CS 280 – High Performance Computing / Architecture

Spring 2014

Assignment 1: Hardware performance counters

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Hardware performance counters

- set of special-purpose registers built into modern microprocessors to store the counts of hardware related activities within computer systems
- low overhead compared to software based methods
- types and meanings of hardware counters vary from one kind of architecture to another due to the variation in hardware organizations.

Hardware performance counters

- The number of available hardware counters in a processor is limited while each cpu model might have a lot of different events that a developer might like to measure. Each counter can be programmed with the index of an event type to be monitored, like a L1 cache miss or a branch misprediction.

PAPI

- PAPI: Performance Application Programming Interface
- Interface to access performance information from hardware counters
- Code sections can be instrumented to monitor CPU activity for potential code optimization
- Documentation page: http://icl.cs.utk.edu/projects/papi/wiki/Main_Page

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Tasks

- Task1:Use PAPI to find out about the Neser cluster system information: processor type, frequency, OS, cache sizes, …
- Task2:
  - Download the rtm_kernel code from blackboard and get acquainted to it (make and run). The code solves a wave equation used in the field of Seismic imaging. More details about the application will be presented in a separate lecture in the last weeks of the semester

Tasks

- Instrument the rtm_kernel in order to use hardware performance counters to determine the behavior of the time loop of the code (the timed section of the code)
- The hardware performance counters should be based on the PAPI library, and you should monitor the following values:
  - Level 1 total cache accesses and misses (include instruction and data caches)
  - Level 2 total cache accesses and misses (include instruction and data caches)
  - Conditional branch instructions
  - Number of floating point operations

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Tasks

- Task 3:
  - Edit the makefile to link with PAPI. To link a simple code with PAPI use

    ```
    gcc example.c -lpapi -o example
    ```

  - Compile your code with different optimization flags
    - The predefined "–O's" optimization levels are required
    - Among the flags listed in lecture 12, find out at which level are these included. If an optimization is not included in any –O level, it should be investigated.
    - Some optimizations (included in the –O's) are parameterized, the effect of modifying such parameters on relevant events is to be investigated

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Tasks

  - Run the modified code on the Neser cluster and generate graphs for the requested events as a function of the applied optimizations in an incremental way. (get averages of multiple measures)
  - Compute the actual performance of the code snippet in terms of flop/s (average of multiple measures)
- Task 4: Write a summary of the presentation given by Peter Ungaro, CEO of Cray inc. on 25/2/2014 about "The Fusion of Supercomputing and Data Analytics To Drive Scientific Discovery".
  - Half page minimum, one page maximum with regular/standard fonts, font sizes (11-12), line spacing (single to 1.5) and margins (1 inch on all sides)

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Environment

- You will be using the Neser cluster for your measurements. You will get your credentials soon after you submit your account application
- Please refer to the user guide http://www.hpc.kaust.edu.sa/documentation/user_guide/ for accessing and submitting jobs to Neser
- It is definitely easier to develop your code / instrumentation on a non-shared computer. So, if you have access to a Linux workstation where you can manage to install PAPI, then you can use it for development. However, the reported measurements are should be thoses performed on the cluster

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Hints

- The PAPI wiki http://icl.cs.utk.edu/projects/papi/wiki/PAPIC:Overview is your reference and it has plenty of examples illustrating the use of the needed functions
- The sections you should be interested in are mainly but not restricted to:
  - Events
  - PAPI Counter Interfaces
  - PAPI System Information

Hints

- Not all events are supported by a given architecture, use `papi_avail` to list the events that are supported
- You should also check *within your code* that the event is supported before assigning it to a counter
- Beware of conflicting events, some can not be monitored at the same time. Instrument your code accordingly, you might need different runs for monitoring conflicting events.

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Submission guidelines

- Deliverables:
  - Source code
  - Report including explanations to the code (mainly PAPI instrumentation) and results (graphs, system information, …)
  - Presentation summary
- Upload to blackboard in the corresponding assignment section
- Deadline: Saturday, 6th April, 2014
- In case of questions, email or ask for appointment