NC State University

Department of Electrical and Computer Engineering

ECE 463/563 (Prof. Rotenberg)

Project #2: Branch Prediction

by

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NCSU Honor Pledge: "I have neither given nor received unauthorized aid on this project."

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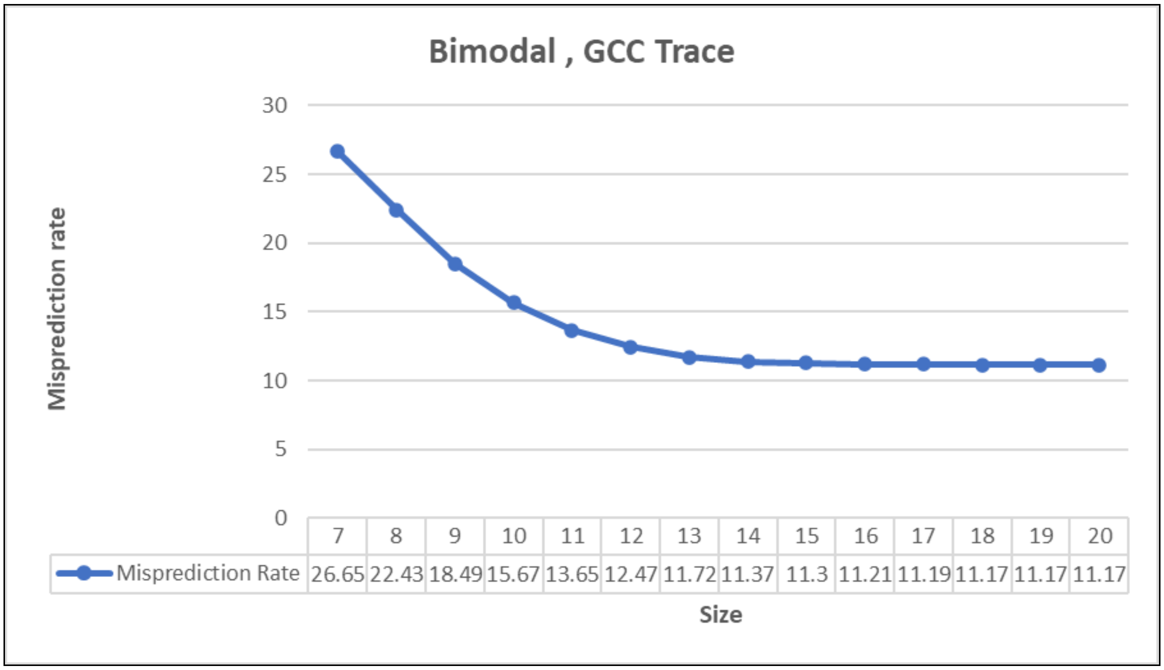
Course number: 563

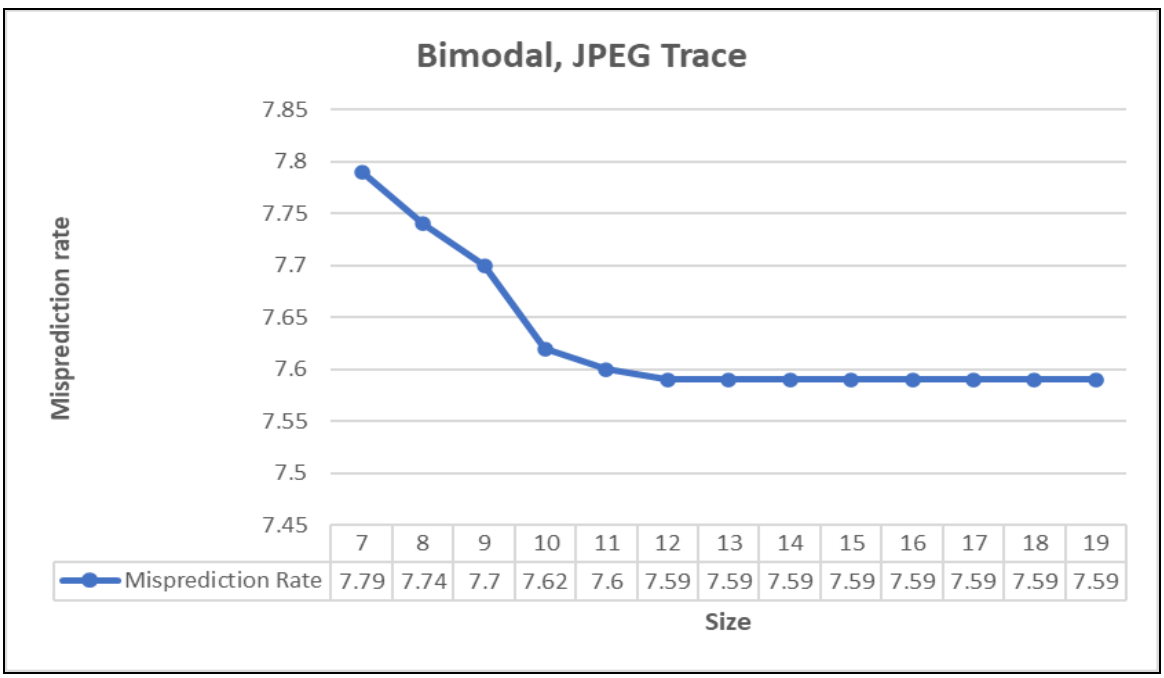
Bimodal Predictor

Bimodal Predictor simulated for different sizes ($7 \leq m \leq 20$) using three different traces (*gcc, jpeg, and perl*).

