

NC State University

Department of Electrical and Computer Engineering

ECE 463/563 (Prof. Rotenberg)

Project #2: Branch Prediction

REPORT TEMPLATE (Version 1.0)

by

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

Student's electronic signature: Padmanabha Nikhil
(sign by typing your name)

Course number: 563

Grading Breakdown, Experiments, and Report

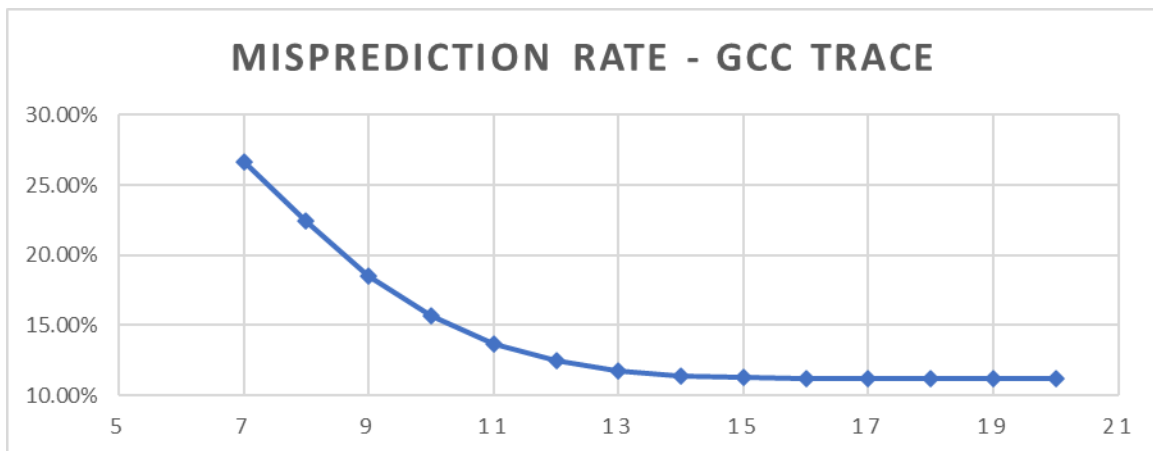
PART 1: BIMODAL PREDICTOR

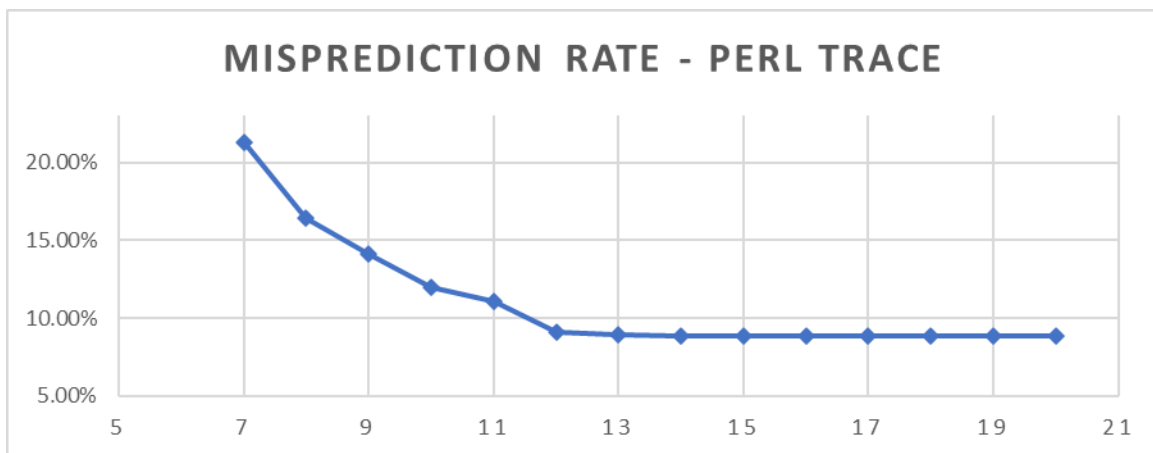
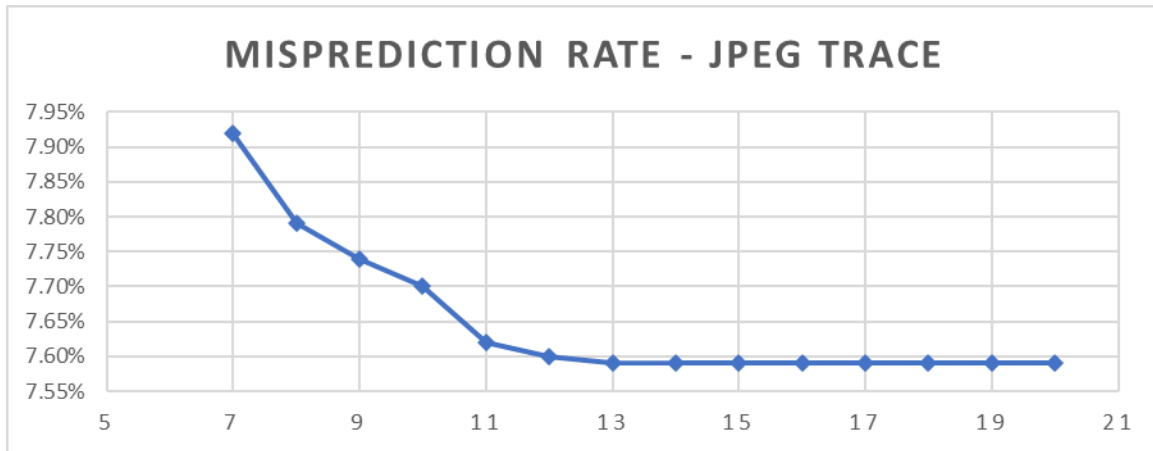
(a) [ECE463: 25 points] or [ECE563: 20 points] Gradescope will evaluate your simulator on the four validation runs “val_bimodal_1.txt”, “val_bimodal_2.txt”, “val_bimodal_3.txt”, and “val_bimodal_4.txt”, posted on the website for the BIMODAL PREDICTOR. Gradescope will also evaluate your simulator on one bimodal predictor mystery run. Each validation run and mystery run is worth $\frac{1}{5}$ of the points for this part (5 or 4 points each). Gradescope must say that you match all four validation runs to get credit for the experiments with the bimodal predictor, however.

(b) [ECE463: 25 points] or [ECE563: 20 points] Simulate BIMODAL PREDICTOR for different sizes ($7 \leq m \leq 20$). Use the traces *gcc*, *jpeg*, and *perl*.

