

**ECE571: Advanced Microprocessor Design – Homework 10**  
Spring 2017

**Due: Thursday 20 April 2017, 11:00am**

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.

**1. stream memory behavior on the x86 Haswell Machine**

For this section, log into the Haswell machine just like in previous homeworks.

Run the stream benchmark on the Haswell machine. Stream is a benchmark that tries to find out the maximum memory (DRAM) bandwidth. Run

```
perf stat -a -e uncore_imc/data_reads/,dTLB-loads, \
dTLB-load-misses,cache-references,cache-misses,power/energy-ram/ \
/opt/ece571/stream-5.10/stream_omp
```

- (a) What were the uncore-imc results? How did these results reported by perf compare to the memory bandwidth reported by stream itself?
- (b) Were there a lot of TLB misses?
- (c) Were there a lot of cache misses? If so, why?
- (d) What was the average power reported used by the benchmark?

**2. Memory Behavior**

Run the benchmarks

```
/opt/ece571/matrix_multiply/matrix_multiply_naive
/opt/ece571/matrix_multiply/matrix_multiply_improved
/opt/ece571/matrix_multiply/matrix_multiply_atlas
```

With the same perf command as before, note the results, and answer the following questions.

The naive version of matrix multiply is an exact implementation of the normal algorithm with three nested loops.

The “improved” version just flips the order of the outer two loops.

The atlas version uses an optimized BLAS library.

- (a) Why does the naive version have such a horrible TLB miss rate?
- (b) Which version has the lowest cache miss ratio? Is it the fastest? Why might a program with a higher cache miss ratio run faster than one with a lower ratio?
- (c) What was the average DRAM power for each benchmark?
- (d) Which program uses the least amount of Energy?  
Which has the best Energy-delay?

**3. 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.