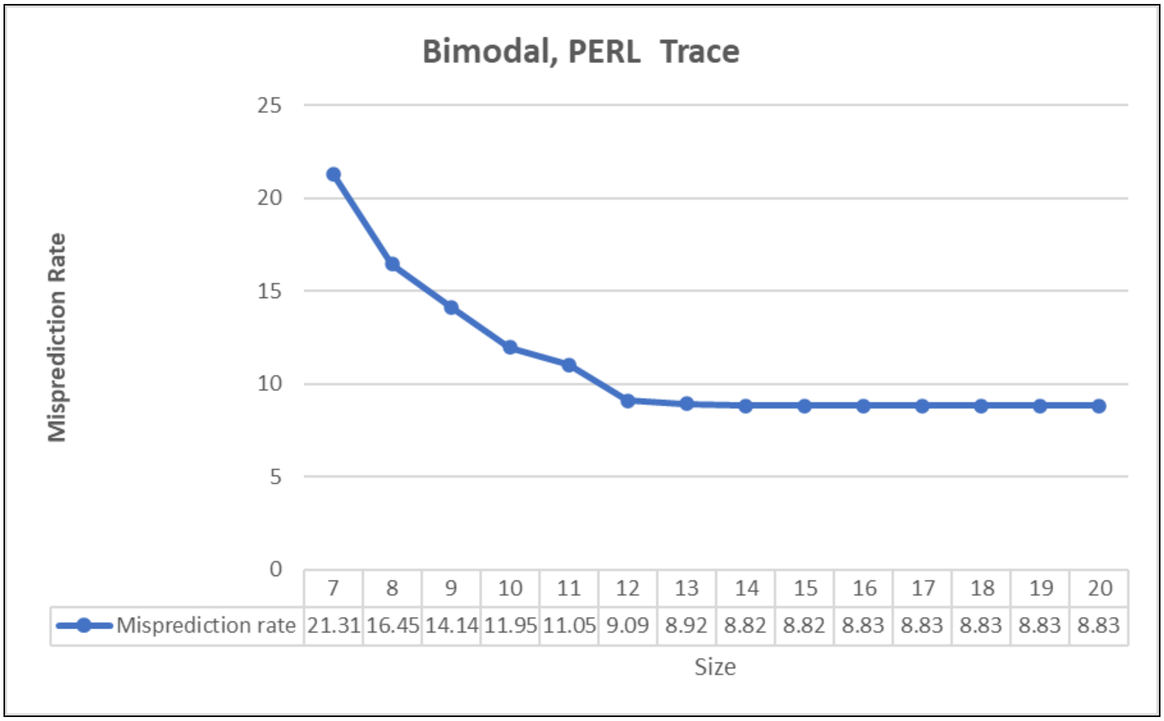
GRAPH #1: (GCC Trace)



GRAPH #2: (JPEG Trace)



GRAPH #2: (PERL Trace)



[5 points] Analysis:

1. [1 point] As the bimodal predictor's table size increases, the branch misprediction rate Decreases.

2. [2 points] For each benchmark, indicate the minimum value of *m* at which the misprediction rate bottoms-out (reaches its minimum) and indicate its minimum misprediction rate.