[20 or 15 points] Graphs: Produce one graph for each benchmark. Graph title: “<benchmark>, bimodal”. Y-axis: branch misprediction rate. X-axis: m . Per graph, there should be only one curve consisting of 14 datapoints (connect the datapoints with a line).

PC Bits Size vs Misprediction Rate - BIMODAL BRANCH PREDICTOR														
GCC														
Table Size	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Misprediction Rate	26.65%	22.43%	18.49%	15.67%	13.65%	12.47%	11.72%	11.37%	11.30%	11.21%	11.19%	11.17%	11.17%	11.17%
JPEG														
Table Size	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Misprediction Rate	7.92%	7.79%	7.74%	7.70%	7.62%	7.60%	7.59%	7.59%	7.59%	7.59%	7.59%	7.59%	7.59%	7.59%
PERL														
Table Size	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Misprediction Rate	21.31%	16.45%	14.14%	11.95%	11.05%	9.09%	8.92%	8.82%	8.82%	8.83%	8.83%	8.83%	8.83%	8.83%





[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. **Fill in the table below.**

Benchmark	Minimum " m " at which misprediction rate reaches its minimum	Minimum misprediction rate
gcc	$m = 18$	11.17%
jpeg	$m = 13$	7.59%
perl	$m = 14$	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 **index** 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.

