

CS203 Fall 2016
LAB 2
ANSWERS

Lalitha Dwarapudi (SID:861310053)

1.

In a 2-bit branch predictor:

If predictor uses k bits from PC to index into BHT, BHT has 2^k entries.

Since predictor uses 6 bits from the PC to index into the BHT, BHT has 2^6 entries.

The number of entries the BHT has is 64.

Since the BHT is a 2-bit branch predictor, it uses 2 bits for prediction.

Size of the BHT = $(2^6 \times 2) / 8$
= 16 bytes

Size of the BHT in bytes is 16 bytes.

2.

In a (4,2) predictor:

If global branch history of m bits is considered, there are a total of 2^m BHT's.

Since m=4, there are 2^4 BHT's.

If predictor uses k bits from PC to index into BHT, each BHT has 2^k entries.

Since predictor uses 6 bits from the PC to index into the BHT, each BHT has 2^6 entries.

Number of entries the predictor has is $2^m \times 2^k$ entries.

The number of entries the predictor has is $(2^6 \times 2^4) = 1024$.

Since each BHT is a 2-bit branch predictor, it uses 2 bits for prediction.

So, the total size of the correlating predictor = $(1024 \times 2) / 8$
= 256 bytes

Total size of the correlating predictor in bytes is 256 bytes.

3. If the number of bits from the PC to index into the branch history table (BHT) is 6:

Misprediction rate for a predictor is calculated as (number of times it is a prediction miss / total number of branches in the trace file).

The misprediction rates of the given traces and predictor are

Trace	(0,1)	(0,2)	(4,1)	(4,2)
gcc-10K.txt	36.86	34.47	26.14	26.79
gcc-8M.txt	37.56	35.47	24	20.69

4.

A global branch history keeps a shared history of the previous branches that are either Taken/Not Taken.

In gcc-10K.txt trace, misprediction rate of a (0,1) predictor is 36.86%

In gcc-10K.txt trace, misprediction rate of (4,1) predictor is 26.14%

Clearly, we can see that using global branch history, misprediction rate is decreased.

If a branch is correlated with the behaviour of other branches, using a global branch history of the previous branches to predict the outcome of that branch is an advantage. The advantage of a shared history is that any correlation between different branches is part of making the predictions. The performance can be improved by adding global information and not just using local information for each branch. The advantage of this is that it can yield higher prediction rates than standard 2-bit scheme and requires only a trivial amount of additional hardware. Global branch prediction is used in AMD processors, and in Intel Pentium M, Core, Core 2 processors.

Generally applications are designed in such a way that the behaviour of one branch is dependent on previous branches. **Not all applications benefit from using global branch history**. For example, if different branches are uncorrelated, the global branch history is diluted by irrelevant information and this may not include any bits from the same branch if there are many other branches in between. In such a case, the history buffer must be longer in order to make a good prediction.

5.

No, all the entries in the branch predictor are not utilized. This is because there are 2^m BHT's and all the entries in each BHT are not utilized. Moreover if the branch PC is 6 bits, all 2^6 PC's are not available in the trace file. **For a (m,n) predictor, for each branch PC, one of the 2^m BHT's is selected based on the global branch history**. So, the other BHT's having the same PC are not utilized for that branch.

Considering branch PC is 6 bits:

For gcc-10K.txt trace, for (4,1) predictor, number of entries that are utilized are 863

For gcc-8M.txt trace, for (4,1) predictor, number of entries that are utilized are 1023

6.

A local branch predictor has a separate history buffer for each branch instruction. The local predictor consists of a 2 level predictor. The local history table consists of 1024 10-bit entries. Each 10-bit entry corresponds to most recent 10 branch outcomes for that entry.

For eg. if that branch was taken 10 or more times in a row, the entry in the local history table will be all 1's. The selected entry from local history table is used to index a table of 1K entries which provides local prediction. It keeps a history of the previous outcomes for that branch thereby helping in the prediction of that branch which improves branch prediction rate. The Intel Pentium MMX, Pentium II and Pentium III have local branch predictors with a local 4-bit history.

Yes, the local predictors can be combined with correlating predictors that are implemented by using a selector. These are called tournament predictors which can achieve better accuracy and also make use of large number of prediction bits effectively. The advantage of tournament predictor is to select the right predictor for a particular branch either the global predictor or the local predictor.