

## ECE571: Advanced Microprocessor Design – Homework 2

**Due: Tuesday 30 September 2014, 3:30PM**

### 1. Background

- For this assignment, log into the Haswell machine just like in HW1.
- Create a document that contains the data and answers described in the sections below. A .pdf or .txt file is preferred but I can accept MS Office or Libreoffice format if necessary.

### 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.
  - 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
```
  - 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 average Power from each.
- 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? Can you explain the GPU vaults you get?

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

- For this problem we will use the `equake_1` version of `equake` that is from the SPEC2001 (SPEC OpenMP) benchmark suite. 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, and 8 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_1.speccomp/equake_1  
< /opt/ece571/equake_1.speccomp/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.
- Create a table that for each thread count (1,2,4,8) 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?

### 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.