

**ECE571: Advanced Microprocessor Design – Homework 3**  
Spring 2018

**Due: Thursday 15 February 2018, 3:30pm**

1. Background

- For this assignment, log into the Quadro/Haswell machine just like in HW#1.
- Create a document that contains the data and answers described in the sections below.

2. Measuring Power using perf/RAPL

- Run the following 4 benchmarks, gathering the Energy and time values from `perf` for `energy-cores`, `energy-gpu`, `energy-pkg` and `energy-dram`. Use these values to calculate the average power for each. Note: the backslashes are a line-continuation character. Leave them in if you are cutting/pasting in one big chunk, but leave them out if you are hand-typing the commands.
  - `sleep`  

```
perf stat -a -e power/energy-cores/,power/energy-gpu/, \
power/energy-pkg/,power/energy-ram/ sleep 10
```
  - `stream`  

```
perf stat -a -e power/energy-cores/,power/energy-gpu/, \
power/energy-pkg/,power/energy-ram/ \
/opt/ece571/stream-5.10/stream_c
```
  - `matrix-matrix multiply`  

```
perf stat -a -e power/energy-cores/,power/energy-gpu/, \
power/energy-pkg/,power/energy-ram/ \
/opt/ece571/matrix_multiply/matrix_multiply_atlas 100
```
  - `iozone`  

```
perf stat -a -e power/energy-cores/,power/energy-gpu/, \
power/energy-pkg/,power/energy-ram/ \
/opt/ece571/iozone3_417/src/current/iozone -a -g 256k
```
- Make a table with the 4 rows being `cores`, `gpu`, `pkg`, `ram` and the columns being the 4 benchmarks, list the Energy from each.
- Make another table like above, but instead of Energy use the Energy and time values to report the average Power.
- Answer the following questions:
  - (a) Which benchmark causes the cores to use the highest average power?
  - (b) Which benchmark causes the RAM to use the highest average power?
  - (c) Did any of the benchmarks use GPU power? Why not?

### 3. Calculating Energy-Delay and Energy-Delay-Squared

- For this problem we will use the `equake_l` version of `equake` that is from the SPECOMP2001 (SPEC OpenMP) benchmark suite (note: that's a lowercase L, not a 1, in the benchmark name). It is a version of the `equake` benchmark parallelized with OpenMP directives so that it can take advantage of multiple cores.
- Run the benchmark with 1, 2, 4, 8, and 16 threads, measuring the energy-cores RAPL counter. The command line for doing this with 1 thread is (all one line):

```
env OMP_NUM_THREADS=1 perf stat -a -e power/energy-cores/ \
/opt/ece571/equake_l.specomp/equake_l \
< /opt/ece571/equake_l.specomp/inp.in
```

Change the `OMP_NUM_THREADS` value to change the number of threads. You probably want to make sure no one else is logged in and running these tests (use `w` or `top` to check) at the same time you are, otherwise you can affect each other's results. Note: running the benchmark will take a while (up to a few minutes).
- Create a table that for each thread count (1,2,4,8,16) shows the elapsed time, the Energy in Joules, the Energy-Delay value, and the Energy-Delay-Squared value.
- Answer the following questions:
  - (a) Which thread count has the fastest time?
  - (b) Which thread count has the lowest energy?
  - (c) Which thread count has the lowest energy-delay?
  - (d) Which thread count has the lowest energy-delay<sup>2</sup>?
  - (e) How well does this benchmark scale when adding additional threads? What could explain the scaling behavior you see?
  - (f) If you check `/proc/cpuinfo` you can see Linux sees 8 cores in the system. Why did the 8 thread run not run much faster than the 4 core run?

### 4. Submitting your work.

- Create the document containing the data as well as answers to the questions asked.
- Please make sure your name appears in the document.
- e-mail the file to me by the homework deadline.