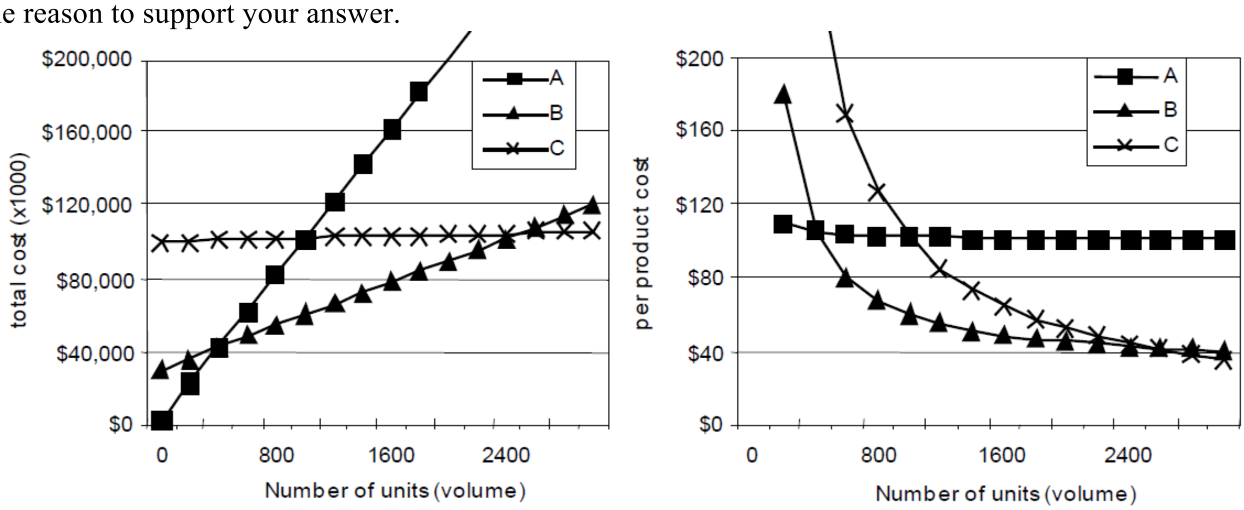
Embedded Operating System Midterm, Chang Gung University, Autumn 2018

Name: Student ID:

1. (9%) Please define the (a) Non-Recurring Engineering (NRE) Cost and (b) the Unit Cost of a system of products. (c) In the following figures, which technology has the highest NRE cost? Please provide the reason to support your answer.



Answer: (a) Unit Cost: the monetary cost of manufacturing each copy of the system
(b) NRE Cost: the one-time monetary cost of designing the system
(c) Technology C.

2. (8%) Why do we need real-time schedulers, such EDF and RM schedulers, in a real-time system?

Answer: The computer resource (CPU) is limited. If there are multiple real-time tasks, a scheduler is needed to arrange the execution time slots for all real-time tasks to meet their deadlines.

3. (8%) To develop software on embedded systems, we usually need the cross-platform development environment consisting of some cross compiler, linker, and source-level debugger. What is the cross compiler?

Answer: cross compiler is a compiler which can run on the host system, such as a PC, and can produce the binary which can run on the target embedded system.

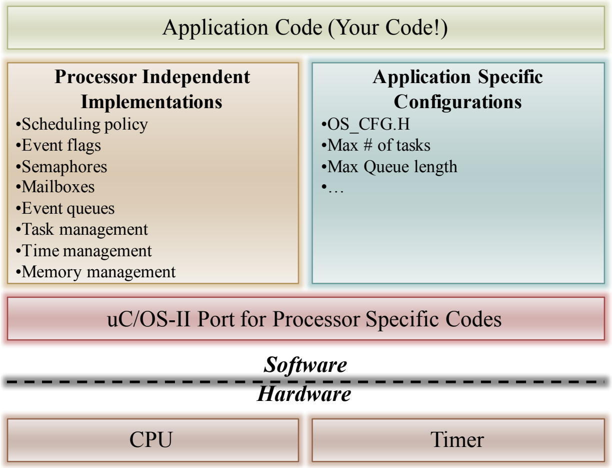
4. (8%) We have to download an executable image onto an embedded system before we run the executable image. During this process, we can use a scatter file to specify the load address and run address of each section in the executable image. Please define the (a) load address and (b) run address.