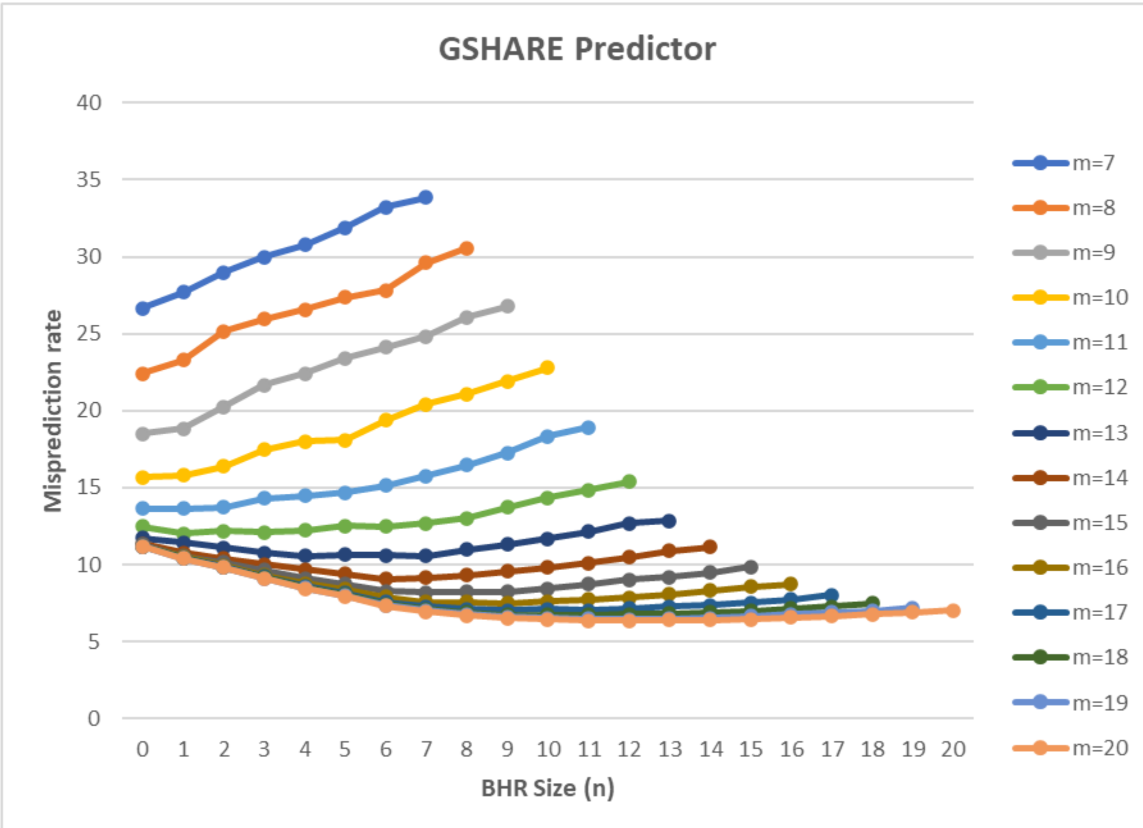
Benchmark	Minimum "*m*" at which misprediction rate (two digits of precision after the decimal point) reaches its minimum	Minimum misprediction rate (two digits of precision after the decimal point)
gcc	*m* = 18	11.17
jpeg	*m* = 12	7.59
perl	*m* = 13	8.82

3. [1 point] At some point, increasing the bimodal predictor's table size is of no value. At this point, each static branch (*i.e.*, each static branch PC) is allocated a dedicated entry in the table. Given that interference among different static branches is eliminated at this point, the only way to improve accuracy further is a better prediction algorithm .

4. [1 point] I infer that ***gcc*** has more static branches (*i.e.*, unique static branch PCs) than ***jpeg***, because ***gcc*** requires more table entries than ***jpeg*** before its misprediction rate bottoms-out.

<u>GSHARE PREDICTOR</u>

GSHARE PREDICTOR simulated for different sizes ($7 \leq m \leq 20$), and for each size, *i.e.*, for each value of m, swept the global history length n from 0 to m using gcc trace.



<u>[5 points] Analysis</u>:

Insight: With the bimodal predictor (n=0: no global history), a given static branch is predicted using only a single 2-bit counter. With the addition of global history, that single counter is *specialized* or *multiplied* into many more counters. All these counters are used by the same static branch for more specialized predictions among its dynamic instances, promising higher accuracy *as long as there are adequate counters available in the table* (not just for this static branch, but for all static branches). Thus, with the addition of global history, there is a need for more 2-bit counters … the key idea being that, at some point, bimodal cannot even take advantage of more counters (see your analysis section for bimodal, above) whereas gshare *can*. Summarizing: *Gshare needs an abundance of counters and, unlike bimodal, it can exploit abundant counters for higher accuracy.*

1. [0.5 points] At small table sizes, global history can <hurt> accuracy. This is because there are <too few> counters.

2. [0.5 points] At large table sizes, global history can <help> accuracy. This is because there are <abundant> counters.

3. [2.5 points] For each table size (*m*), indicate the smallest global history length (*n*) that yields the lowest misprediction rate (use a precision of two digits after the decimal point for misprediction rate; that's what should be in your simulator's output file, in any case), indicate what that lowest misprediction rate is, and indicate the misprediction rate for bimodal.

m	Smallest global history length (*n*) that yields the lowest misprediction rate (two digits of precision after the decimal point)	Lowest misprediction rate (two digits of precision after the decimal point)	Bimodal misprediction rate (*i.e.*, for *n*=0) (two digits of precision after the decimal point)
7	1	27.71	26.65
8	1	23.27	22.43
9	1	18.83	18.49
10	1	15.79	15.67
11	1	13.64	13.65
12	1	12.04	12.47
13	7	10.56	11.72
14	6	9.08	11.37
15	7	8.20	11.30
16	9	7.49	11.21
17	11	7.03	11.19
18	10	6.73	11.17
19	12	6.47	11.17
20	11	6.37	11.17

4. [0.5 points] The *smallest* bimodal predictor that achieves the best bimodal accuracy (lowest misprediction rate, using two digits after the decimal point, among all bimodal configurations) is as follows:

Best bimodal: *m* = 18, misp. rate = 11.17.

5. [0.5 points] The *smallest* gshare predictor that achieves the best gshare accuracy (lowest misprediction rate, using two digits after the decimal point, among all gshare configurations) is as follows:

Best gshare: *m* = 20, *n* = 11, misp. rate = 6.37.

6. [0.5 points] In conclusion, with adequate predictor storage budget, gshare <rocks>.