Homework 4:

Please work on the homework independently. This homework is due Tuesday, November 5th, in class.

Please circle 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. (1 point per question)

1) A processor uses 10mW of power when running at full speed and 4mW of power when running at half speed. Approximately what percentage of energy is saved on task execution when the processor runs at half speed compared to full speed, when executing a *memory-intensive* task?

a) 20%

b) 40%

c) 50%

d) 60% (because the execution time of a memory-intensive task does not change with proc. frequency)

e) 80%

2) In the processor mentioned in Question (1) above, approximately what percentage of energy is saved on task execution at half speed compared to full speed, when executing a *compute-intensive* task?

a) 20% (execution time doubles so for each 10mW, you'll spend 2x4mW at half speed)

b) 40%

c) 50%

d) 60%

e) 80%

3) If your processor has a fixed voltage, an adjustable frequency, 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) if 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 (that does not overload the processor)

b) Run all tasks at an optimal frequency which is usually somewhere between the maximum and minimum frequency

c) Run all tasks at the maximum frequency (directly from lecture slides)

d) Run short tasks at the lowest frequency and long tasks at the maximum frequency.

e) None of the above.

4) For some processor, the energy consumed in executing a task is given by $E = 16 f^2 + 13.5/f + 5$, 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=0.75 (Note: $dE/df = 32 f - 13.5 / f^2 = 0$, then solve for f.)

b) f=0.5

c) f=0.3

d) f=0.2

e) f=0.15

5) A processor consumes power at a rate 1.1 W when active, and at a rate of 0.1 W when asleep. The wake-up cost is 0.5 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) 50 ms

b) 100 ms

c) 200 ms

d) 250 ms

e) 500 ms (you are saving 1 Joule every second of sleep, so you need 0.5 seconds to save 0.5 Joules)

Reminder: 1 Watt = 1 Joule/Second

6) You are trying to schedule a single 500ms task on the above processor. The task should execute once within each window of 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) 0.1 Joule

b) 0.6 Joule

c) 0.85 Joule (0.5 sec * 0.1 + 0.5 sec * 1.1 + 0.5 Joule/2)

Note now the wake-up cost is amortized over two periods. We discussed this in class. The idea is to schedule like this: || sleep 0.5 s| Run 0.5 sec || Run 0.5 sec | Sleep 0.5 sec|| then repeat. Every period of 1 sec, you run once, but you incur wake up cost only every other period (depicted by blue bar: |)

d) 1.1 Joule

e) 1.35 Joule

7) Two tasks, A and B, have the same execution time when executed at the maximum frequency of a processor. Task A is CPU-intensive. Task B is memory-intensive. When the processor frequency is

dropped in half, the total energy consumption of task B drops by 30%. Which of the following is true of the energy consumption of Task A when processor frequency is dropped in half?

a) The energy consumption of Task A will drop by 30%

b) The energy consumption of Task A will drop by more than 30%

c) The energy consumption of Task A will drop by an amount between 0 and 30%

d) The energy consumption of Task A will increase (because the execution time will double compared to task B so you will spend 70% times 2 or 140% of the original energy).

e) Either (c) or (d)

8) Use Internet resources to answer the questions below about the Intel Atom® processor S1200. An example resource is:

https://www.intel.com/content/www/us/en/products/docs/processors/atom/technical-resources.html

(3 points)

On the above page, you will find the datasheet: atom-processor-s1200-datasheet-vol-1.pdf

a) What is the core voltage range when core is running (in mode C0)? 0.75-1.1V (Table 4-3)

b) In global state G1, what is the state of CPU caches (e.g., on, flushed, off, etc)? Off (Table 4-7)

c) Which CPU C-state is entered when executing the auto-halt instruction? C1 (Table 4-7)