Answer: (a) Load address: the address in ROM or non-volatile storage for downloading the sections
(b) Run address: the location where the section is at the time of execution

5. (8%) For real-time operating systems, please define (a) Pure Real-Time OS and (b) Real-Time Extension of a General OS.

Answer: (a) A pure real-time OS is designed for real-time requirements and should be completely real-time compliant
(b) A real-time extension of a general OS is to extend an OS by real-time components so as to support real-time applications and non-real-time applications.

6. (8%) The following figure shows the structure of μC/OS-II. If now we want to launch a new application on a running system with μC/OS-II, please explain the process for running the new application on μC/OS-II.



Answer: We have to compile the whole package including the OS and application source files, shutdown the system, install the whole image, and reboot the system.

7. (8%) RM assigns a static priority for each real-time task, and EDF assigns dynamic priorities for real-time tasks. Please define (a) a static priority and (b) a dynamic priority.

Answer: (a) When a priority is assigned to a task, it is fixed and can not be changed.
(b) A dynamic priority is assigned to a task according to the current conditions. Thus, a dynamic priority of a task can be changed from time to time.

8. (8%) For many applications and systems, it is (computationally) impossible to derive the Worst Case Execution Time (WCET) of them. However, when conducting real-time task scheduling, we need to have a value for the execution time of each task. What should we do for getting some value for the execution time of each task?

Answer: We should get a safe upper bound of the real WCET and use the upper bound as the execution time for the scheduling algorithm. For the quality of the WCET analysis, we should push the upper bound as close to the real WCET as possible.

9. (8%) For real-time scheduling on multi-core platforms, please define: (a) What is a partitioned scheduling algorithm? (b) What is a global scheduling algorithm?

Answer: (a) Partitioned scheduling statically assign each task to a core. Whenever an instance of the task arrives, it should run on the designated core.
(b) Global scheduling maintains a global ready queue. When any instance of a task arrives, it is placed in the ready queue. Whenever a core is available (idle), a task instance is dequeued from the head of the ready queue and runs on the core.

10. (10%) For three periodic tasks P_1, P_2 and P_3. P_1 has its period 30 and execution time 5. P_2 has its period 20 and execution time 10. P_3 has its period 40 and execution time 10. Please draw the scheduling results of (a) the Earliest Deadline First scheduling and (b) the Rate Monotonic Scheduling from time 0 to time 120. If there is any deadline missing, please point it out and stop the scheduling when it has the deadline missing.

Answer: (a)

P_2	P_1	P_3	P_2	P_1	P_2	P_3	P_2	P_1		P_2	P_3	P_1	P_2	

0 10 20 30 40 50 60 70 80 90 100 110 120

(b)

P_2	P_1	P_3	P_2	P_1	P_3	P_2	P_3	P_2	P_1		P_2	P_1	P_3	P_2	P_3

0 10 20 30 40 50 60 70 80 90 100 110 120

Task P_3 misses its deadline at time 40.

11. (10%) Consider 4 tasks, t_1, t_2, t_3, and t_4 which have priorities x_1, x_2, x_3, and x_4, respectively, and assume $x_1 > x_2 > x_3 > x_4$ (x_1 is the highest priority). After we profile the programs of the 4 tasks, we have the following information:

- Task t_1 will lock semaphore S_1 for 20 ms.
- Task t_2 will lock semaphore S_2 for 12 ms and lock semaphore S_1 for 16 ms.
- Task t_3 will lock semaphore S_2 for 10 ms and lock semaphore S_3 for 14 ms.
- Task t_4 will lock semaphore S_1 for 8 ms and lock semaphore S_3 for 6 ms.

Please derive the priority ceiling of each semaphore. If the Priority Ceiling Protocol (PCP) is used to manage the semaphore locking, please derive the worst-case blocking time of each task.

Answer: Priority Ceiling: S_1: x_1, S_2: x_2, S_3: x_3 (5% 錯一個扣兩分)

Blocking Time: t_1: 16 ms, t_2: 10 ms, t_3: 8 ms, t_4: 0ms (5% 錯一個扣兩分)

12. (10%) A sporadic server has a replenishment period 5 and the maximum execution budget 2. Let the sporadic server have the budget 2 at time 0. Assume that events arrive at 1, 2, 6, 10, 12, and each event consumes the execution time 1. Please draw a diagram to show the changing of the execution budget from time 0 to time 20.

Answer: