

# **16.482 / 16.561: Computer Architecture and Design**

Fall 2013

## Lecture 6: Key Questions October 16, 2013

1. (Review) What is the cause of a control (or branch) hazard?
2. What are the potential solutions for control hazards?
3. What is instruction-level parallelism?
4. Why is ILP limited in basic blocks?

5. What is loop-level parallelism, and how can we exploit it?

6. Briefly describe loop unrolling.

7. Define/describe a branch history table.

8. How do we choose a BHT entry for a given branch?

9. Draw the state diagram for a 2-bit BHT.



11. BHT Example 2: You are given the nested loop shown below. The outer loop starts at address 0 and concludes with the BEQ at address 28; the inner loop starts at address 8 and concludes with the BNE at address 16:

Address		
0	Loop1:	...
8	Loop2:	...
16		<b>BNE R4, Loop2</b>
20		...
28		<b>BEQ R7, Loop1</b>

Assume you have a 4-entry BHT, with all entries initialized to 00. Answer the following:

- How many PC bits do you need to index into this BHT?
- Which PC bits should you use?
- What is the initial prediction for every branch?
- Assume the inner loop has 8 iterations and the outer loop has 4. What is the misprediction rate (i.e., how many mispredictions occur)?  
Hint: The easiest way to track this may be through the use of a table that looks at every branch, the BHT entry it accesses, the prediction (and whether or not it is correct), and any changes to the BHT entry.

**Extra space for BHT Example 2**

12. Define/describe a correlated branch predictor. What are the key differences between a correlated predictor and a simple BHT?

13. Correlating example: Say we have one entry of a simple (2,2) predictor. Assume:

- Entry state is currently: (00, 10, 11, 01)
- Global history is currently: 01 → Last 2 branches were NT, T (T most recent)

Say we have a branch accessing this entry of the table, and that instruction executes five times. What are the predictions for this branch, and how does the predictor entry change, given that:

- The first 2 times, the branch is taken
- The next 2 times, the branch is not taken
- The final time, the branch is taken



14. Describe the operation and purpose of a branch target buffer.