THE UNIVERSITY OF THE WEST INDIES

EXAMINATIONS OF DECEMBER 2006

Code and Name of Course: **ECNG 3006 Microprocessor Systems Design and Applications** Paper:

Date and Time: Duration: **Three Hours**

INSTRUCTIONS TO CANDIDATES: This paper has 3 pages and 4 questions

Answer ALL questions.
Q1 is worth 12 marks.
Q2 is worth 13 marks.
Q4 is worth 11 marks.
Q4 is worth 14 marks.

Q1. (a) The FreeRTOS real-time kernel allows the use of two types of scheduling algorithms: preemptive and cooperative. Its features include semaphores and message queues.

i. Contrast the two types of scheduling algorithms that can be used in FreeRTOS. *2 marks*

ii. Give an example each of the use of semaphores and message queues. *2 marks*

(b) The functions, xQueueSendFromISR and xSemaphoreGiveFromISR, return a value, which is either pdTRUE or pdFALSE.

i. When this value is pdTRUE, what does it signify? *1 mark*

ii. Create code to illustrate the use of the returned value from xSemaphoreGiveFromISR. Assume that there is a task waiting on the release of the semaphore **xSemaphoreEvent**. *5 marks*

(c) Code, created to service an external event, releases an aperiodic task. The task is currently on the message queue receive task-waiting list. When the event occurs, a message is posted on the empty message queue. What will happen after a message is posted on the message queue? *2 marks*

Q2. (a) Real-time systems can be classified according to their timing attributes as purely cyclic, mostly cyclic, asynchronous and somewhat predictable, and asynchronous and unpredictable. Describe **TWO** of these classifications. *2 marks*

(b) With respect to the periodic task model, give the meaning of the following terms:

i. Release time, r_i of a job

ii. Absolute deadline, d_i of a job

iii. Relative deadline, D_i of a job

iv. Execution time, e_i of a job

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INSTRUCTIONS: Each page of this draft must be signed by the UNIVERSITY EXAMINER. Completed forms should be handed to the Senior Assistant Registrar (Examinations). The EXTERNAL EXAMINER is requested to sign the draft paper and return it with comments, if any, to the Senior Assistant Registrar (Examinations).

First Examiner	Second Examiner	External Examiner
Date: 20...../...../.....	Date: 20...../...../.....	Date: 20...../...../.....

v. Period, p_i, of periodic task
vi. Phase, ϕ_i, of periodic task
vii. Hyperperiod, H_i, of periodic tasks *7 marks*

(c) There are four periodic tasks. The tasks have execution times of 1, 1, 2 and 3 respectively. The tasks have periods of 8, 8, 9 and 12 respectively. Calculate the total utilisation of all the tasks. *3 marks*

(d) Explain release-time jitter (or jitter in release time). *1 mark*

Q3. The Reference Model for real-time systems characterises each system according to a workload model, a resource model and scheduling algorithms.

(a) Name the graph, explored in this course, which can describe the resource model. Also, in your own words, explain how this graph describes the resource model. *2 marks*

(b) Premptivity and criticality are two functional parameters used to describe jobs. Explain these two parameters. *2 marks*

(c) Contrast off-line and on-line scheduling. *3 marks*

(d) In an article, an engineer wrote:

> "“The application contains only hard real-time periodic jobs. A static, clock-driven scheduling approach is chosen to implement this application. This scheduling approach can be classified as an on-line scheduling approach.”"

i. What additional information is needed to validate the engineer's choice of a static, clock-driven scheduling approach? *1 mark*
ii. Do you agree or disagree with the engineer's view that this system uses on-line scheduling? Justify your answer. *1 mark*

(e) Identify one dynamic priority-driven scheduling approach and state whether it typically uses on-line or off-line scheduling. *2 marks*

Q4. (a) i. Explain the Latest Release Time (LRT) scheduling approach. *1 mark*
ii. Is the Latest Release Time (LRT) scheduling approach a priority-driven algorithm? Justify your answer. *1 mark*

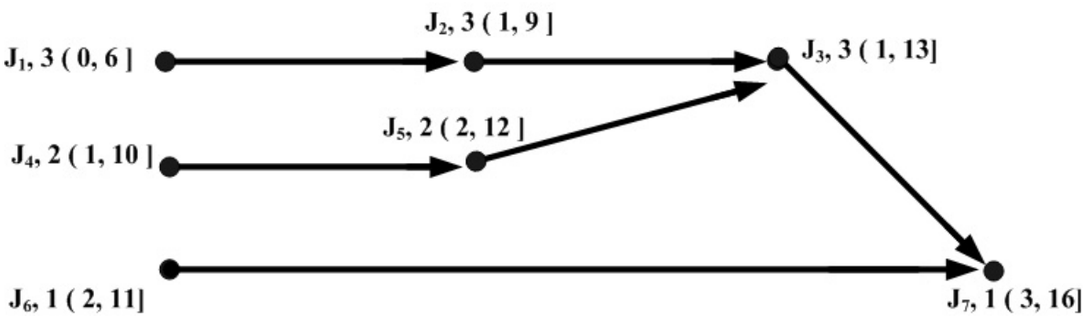

Figure 1: Precedence Graph for Q4(b)i

(b) In the precedence graph for a set of jobs shown in Figures 1 and 2, each job is given as J_i, e_i (r_i, d_i], where e_i is the execution time, r_i is the release time and d_i is the deadline. Use the precedence graph in Figure 1 to answer part Q4(b)i. Use the precedence graph in Figure 2 to answer parts Q4(b)ii, Q4(b)iii .

i. Does a feasible schedule exist for the precedence graph in Figure 1? Show all reasoning. *4 marks*

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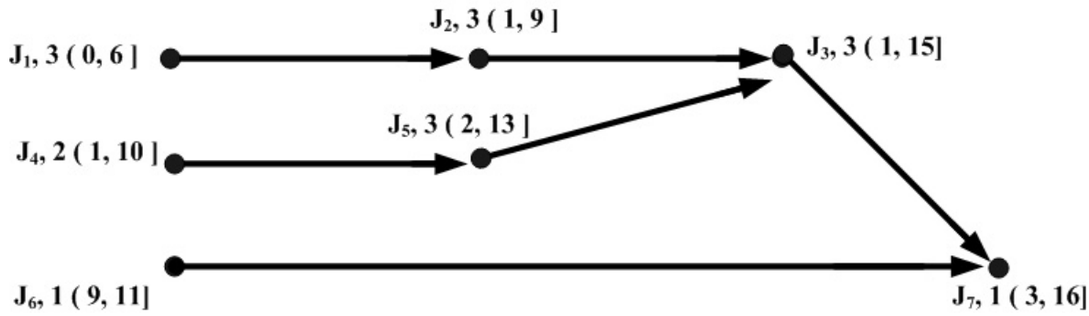

Figure 2: Precedence Graph for Q4(b)ii, Q4(b)iii

ii. Using a non-preemptive Earliest Deadline First(EDF) scheduling algorithm produce the schedule for the precedence graph in Figure 2. *4 marks*

iii. Using a pre-emptive Least Slack Time First(LST) scheduling algorithm produce the schedule for the precedence graph in Figure 2. *4 marks*

END OF QUESTION PAPER