**ECE571: Advanced Microprocessor Design – Homework 4**

**Due: Friday 5 April 2013, 5:00PM**

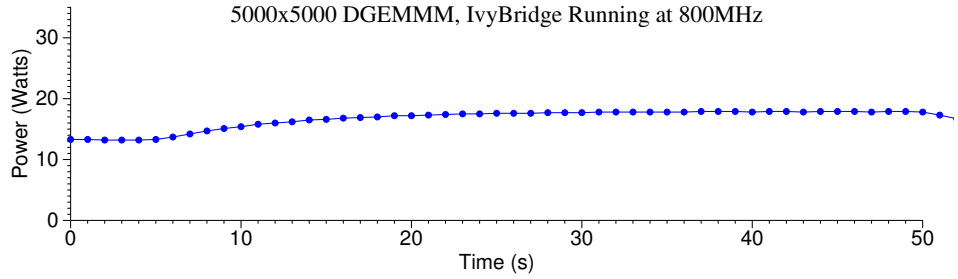
1. Energy

   - The following is data collected with a WattsUpPro Power Meter on an Ivy Bridge MacBook Air laptop. The benchmark run was a DEGEMMM 5000x5000 matrix-matrix multiply that used two threads.

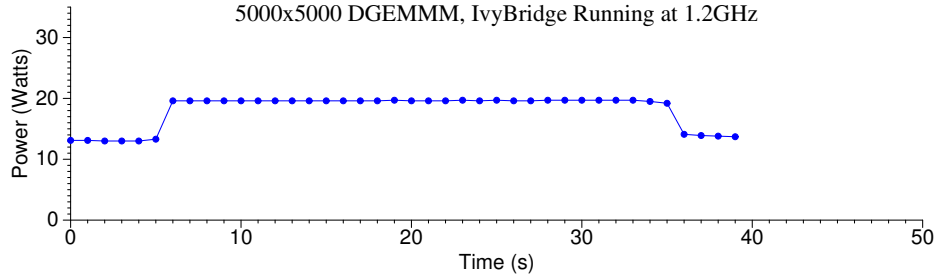
     The CPU frequency of the laptop was scaled using the `cpufreq-set` command. First `cpufreq-set -g userspace` to set the governor, then `cpufreq-set -c0 -r -f 800MHz` or similar to set the frequency.

     The processor has turbo-boost enabled, so when set to 1.8GHz the cpu can automatically scale up to 3.0GHz if it thinks it has the power/thermal overhead to allow it.

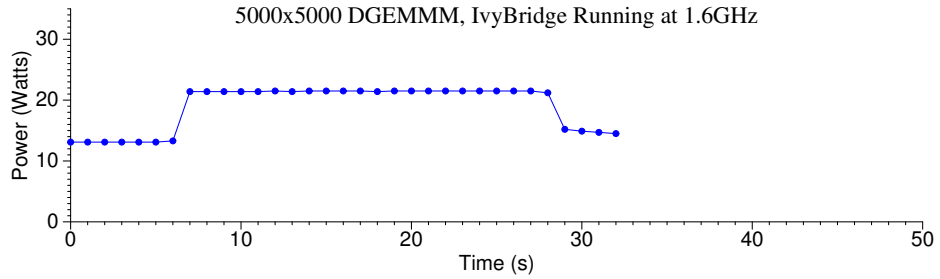
   - For each data point below, included is a graph for reference, the average Power you can use (for simplicity) when calculating results, and the output of the "time" command.
     - 800MHz. Average Power 17.3W. Time: 45.8s



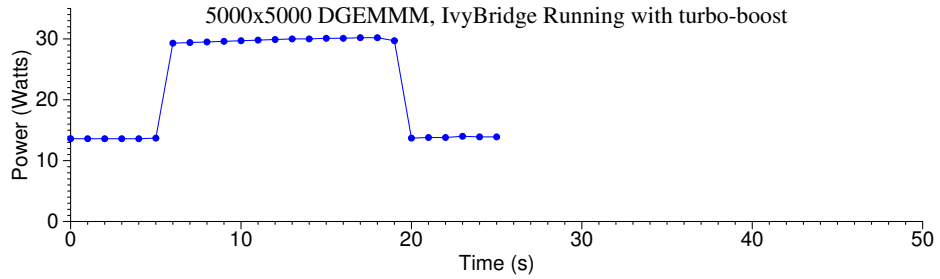

     - 1.2GHz. Average power 19.6W. Time 30.8s




     - 1.6GHz. Average power 21.5W. Time 22.8s



– TurboBoost. Average power 30.2W. Time 14.1s




- Make a table using the above data that shows the CPU frequency, time, average power, total Energy (calculated from average power and time), energy delay, and energy delay squared.
- Questions
  (a) For this processor and benchmark, what frequency setting gives the best Energy Delay Squared result? Would picking the best run based on Energy Delay or total Energy be any different?
  (b) If you are running your laptop off of battery power (not plugged into the wall), which frequency setting would give you the best battery life?
  (c) This particular laptop occasionally gives the error: `CPU1: Core temperature above threshold, cpu clock throttled` in the logs. Why might this happen?

2. Project Status — Required Equipment

- List any hardware you plan to use for your project. Note if it is something you own or have access to yourself of if it's something I mentioned in class or the project website.

  This is mostly so I know which machines I might need to have in fully working condition, and also so I can do things like create accounts, and start figuring out a schedule for shared resources (likely the WattsUpPro meter will have to be moved around between machines as I only have one of them).

  If you are working in a group, only one equipment list needs to be submitted, the other member of the group can just say to see the other submission.

3. Project Status — Related Work

- Find five sources of related work about the project you are undertaking (typically this will be academic papers, but can be other sources). Include a brief summary of the source, and how it relates (is the same or different) from what you plan to do.

  If you are working in a group, you *each* have to do this and I'd prefer the sources you find do not overlap.

  You can use the answer to this question as a basis to the "Related work" section of your final project writeup, though for that you might want to cite more than 5 sources depending on how much previous work you find.

  An example of what I expect for one source:

  Weaver and McKee[1] investigate the energy consumption of the 6502 processor as found in 1980s video game systems. They estimate the energy usage based on the current score and whether the main character has found a fire-flower yet. Our research is different, in that we use

a newer console with a 16-bit 65c816 processor, and plan to base the energy estimate on how many times the background theme music has repeated.

[1] V.M. Weaver and S. McKee. "Energy Impacts of 8-bit Sprite Based Video Games," *Proceedings of the IEEE Conference on Improbable Video Game Research*, pages 34-95, 2011.

4. Submitting your work.

   - Include your answers in a text or PDF file.
   - Please make sure your name appears in the document.
   - e-mail the file to me by the homework deadline.