*(S_2)

   Consider the following execution scenario that leads to priority inversion.
   a) T1 starts execution
   b) T1 locks S2
   c) T2 becomes active and preempts T1 due to higher priority
   d) T2 locks S1
   e) T3 becomes active and preempts T2 due to higher priority
   f) T3 attempts to lock S2 but get blocked
   g) T2 resumes execution and completes
   h) T1 locks S1 and completes execution
   i) T3 obtains the lock and completes

   It is to be noted that T3 finished here after T1 and T2 (priority inversion). (4 Marks)

   The Question:- Show the execution scenario for this example using Priority ceiling protocol.

8. For the following robotic application, identify the precedence relation among tasks (i.e., show the precedence graph). (3 Marks)

Robotic Application: A number of objects moving on a conveyor belt must be recognized and classified using a stereo vision system, consisting of two cameras mounted in a suitable location (above the conveyor belt). Suppose that the recognition process is carried out by integrating the two-dimensional features of the top view of the objects with the height information extracted by the pixel disparity on the two images. As a consequence, the computational activities of the application can be organized by defining the following tasks:

a) Two tasks (one for each camera) dedicated to image acquisition, whose objective is to transfer the image from the camera to the processor memory (they are identified by *acq1* and *acq2);*

b) Two tasks (one for each camera) dedicated to low-level image processing (typical operations performed at this level include digital filtering for noise reduction and edge detection; we identify these tasks as *edge1* and *edge2*);

c) A task for computing the pixel disparities from the two images (it is referred as *disp*);

d) A task for extracting two-dimensional features from the object contours (it is referred as *shape*);

e) A task for determining the object height from the results achieved by the *disp* task (it is referred as H;

f) A task performing the final recognition (this task integrates the geometrical features of the object contour with the height information and tries to match these data with those stored in the data base; it is referred as *rec*).

9. The problem is to design a defense system that is capable of simultaneously handling up to 10000 "tracks" of possible "threats" (targets), up to 1000 know threats (tracks that have previously been identified as targets), and up to 100 engagements where an engagement means that a defensive weapon system is being employed against a known target. Tracks may include many things other than threats, like civilian aircraft in the area, friendly aircraft, decoys, birds, etc., as well as real threats. When a track is classified as a target, it then has to be "monitored" once a second each time the radar "illuminates" the target. All targets get illuminated approximately once a second, but since the targets are moving with respect to the radar the time interval between successive illuminations may not be constant and therefore need not be strictly periodic for an individual target. During this monitoring of the track, additional tests are run to determine the lethality of the target which influences the significance of the target. Finally, once a target is identified, it must be engaged within 2 seconds provided there is a weapon system available to engage it, with priority being given to engaging the most important threats first. For targets that are currently engaged, guidance update information has to be relayed to the defensive weapon every second while it is homing in on the target. Answer the following:

a) Identify all the possible tasks in the systems. Indicate the nature of the tasks: periodic / aperiodic, hard / firm / soft deadline. Also identify the resource requirements and the precedence relationship among the tasks.
b) Which or which combination of scheduling paradigm(s) is suitable for this problem. Justify your answer.
c) What is the most suitable computing system (uniprocessor, multiprocessor, distributed system) for the problem. Justify your answer. (5 Marks)

10. Consider three dependent tasks T_1, T_2, and T_3. The tasks T_1 and T_3 have access to a shared resource R. in order to describe this task set with the critical sections of task T_1 and T_3, we add new parameters that specify the computation time c_i as follows:
c^x_i: task duration before entering the critical section,
c^y_i: critical section duration,
c^z_i: task duration after the critical section.

Of course, we have $c_i = c^x_i + c^y_i + c^y_i$. So the task set is described by the parameters given in the following table. As we know, each task in a critical section can be preempted by a higher priority task which dooes not need this resource.

Task (Ti)	c_i	p_i	c^x_i	c^y_i	c^z_i
T_1	4	12	2	2	0
T_2	4	16	4	0	0
T_3	8	24	0	8	0

Answer the following:
a) Construct the schedule (up to 32 time units) obtained under the RMS algorithm. Indicate the times at which direct blocking and priority inversion occur.
b) In order to prevent this priority inversion, apply priority inheritance protocol. Construct the schedule obtained using RMS algorithm (up to 32 time units) with priority inheritance protocol enabled. Indicate the times at which direct blocking and inheritance blocking occur. (4 Marks)

11. Design a Finite State Machine for the following problem definition: Consider the behavior and associated events of a gate at a train crossing. Suppose that there is a road crossing railway track, and a gate that opens and closes over the road. When a train approaches the crossing, the gate should close. More than one train can be crossing area at once, for example, a convoy of trains, each with a single engine and no cars. When the last train has left and the area is empty of trains, the gate should open. The gate could be in one of four states: **open, closed, opening,** and **closing**. The relevant events are: **cg** and **og** which are commands to close and open the gate, respectively; and **o-o** and **c-c** indicating from sensor input that the gate has completed opening (and thus changed from the opening to the opened state), and that the gate has completed closing, respectively. The initial state is closed and there are no stop states. The Finite state machine accepts the **cg** and **og** commands in all its states; thus, for example, the gate may be commanded to close while it is opening. (5 marks)

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BITS Pilani - Dubai Campus

Knowledge Village, Dubai.

