Homework 5, due May 2nd 5pm CST

Handin at 1102 DCL. Slide under door if TA not present.

Important: Please type or *neatly* write your solutions. Anything we can't read will receive no credit. You must show work to receive full credit.

1. (20 points) There are 5 periodic tasks with the following computation times and periods.

   - τ_1: $C_1 = 3$, $T_1 = 70$
   - τ_2: $C_2 = 7$, $T_2 = 80$
   - τ_3: $C_3 = 18$, $T_3 = 95$
   - τ_4: $C_4 = 20$, $T_4 = 100$
   - τ_5: $C_5 = 30$, $T_5 = 160$

   In addition, assume the following are true.

   - Each context switch requires exactly 1 unit of time.
   - τ_3 can block all higher-priority tasks for a duration of 3.
   - τ_4 can block all higher-priority tasks for a duration of 5.
   - τ_4 has a pre-period deadline of 15.
   - τ_5 has a pre-period deadline of 18.

   Use the UB and Exact Schedulability tests to see if all tasks are schedulable.

2. (30 points) There are 3 periodic tasks, τ_1, τ_2, and τ_3 and 2 shared data structures among the tasks. First, τ_1 and τ_2 share DS_1 where both τ_1's and τ_2's critical sections are 5 (units of time). Second, τ_2 and τ_3 share DS_2 where τ_2's critical section is 7 and τ_3's critical section is 10.

   (a) Assuming that semaphores *cannot* be nested, what are the worst case blocking times of each task if the Basic Priority Inheritance protocol is used for synchronization? (5 points)

   (b) Assuming that semaphores *can* be nested, what are the worst case blocking times of each task if the Basic Priority Inheritance protocol is used for synchronization? (10 points)

   (c) Assuming that semaphores *cannot* be nested, what are the worst case blocking times of each task if the Priority-Ceiling Protocol is used for synchronization? (5 points)

   (d) Assuming that semaphores *can* be nested, what are the worst case blocking times of each task if the Priority-Ceiling Protocol is used for synchronization? (10 points)

3. (30 points) There are three periodic tasks with the following computation times (C), periods (T), blocking times (B), and pre-period deadlines (D). The context switching time is $S = \frac{1}{2}$.

Task	C	T	B	D	S
τ_1	5	35	5	14	1
τ_2	20	90	10	28	1
τ_3	15	120	0	35	1

   (a) (10 points) Use the Utilization Bound and Exact Schedulability tests as needed to show that the task set is schedulable. Show your work.

   (b) (20 points) A fourth aperiodic server will now be added to the task set to maximally utilize the leftover CPU cycles. The new server τ_a has computation time C_a, period $T_a = 34$, blocking time $B_a = 0$, and pre-period deadline $D_a = 0$. What is the largest integer value for C_a that will allow all four tasks to meet their deadlines? Hint: you might want to write a simple program to calculate this. Do not include your program in the solutions, but you must show that your solution is indeed the largest integer possible, i.e., (your answer + 1) does not work.

Task	C	T	B	D	S
τ_a	C_a	34	0	0	1
τ_1	5	35	5	14	1
τ_2	20	90	10	28	1
τ_3	15	120	0	35	1

4. (20 points) There are three stations S_1 through S_3 connected to a 1 Mbit/sec FDDI ring.

   Station S_1 transmits periodic sensor data stream to S_3: $\{(C_{13} = 10, T_{13} = 90)\}$.

   Station S_2 is attached to a 10 frames-per-second video camera that captures 256 by 128 pixel frames at 2 bits per pixel. It transmits them in an uncompressed format to station S_3.

   Station S_3 transmits two periodic sensor data streams. One stream goes to S_1: $\{(C_{31} = 5,\ T_{31} = 50)\}$. The other stream goes to S_2: $\{(C_{32} = 40,\ T_{32} = 300)\}$.

   S_1 holds the token for a maximum of $H_1 = 10$ msec. S_2 holds the token for a maximum of $H_2 = 15$ msec. S_3 holds the token for a maximum of $H_3 = 20$ msec. The walk time is $W = 25$ msec.

   For each of the three stations, show the equivalent periodic task set (include each task's computation time and period). You do **not** need to perform any schedulability analysis on the tasks.