

# CMSC611: Advanced Computer Architecture

## Homework 4

**Question 1:**

(50 points)

Consider a section of code containing three branch instructions, B1, B2, and B3. Looking just at the branch instructions, they are executed in the following order with the action shown at each execution.

Branch Instruction	B1	B2	B1	B2	B1	B2	B3	B1	B2	B1	B2	B3	B2
Action	NT	T	NT	T	T	NT	T	NT	T	T	NT	NT	NT

Here, “T” denotes to “branch taken”, while “NT” denotes to “branch not taken”. **You are asked to use branch predictors to predict branch B2 for each execution.** You need to consider two kinds of branch predictors using different history states: a local predictor, which tracks the last N actions for branch B2, independent of any other branches; and a global predictor, which tracks the actions for the last N branches, across all branches.

- a) Show your prediction results in following tables using a (2,1) predictor. Assume the initial state of the 1-bit predictor is “not taken”.

B2 Execution	Local History	Prediction	Action	New Prediction State			
				NT, NT	NT, T	T, NT	T, T
1							
2							
3							
4							
5							
6							

B2 Execution	Global History	Prediction	Action	New Prediction State			
				NT, NT	NT, T	T, NT	T, T
1							
2							
3							
4							
5							
6							

- b) Show your prediction results in following tables using local or global (2,2) predictors. Assume the initial state of the 2-bit predictor is “weak not taken”. You need to show specific prediction states of the 2-bit predictor in the table using the following notations: strong not taken (00), weak not taken (01), weak taken (10), strong taken (11). For example, if the prediction state is “weak taken”, you would write the prediction as T(10). If the branch is taken, you would write the action as T. That will make the new prediction state “strongly taken”, which you would write as T(11).

B2 Execution	Local History	Prediction	Action	New Prediction State			
				NT, NT	NT, T	T, NT	T, T
1							
2							
3							
4							
5							
6							

B2 Execution	Global History	Prediction	Action	New Prediction State			
				NT, NT	NT, T	T, NT	T, T
1							
2							
3							
4							
5							
6							

**Question 2:**

(50 points)

Assume a sequence of 32-bit memory reads from the following list of addresses:

4	16	32	4	20	80	68	76	224	36	44	16	172	20	24	36	68
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- a) For each of these references, identify the tag and index given a direct-mapped cache with 16 one-word blocks. Make a list to show if each reference is a hit or a miss in the cache and indicate the specific data currently stored in the cache. For example, if a data with the word address “4” is stored in the cache, use “M(4)” to indicate the data in one block of the cache. Assume the cache is initially empty.
- b) Repeat part a) for a direct-mapped cache with 8 two-word blocks.
- c) Repeat part a) for a fully associative cache with 16 one-word blocks. Use LRU replacement if it is needed.