Lab #1: Hardware Counter Guided Transformation

Lab 1 is due Monday, September 25. Your lab report and source code must be submitted by **1:50 PM** before class. The late policy applies to this lab project.

This lab is to be done individually. Get started early! Also, remember to **put your name** on the lab report!

Table of Contents

The PAPI Hardware Counter Library:1

How to install PAPI:1

Compile and run programs with PAPI:2

Departmental Machine:2

Problem 1: Transform Code Guided By Hardware Counters2

How to Submit:3

The PAPI Hardware Counter Library:

You can solve the Problems on any machine with a C compiler and support for the PAPI library. It is recommended to install PAPI on your own computer. Please describe the CPU configuration, the OS and the compiler on that system in your lab report.

How to install PAPI:

(1) If you are using Windows or MacOS, install Vmware from https://udeploy.udel.edu/software/vmware-for-univers ity-of-delaware/. Then install a Linux OS of your choice in Vmware.

(2) Enable Hardware counter access on your computer:

   a. Vmware:

      i. Right-click a virtual machine in the inventory and select **Edit Settings**.

      ii. On the **Virtual Hardware** tab, expand **CPU** and select the **Enable virtualized CPU performance counters** check-box.

   b. Ubuntu:

      i. "sudo sh -c 'echo 1 >/proc/sys/kernel/perf_event_paranoid' "

      Or

ii. *"sudo sysctl -w kernel.perf_event_paranoid=1"*

(3) Install PAPI:
   a. On Ubuntu
      i. "sudo apt install libpapi-dev papi-tools"
   b. From source code
      i. Download source code:
         1. *"git clone https://bitbucket.org/icl/papi.git"*
      ii. Configure and install:
         1. *"cd papi/src; ./configure"*
         2. *"make"*
         3. *"sudo make install"*

Compile and run programs with PAPI:

If you follow the previous instructions, the PAPI library has been installed under the directory /usr/local. The library binaries are in /usr/local/lib, and the library header files are in /usr/local/include. When you need to compile your program with PAPI, you can use the command line: "gcc -I/usr/local/include your_program_file -L/usr/local/lib -lpapi".

Departmental Machine:

Instead of using your own machine, you can also use a departmental machine that is configured for this course. The machine host name is cpeg655.ece.udel.edu.

(1) First you need an EECIS account. If you don't have one, apply at www.eecis.udel.edu. Choose the account type to be "Academic", and me as the sponsor.
(2) After your EECIS account is ready, access the machine through two hops:
   a. *"ssh your_account@go.eecis.udel.edu"*
   b. From go.eecis.udel.edu, *"ssh cpeg655.ece.udel.edu"*
(3) The PAPI library is installed under "/usa/xli/local/lib". The header files can be found at "/usa/xli/local/include". Or alternatively, you can also install the PAPI under your own home folder.

Problem 1: Transform Code Guided By Hardware Counters

Transform the "func" function of mem1.c and mem2.c to achieve ***maximum*** cache misses. Do the "de-optimization" for L2 cache miss and TLB miss. L2 and TLB metrics can be replaced with other two memory hierarchy levels such as L1 and L2 if the metrics are not working on machine. The "func" is basically a sequence of memory accesses with basic operations. You can change the order of the memory accesses, but you cannot add or remove memory accesses to the sequence.

Submit your code and measurements, together with your explanation of the transformations, i.e., why they work. (Hint: Optimize/de-optimize by avoiding/creating cache or TLB conflicts.)

How to Submit:

Copy your lab report, which is a .pdf, a .doc, or a .html file, and all your source code into an empty directory. Assuming the directory is "submission", make a tar ball of the directory using the following command:

tar czvf [your_first_name]_[your_last_name]_lab1.tar.gz submission.

Replace [your_first_name] and [your_last_name] with your first name and your last name.

Submit the tar ball. The submission time will be used as the time-stamp of your submission.