First Semester 2006-07

IV – Year Computer Science

No. of Questions: 8
No. of Pages : 2

Course	:	**Real-Time Systems – CS UC444 (Elective)**
Component	:	**Test – I**
Nature of Component	:	Closed Book
Date & Day	:	**29.10.2006**, Sunday
Duration	:	50 mins
Weightage	:	20 % Max. Marks : (20 Marks)

Note: 1. Answer all questions.
2. Start answering each question in a fresh page.
3. Please read the instruction given in the front page of the main answer book.

1. State whether the following statement is true or false. (½ Mark each)
   a) We can say that jobs have no release time if all the jobs are released when the system begins execution.
   b) The definition of hard and soft real-time constraints is based on the functionality critically of jobs, usefulness of late results, and deterministic or probabilistic nature of the constraints.
   c) Many embedded systems are soft real-time systems. The deadlines of jobs in an embedded system are typically derived from the required responsiveness of the sensors and actuators monitored and controlled by it. Example, braking actions of a train.
   d) Real-Time systems do not have to be "fast systems."
   e) Macroinstruction or macrocodes are the lowest-level instructions available to the programmer and these instructions differ depending on the computer architecture. But microinstructions needed for constructing micro programs are not generally known to the programmer.
   f) Co-processors improve real-time performance because they extend the instruction set to support faster, specialized instructions.
2. Describe the relationship between the main processor and coprocessor in a system with which you are familiar. If you are not familiar with any, use the Intel 8086 microprocessor and its associated coprocessor, the 8087. (2 Marks)
3. Why does memory technology switched over to semiconductor technology from ferrite core technology? Mentioned the merits / demerits if exist in both the technology.(2 Marks)
4. Write a program that performs the calculation (2 Marks)

$$z = \frac{x^2 - x*y + y^2}{x^2 + y^2}$$

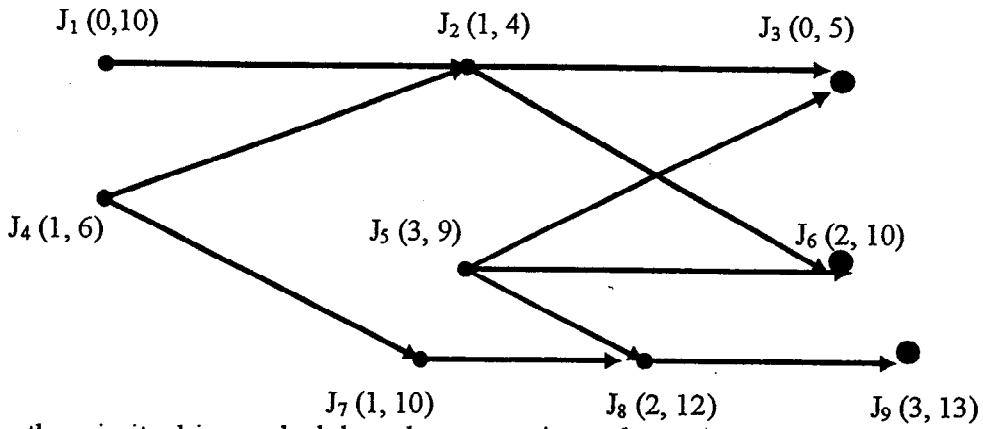
where x, y, and z are symbolic locations. x and y are real numbers. Do this using the generic assembly language for a

a) 0 - address machine.

5. Why is DMA controller access to main memory in most systems given higher priority than CPU access to main memory? (2 Marks)

6. Schedule the given set of jobs using LRT algorithm and the precedence graph with set of jobs are given below, check the scheduling using LRT algorithm meets the actual deadlines of given set of jobs. (2 Marks)

7. The feasible interval of each job in the precedence graph in the figure given below is given next to its name. The execution times of all are equal to 1.
   a) Find the effective release times and deadlines of the jobs in the precedence graph.
   b) Find an EDF schedule of the jobs. (5 Marks)



8. Give the priority driven schedule under preemptive and non-preemptive approaches for the below problem description. Show the schedule of the jobs on the two processors if all jobs are released at time 0, except J_5, it is released at time 4. J_3 execution time is 3 and it does not have any successor. J_2 execution time is 1 and it has the successors as J_3 with execution time of 2 and its successor is J_4, J_4 with execution time of 2 and J_6 with execution time 4. J_6 is also a successor of J_5, where J_5 execution time is 2 and its also has an another successor J_8 with execution time 1, J_8 is also a successor of J_7, its execution time is 4. J_7 also has another successor J_6. (2 Marks)

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