Answer of Quiz 1

謝仁偉 助理教授
jenwei@mail.ntust.edu.tw
國立台灣科技大學 資訊工程系
2008 Fall

1. Please define the following terminologies. (20%)
   A. Relative deadline: the maximum allowable response time of a job.
   B. Absolute deadline: release time + relative deadline
   C. Response time: The length of time from the release time of the job to the instant when it completes.
   D. In phase: The release time of the first job for every task are identical.
   E. Slack: At time t, the slack of a job whose remaining execution time is x and whose deadline is d is equal to $d - t - x$.

2. Please explain how the following scheduling algorithms assign priorities to tasks/jobs: RM, DM, EDF, and LST. (16%)
   - Rate-Monotonic Algorithm. Assign priorities to tasks based on their period: the shorter the period, the higher the priority.
   - Deadline-Monotonic Algorithm: Assign priorities to tasks according their relative deadlines: the shorter the relative deadline, the higher the priority.
   - Earliest-Deadline-First Algorithm: Assign priorities to individual jobs in the tasks according to their absolute deadlines.

- Least-Slack-Time First Algorithm: The scheduler checks the slacks of all the ready jobs each time a new job is released and orders the new job and the existing jobs on the basis of their slacks: the smaller the slack, the higher the priority.

3. Why we need to introduce the notion of critical instants? (8%)

- Because we cannot count on any relationship among the release times to hold, we must first identify the worst-case combination of release times of any job $J_{i,c}$ in T_i and all the jobs that have higher priorities than $J_{i,c}$.
- Whenever release-time jitters are not negligible, the information on release times cannot be used to determine whether any algorithm can feasibly schedule the given system of tasks.

4. What is accelerated set? Why we introduce the notion of accelerated set? (10%)

   For a given system $\mathbf{T}$ of tasks, $\mathbf{T'}$ is an accelerated set of $\mathbf{T}$ if following properties hold:

   1. There is a task T_i' in $\mathbf{T'}$ if and only if there is a task T_i in $\mathbf{T}$.
   2. The execution time of T_i' is equal to the execution time of T_i.
   3. The period of T_i' is shorter than the period of T_i.

- A system $\mathbf{T}$ of independent, preemptive periodic tasks whose relative deadlines are equal to their respective periods is schedulable according the RM algorithm if it has an accelerated set $\mathbf{T'}$ which is simply periodic and has a total utilization equal to or less than 1.

5. Recall from Theorem 5, in which we want to prove a critical instant of any task T_i occurs when one of its job $J_{i,c}$ is released at the same time with a job in every higher-priority task. Please complete the fragment of the proof. (10%)

… …

Let $W_{i,1}$ denote the response time of $J_{i,1}$. From the release time of ϕ_k the first job in T_k to the instant $\phi_i + W_{i,1}$ when the first job $J_{i,1}$ in T_i completes, at most ___(1)___ job in T_k become ready for execution.

… …

At time $W_{i,1} + \phi_i$ when $J_{i,1}$ completes, the supply of processor time becomes sufficient to meet this total demand for the processor time for first time since time 0. In other words, $W_{i,1}$ is equal to the smallest of all solutions of ____(2)____ if this equation has solution in the range $(0, p_i]$.

… …

(1) $\lceil (W_{i,1} + \phi_i - \phi_k) / p_k \rceil$

(2) $W_{i,1} = e_i + \sum_{k=1}^{i-1} \left\lceil \frac{W_{i,1} + \phi_i - \phi_k}{p_k} \right\rceil e_k - \phi_i$

6. Given a task set: $T_1 = (3, 1.5)$, $T_2 = (4, 1.8)$, and $T_3 = (9, 0.2)$. Please identify the 1st level-2 busy interval and the 2nd level-3 busy interval. (10%)

- The 1st level-2 busy interval = (0, 11.4]
- The 2nd level-3 busy interval = (12, 23.6]

7. Given a task set: $T_1 = (3,1.5)$, $T_2 = (4,1.8)$, and $T_3 = (9,0.2)$. Please find $W_{2,2}$ and $W_{3,2}$. (10%)

7. Given a task set: $T_1 = (3,1.5)$, $T_2 = (4,1.8)$, and $T_3 = (9,0.2)$. Please find $W_{2,2}$ and $W_{3,2}$. (10%)

- $t = w_{i,j}(t + (j-1)p_i) - (j-1)p_i$
- $w_{i,j}(t) = je_i + \sum_{k=1}^{i-1} \lceil t / p_k \rceil \cdot e_k$ for $(j-1)p_i < t \le w_{i,j}(t)$

$$t = 2 \times 1.8 + \lceil (t+4)/3 \rceil \times 1.5 - 4$$

Substitute $t^{(1)} = 1.8$ on the right hand side of the equation.

We obtain: $W_{2,2} = 4.1$

$$t = 2 \times 0.2 + \lceil (t+9)/3 \rceil \times 1.5 + \lceil (t+9)/4 \rceil \times 1.8 - 9$$

We obtain: $W_{3,2} = 2.8$

8. Given a task set **T** = {T_1 = (3, 1), T_2 = (5, 1), T_3 = (7, 1.75) , T_4 = (8, 0.4), T_5 = (12, 0. 5)}. Under the RM scheduling, show me which task is schedulable or unschedulable. (16%)

- T_1: U1 = 0.333 < 1 (schedulable)
- T_2: U2 = 0.533 < 0.828 (schedulable)
- T_3: U3 = 0.783 > 0.779
  (1+0.333) x 1.2 x 1.25 = 2 (schedulable)
- T_4: $0.4+\left\lceil \frac{t}{3} \right\rceil \times 1+\left\lceil \frac{t}{5} \right\rceil \times 1+\left\lceil \frac{t}{7} \right\rceil \times 1.75$ (unschedulable)
- T_5: $0.5+\left\lceil \frac{t}{3} \right\rceil \times 1+\left\lceil \frac{t}{5} \right\rceil \times 1+\left\lceil \frac{t}{7} \right\rceil \times 1.75+\left\lceil \frac{t}{8} \right\rceil \times 0.4$
  converges on 11.8 (schedulable)