CS 424   Homework 4 (Solved)

Please work on the homework independently. This homework is due Thursday, November 3rd, in class.

Please return the answer sheet only (i.e., the last page).

Q1) Please choose the best answer to each of the following questions. Please note that in the questions below, the words "power" and "energy" are NOT used interchangeably. Unless otherwise stated, for simplicity, when a "processor" is mentioned, assume a single-core processor. (7 points)

1) A processor uses 50mW of power when running at full speed and 22.5mW of power when running at half speed. What percentage of energy is saved on task execution at half speed compared to full speed, when executing a compute-intensive task?

a) 10%

b) 20%

c) 30%

d) 40%

e) 60%

2) If your processor has an adjustable frequency and voltage (where both change proportionally), an efficient sleep mode (in which the power consumed is negligible), and no wakeup cost, which of the following saving policies are energy-optimal (i.e., consume the least energy)? You may assume that all tasks are CPU-bound and that the processor will be in sleep mode when not executing a task.

a) Run all tasks at the lowest frequency

b) Run all tasks at the highest frequency

c) Run all tasks at an optimal frequency, which can potentially be different from the maximum and minimum frequencies

d) Run all tasks at the lowest frequency *that is schedulable*

e) Run all tasks at the *lower* of the two frequencies mentioned in (c) and (d).

3) For some processor, the energy consumed in executing a task is given by E = 16 f^2 + 0.5/f, where f is the normalized frequency (such that f=1 when the processor is running at maximum frequency). At what value of normalized frequency should the processor operate in order to be energy-optimal?

a) f=1

b) f=0.5

c) f=0.25

d) f=0.2

e) f=0.1

4) A processor consumes power at a rate 12 W when active, and at a rate of 2 W when asleep. The wake-up cost is 0.3 Joules. If this processor goes to sleep, what is the shortest sleep interval such that dropping below it will actually waste more energy compared to not sleeping?

a) 10 ms

b) 30 ms

c) 100 ms

d) 300 ms

e) 3 s

Reminder: 1 Joule = 1 Watt Second

5) You are trying to schedule a single 100ms task on the above processor. The task should execute once within each window of 1.1 seconds. It does not matter where the task executes within the window. Taking wakeup cost into account, when an energy-optimal schedule is used, what amount of *energy* is spent *on average* per one period of the above task? If you do not see the correct answer, pick the nearest approximation.

a) 3.2 Joule

b) 3.35 Joule   (0.1 * 12 + 1 * 2 + 0.3 * 0.5) Note that wakeup cost will be amortized over two periods if we execute successive pairs of task instances back to back.

c) 3.5 Joule

d) 4.7 Joule

e) 6.2 Joule

6) Which of the following comes closest to a condition of stability of closed loop systems?

a) The loop gain is more than 1

b) The loop gain is equal to 1

c) The loop gain is less than 1 at the lowest frequency

d) The loop gain is less than 1 at the natural frequency of oscillation (the resonant frequency)

e) The loop gain is equal to 1 at the highest frequency

7) In the ACPI standard, P-states stand for:

a) Processor states

b) Power states

c) Performance states

d) Pending states

e) Priority states

Q2) Using the exact schedulability test, determine the exact worst case response time of task T_2 in each of the following three task sets. In each task set, C_i, P_i, and D_i denote the processing time, period, and relative deadline of task i respectively. Assume that *deadline-monotonic* scheduling is used. **(3 points)**

8)
Task 1: $C_1 = 2$, $P_1 = 6$, $D_1 = 6$
Task 2: $C_2 = 4.1$, $P_2 = 11$, $D_2 = 9$
Answer: 8.1

9)
Task 1: $C_1 = 2$, $P_1 = 12$, $D_1 = 12$
Task 2: $C_2 = 8$, $P_2 = 20$, $D_2 = 9$
Answer: 8 (note that Task 2 is the highest priority task here because it has the smallest relative deadline)

10)
Task 1: $C_1 = 5$, $P_1 = 10$, $D_1 = 9$
Task 2: $C_2 = 6$, $P_2 = 11$, $D_2 = 11$
Answer: Infinity. Note that the utilization is more than 100% here, so infinite delays will build up.