CSE530 Assignment 100

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1. Automation Script-

The automation script automates the result generation (MPKI- Mispredictions Per 1K Instructions) for all combinations of the index length and history bits (by taking into consideration the history bits < index length condition) for all the 4 types of branch predictors (BiModal, gShare, Yeh-Patt and Hybrid).
In order for the automate script to run as expected, one minor change was done in the run csh script and a few minor changes in the #defines in all the *_bp* (1, 2, 3 and 4) branch predictor implementation files (the original files will need to be replaced with these ones for the script to work correctly, and the script will have to placed at the root level of the git repository folder/directory).

Execution-

```
Usage: source ./automate.sh bimodal/gshare/yehpatt/hybrid/all
```

Note- The 'all' option above generates results for all the branch predictors sequentially i.e. the average MPKI values calculated across all the traces for valid combinations of the index length and the number of history bits.

2. Branch Predictor Results-

1. BiModal

Index Length	MPKI
7	18.35
8	15.21
9	12.9
10	11.58
11	10.71
12	10.2
13	9.89
14	9.83
15	9.76

2. gShare

Index Length	History Bits	MPKI
7	2	18.6
	4	20.21
	6	21.53
8	2	15.62
	4	15.88
	6	17.53

9	2	12.41
	4	13.24
	6	14.21
	8	15.14
10	2	10.49
	4	11.36
	6	11.3
	8	12.18
11	2	9.43
	4	9.31
	6	9.39
	8	9.84
	10	10.46
12	2	8.85
	4	8.31
	6	8.33
	8	8.31
	10	8.7
13	2	8.54
	4	7.83
	6	7.39
	8	7.25
	10	7.4
	12	7.73
14	2	8.37
	4	7.49
	6	6.95
	8	6.69
	10	6.82
	12	6.93
15	2	8.28
	4	7.39
	6	6.74
	8	6.42
	10	6.27
	12	6.29

3. Yeh-Patt

Index Length	History Bits	MPKI
7	2	20.39
	4	17.64
	6	16.17
8	2	17.12
	4	14.51
	6	13.31
9	2	14.89
	4	12.39
	6	11.35
	8	10.28
10	2	13.18
	4	10.84
	6	9.89
	8	8.92
11	2	12.35
	4	10
	6	9.12
	8	8.18
	10	7.72
12	2	11.83
	4	9.47
	6	8.65
	8	7.76
	10	7.35
13	2	11.45
	4	9.13
	6	8.36
	8	7.51
	10	7.12
	12	6.8
14	2	11.22
	4	8.95
	6	8.21
	8	7.36
	10	6.99

	12	6.68
15	2	11.15
	4	8.9
	6	8.16
	8	7.31
	10	6.94
	12	6.63

4. Hybrid

Index Length	History Bits	MPKI
7	2	18.36
	4	20.05
	6	21.32
8	2	15.24
	4	15.21
	6	16.6
9	2	11.88
	4	12.19
	6	12.91
	8	13.42
10	2	10.04
	4	9.58
	6	10.15
	8	10.28
11	2	9.2
	4	8.33
	6	8.39
	8	8.24
	10	8.73
12	2	9.02
	4	7.59
	6	7.15
	8	6.98
	10	7.33
13	2	8.81
	4	7.29
	6	6.79

	8	6.3
	10	6.35
	12	6.61
14	2	8.68
	4	7.1
	6	6.54
	8	6.02
	10	5.82
	12	6
15	2	8.5
	4	7.05
	6	6.47
	8	6.04
	10	5.61
	12	5.69

3. Explanation-

One general observation across all branch predictors is that when the index length increases, the MPKI decreases (for predictors which also have a variation in terms of the history bits used, consider this trend for a constant number of history bits). This is because increasing the index length results in more number of conditional branches' information capable of being stored, since the index length represents the index bits from the LSB of the branch addresses, and as the number of these bits increase, history for more branch addresses can be captured.

BiModal BP- The above observation holds true for this predictor, and as it does not require any history bits by design, there is no observable trend on their basis.

gShare BP- For a constant index length, increasing the history bits also increases the MPKI, up to the point where the index length is 11. As the number of history bits increase, their component/contribution in the XOR with the index bits accounts for more influence. Since this predictor has a global branch history register, unlike the next predictor which maintains multiple local branch history registers in a branch history table, the effect of all conditional branches coincides. This is helpful if the branches are correlated, but if not, the history gets diluted by irrelevant information. With an increase in the history bits, the effect of this dilution, if any, is more prevalent. Then there is also the aliasing problem, where the XORed index into the branch prediction table is the same for two different branches, in which case the prediction accuracy suffers. But at index length equal to 11, change in the number of history bits results in the MPKI values varying within a certain range (both increasing and decreasing at times). Beyond this index length, an increase in the history bits results in a decrease in the MPKI, except for the last one or two counts of the history bits, where the MPKI slightly rises again.

Yeh-Patt BP- For a constant index length, increasing the history bits reduces the MPKI. Here, when the history bits increase, the capability of accessing a higher span/range of the branch predictor table increases. Also, the probability of different branches having the same history in the branch history table reduces. The problem with different branches having the same histories

is that if they don't have any correlation, then the chances of they causing destructive interference for each other increase, since the branch predictor table is shared among all the branches.

Hybrid BP- For a constant index length, up to 10, an increase in the history bits increases the MPKI. For index length 11, with an increase in the history bits, the MPKI hovers around a relatively constant range of values. For an index length of 12 onward, the MPKI decreases with an increasing number of history bits, except for the last value of the history bits, where there is a rise in the MPKI again. These results closely reflect the same trend that was observed in the results for gShare. One observable difference is that with an increase in the index length, the amount by which the MPKI reduces when the history bits are increased is higher in case of this predictor as compared to the gShare predictor. The purpose of using a hybrid predictor is to enable having a choice of selecting the best prediction out of the predictions made by two different predictors, relying on the case where mispredictions by one of these predictors will overlap with correct predictions by the other predictor, thereby allowing the system to get the correct prediction overall, most of the times (but not always, because there could be cases when both of them predicted incorrectly, though the choice of the two predictors is such that this case would become a rare occurrence).