Project 4:
Research Project

ECE 721: Advanced Microarchitecture
Spring 2020, Prof. Rotenberg

1. Important Dates

Proposal Due: Friday, March 20 (5:00 PM)
Presentations: April 9, 14, 16, 21, 23
Paper Due: Friday, May 1 (11:00 PM)

2. Proposal

For this course you are required to propose and carry out a research project. The depth of the project is such that you are expected to work in groups of two. Consult me for exceptions.

You may use the project ideas posted on the course website as a starting point for brainstorming and coming up with your own project.

Submit a **2-page proposal** by the due date indicated above. The proposal must include the following.

- **Project title and author(s)**
- **Key outcomes of project**
  Examples:
  - A working structural simulator of a baseline trace processor.
  - A detailed quantitative comparison (IPCs) of trace processors and equally-provisioned superscalar processors. Insight into the IPC impact of distributing a wide-issue processor among PEs.
  - A novel working implementation of Dynamic Hammock Predication (DHP) in a trace cache or trace processor.
  - Insight into the achievable speedups of a realistic implementation of DHP in a trace cache or trace processor.
- **Major tasks, and assignment of tasks to students**
  Examples:
  - Create a PE class that has an issue queue, execution lanes, LRF, GRF replica, forwarding queues for global result buses, …
  - Create a trace cache class that has a trace cache, trace miss unit (BP, I$), trace pre-processing unit (pre-renaming, …), …
- **Experimental plan**
  Enumerate the different classes of experiments you will perform to evaluate your microarchitecture. For each class of experiment, describe what insight you are trying to gain; describe and justify the baseline for comparison; propose a hypothesis that will be confirmed or refuted by the class of experiment; *etc*. Where warranted, propose "sensitivity studies": these are studies performed after the "main" experiments, to understand the sensitivity of primary results to parameter variations. In all classes of experiments, indicate what metric or metrics will be plotted (IPC, speedup, mispredictions per thousand instructions, *etc*.).

Examples:
- Perform an extensive design space exploration of the trace processor. Measure IPCs for different trace processor configurations, varying the following parameters: …
- Compare IPCs of a trace processor and an equally-provisioned superscalar processor to understand the IPC impact of a distributed microarchitecture. Vary the following parameters of the trace processor and provision the superscalar equivalently: …
- Compare IPC with and without DHP. Vary key parameters that affect DHP coverage, such as trace length. Vary other parameters of the trace processor for sensitivity studies.

- **Contingency plan**
  Some outcomes of the project may involve risk. Later, if you determine these outcomes are unachievable *for reasons beyond your control*, have a backup plan for redirecting the research to alternative outcomes. *Also, break-out your proposal into clear and logical phases, and stage those phases to maximize the number of objectives that can be met.*
  Examples:
  - "We may find that the replay buffer style of selective re-execution is too challenging to get working. As a contingency, we will implement selective re-execution from the existing issue queue using dependency vectors to guide when to re-execute, when to release an instruction from the IQ, *etc*."
  - "We may run into obstacles while implementing the full trace processor. As a contingency, we will focus on the frontend and do more with it, such as implement DHP and other novel trace selection policies to improve the overall efficiency and accuracy of the trace predictor and trace cache combination."
- **References**
  In your proposal, it is appropriate and recommended that you cite any relevant papers in the literature. Include citations in the body of your proposal and a bibliography section (references) at the end.

3. Feedback and Redirection

The instructor will work with each group to ensure a reasonable and mutually-acceptable project is undertaken. Once your proposal is submitted, the instructor will identify problems with the proposal (tasks not described in enough detail, certain aspects infeasible or risky, contingency plan insufficient, project too aggressive, project not aggressive enough, *etc*.). Of course, seek advice continuously both before and after submitting your proposal.

Several weeks into the project, you may discover a major roadblock. Major redirections are allowed under valid circumstances if the instructor is notified and agrees to the changes.

4. Presentation

4.1. Logistics

The last four lectures of the semester are devoted to project presentations. The classroom is equipped with a PC and projector.

- Your presentation must be in Powerpoint format.
- Use Wolfware to hand in the Powerpoint file. It is due by 9 AM the day of your presentation. 1 point (out of 5) will be deducted for every 1 hour you are late. The

instructor will ensure the file is available from the classroom PC, and will open and test it before class begins.

- Presentations will be 15 minutes in duration. The allotted time includes time for questions (~ 2-5 minutes). Obviously, due to schedule constraints, your project does not need to be complete to give the presentation. All group members must take a turn at presenting. The time limit will be strictly enforced. It is wise to practice your talk, time it, and trim it down to the allotted time. (1 slide per minute is a good rule-of-thumb, *e.g.*, 10 minute presentation should have 10 or fewer slides. This is just a guideline for staying within your time budget.)

4.2. Presentation guidelines

Presentation guidelines will be posted on the Wolfware website and I will dedicate a few minutes in class to discuss these guidelines.

In addition, please try to have at least one experimental result by the time of your presentation. This can be anything of an empirical nature.

- For example, if you are implementing DHP, even if the implementation is not complete, it is possible to gather data on the lengths of predicted and alternate paths of if-then-else branches, the total misprediction contribution (%) by these branches versus all branches, the distribution of the number of CMOVs required per predicated branch, *etc*.

5. Paper

Write a **5-page report** that describes your microarchitecture and presents your experimental results and analyses. Assume the reader (me) is a microarchitecture expert, which means there is no need to explain known concepts. Instead, get to the point about your microarchitecture (design choices, policies, mechanisms, *etc*.). Also, do not explain things in terms of simulator implementation or hacks – explain from the view of microarchitecture.

The report should contain the following sections: a template will be provided on the course website.

- Title and authors
- Project outcomes: outcomes achieved, and outcomes attempted but not achieved
- Microarchitecture description (please be organized in the way this is presented)
- Results section (experimental results, graphs, analysis, observations, *etc*.)
- Future work
- References

6. Grading

Proposal (5 points)

Presentation (5 points AND required to receive a grade for your project)

Research & Paper (90 points)

60+ points (C grade range) - No satisfactory outcomes but significant effort.
70+ points (B grade range) - Achieved some outcomes satisfactorily
80+ points (A grade range) - Achieved all outcomes satisfactorily
90 points (A+ grade) - Excelled in all outcomes

Here's the bottom-line: you need to impress me with your project to receive a good grade. A mediocre project will receive a mediocre grade.