**NC State University**

**Department of Electrical and Computer Engineering**

**ECE 463/563: Fall 2019 (Dr. Huiyang Zhou)**

**Project #2: Branch Prediction**

**By**

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**NCSU Honor Pledge: “I have neither given nor received unauthorized aid on this test or assignment.”**

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**Course Number: \_\_\_\_563\_\_\_\_\_\_\_\_\_\_\_\_**

## Bimodal Predictor

### Graphs

|  |  |
| --- | --- |
| **m** | **Misprediction Rate** |
| 7 | 26.65 |
| 8 | 22.43 |
| 9 | 18.49 |
| 10 | 15.67 |
| 11 | 13.65 |
| 12 | 12.47 |

### Analysis

As we can see from the graph there is a significant drop in the misprediction rate as we increase the size of the bimodal table which tapers off around m=12

### Design

We can minimize costs and obtain a reasonably good misprediction rate if we set m=13 as increasing the table size after that does not result in much drop in the misprediction rate.

### Graphs

|  |  |
| --- | --- |
| **m** | **Misprediction Rate** |
| 7 | 7.92 |
| 8 | 7.79 |
| 9 | 7.74 |
| 10 | 7.7 |
| 11 | 7.62 |
| 12 | 7.6 |

### Analysis

For the jpeg\_trace dataset increasing the table size has no significant impact on the misprediction rate which decreases by just 0.3% when we increase the table size from 64 bits to 8192 bits.

### Design

Considering the lack of improvement in the misprediction rate even though we increase the size of this dataset the ideal size would be to set the index size to m=8 taking the table size to 64 bytes.

### Graphs

|  |  |
| --- | --- |
| **m** | **Misprediction Rate** |
| 7 | 21.31 |
| 8 | 16.45 |
| 9 | 14.14 |
| 10 | 11.95 |
| 11 | 11.05 |
| 12 | 9.09 |

### Analysis

From the analysis of the graph and the values of m till 16 we are able to observe that the misprediction rate tapers off around m=12 at a misprediction rate of around 9%.

### Design

To minimize cost and maintain reasonable prediction accuracy I would set the table size to around m=12 as the subsequent gains in prediction accuracy are not proportional to the required increase in table size. The table size would then be 1KB.

## Gshare Predictor

### Graphs

For gcc\_trace.txt

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **m** | **n=2** | **n=4** | **n=6** | **n=8** | **n=10** | **n=12** |
| 7 | 28.98 | 30.76 | 33.22 |  |  |  |
| 8 | 25.18 | 26.57 | 27.82 | 30.56 |  |  |
| 9 | 20.25 | 22.43 | 24.14 | 26.08 |  |  |
| 10 | 16.39 | 17.99 | 19.36 | 21.1 | 22.77 |  |
| 11 | 13.71 | 14.49 | 15.14 | 16.47 | 18.34 |  |
| 12 | 12.2 | 12.23 | 12.46 | 13 | 14.33 | 15.4 |

### Analysis

The misprediction rate drops at an almost linear rate before tapering off at around m=12 and a misprediction rate of approximately 10%. The best prediction accuracy is observed at m=16 and n=10 at 7.61%.

### Design

Although the best prediction accuracy (7.61%) is observed at m=16 and n=10 which leaves the branch history table at size 16KB. We can also get a prediction accuracy of 9.83% for m=14 and n=10 with the prediction table size of 4KB which would be preferred if lowering the footprint of the BPU is a priority.

### Graphs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **m** | **n=2** | **n=4** | **n=6** | **n=8** | **n=10** | **n=12** |
| 7 | 8.08 | 8.92 | 9.74 |  |  |  |
| 8 | 7.79 | 7.88 | 8.87 | 9.2 |  |  |
| 9 | 7.58 | 7.68 | 8.13 | 8.3 |  |  |
| 10 | 7.49 | 7.38 | 7.58 | 7.45 | 7.95 |  |
| 11 | 7.45 | 7.27 | 7.38 | 7.17 | 7.44 |  |
| 12 | 7.44 | 7.26 | 7.19 | 6.84 | 7.18 | 7.35 |

### Analysis

The misprediction rate for the values of m from 7 to 16 is varies from 9% to 6.66%. We saw a similar trend for the jpeg\_trace dataset for the bimodal predictor as well and can be attributed to the peculiarity of the dataset with high similarity in the branches taken.

### Design

Setting the value of m to 9 and the size of the BHR to n=2 should give us a misprediction rate of 7.58% which limits the size of the prediction tables to just 64 bytes while maintaining a high prediction accuracy.

### Graphs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **m** | **n=2** | **n=4** | **n=6** | **n=8** | **n=10** | **n=12** |
| 7 | 24.34 | 25.96 | 28.71 |  |  |  |
| 8 | 16.92 | 19.09 | 20.45 | 24.79 |  |  |
| 9 | 13.57 | 14.68 | 16.25 | 17.66 |  |  |
| 10 | 10.63 | 11.35 | 11.52 | 12.42 | 14.57 |  |
| 11 | 10.11 | 9.68 | 8.6 | 9 | 8.98 |  |
| 12 | 9.03 | 8.09 | 7.5 | 6.49 | 6.71 | 7.16 |

### Analysis

From the analysis of all the configurations in the 16KB budget we can see that the lowest misprediction rate was observed when m=16 and n=16 at 2.91%. We were successfully able to reduce the misprediction rate all the way from 30% to this range by taking advantage of recognizing the patterns using the BHR.

### Design

Although we get the best misprediction rate at m=16, n=16 we can achieve reasonably close prediction accuracy at m=14 and n=12 at a quarter of the size and it can be an ideal tradeoff. The branch predictor table size would be 4KB.