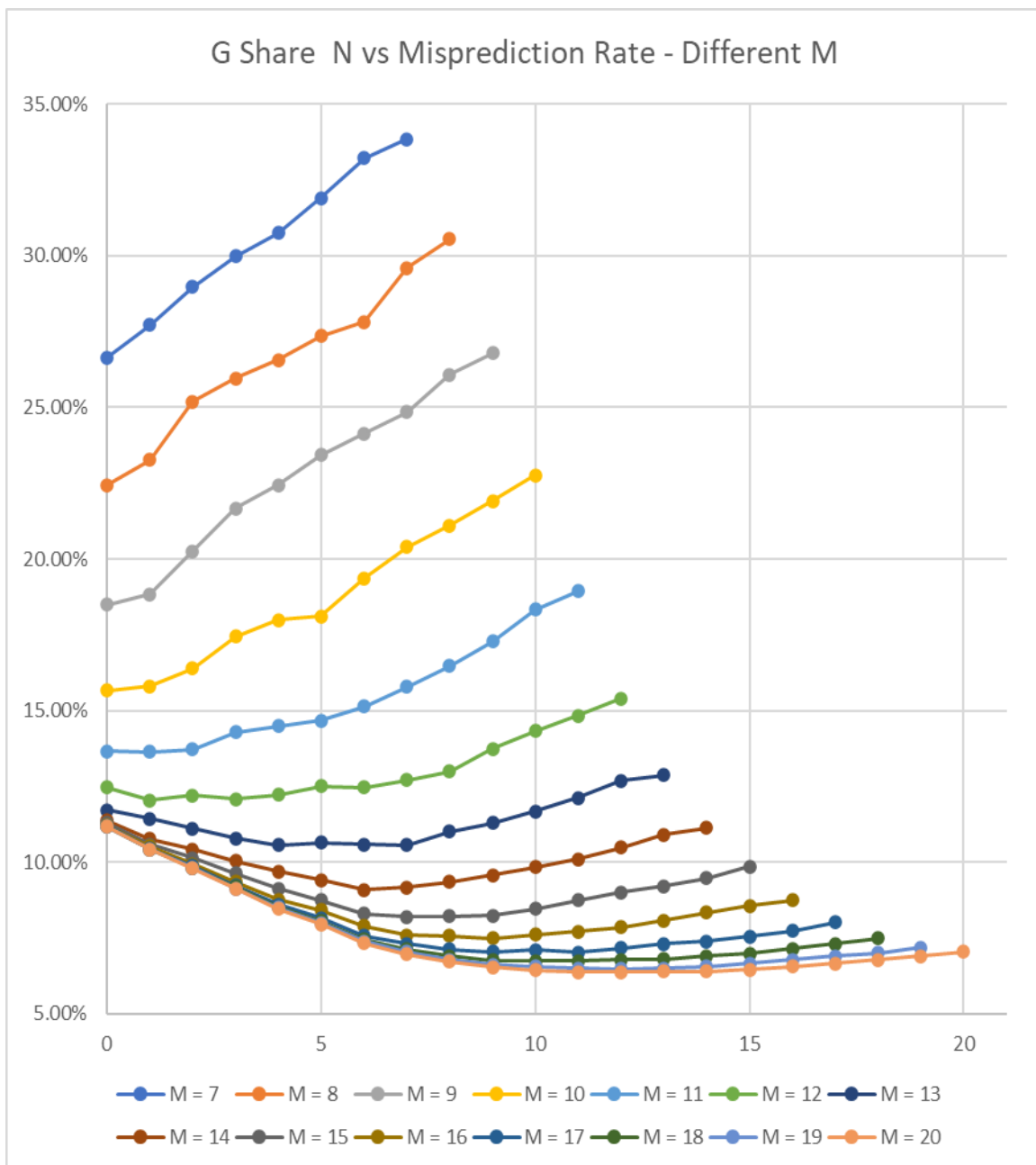
(a) **[ECE463: 25 points]** or **[ECE563: 20 points]** Gradescope will evaluate your simulator on the four validation runs “val_gshare_1.txt”, “val_gshare_2.txt”, “val_gshare_3.txt”, and “val_gshare_4.txt”, posted on the website for the GSHARE PREDICTOR. Gradescope will also evaluate your simulator on one gshare predictor mystery run. Each validation run and mystery run is worth $\frac{1}{5}$ of the points for this part (5 or 4 points each). Gradescope must say that you match all four validation runs to get credit for the experiments with the gshare predictor, however.

[20 or 15 points] **Graphs:** Produce one graph for **gcc**. Graph title: “gcc, gshare”. Y-axis: branch misprediction rate. X-axis: n (spanning $n=0$ to $n=20$). For this graph, there should be a total of 203 datapoints plotted as 14 curves. Datapoints having the same value of m (same predictor size) are connected with a line, *i.e.*, one curve for each value of m . Note that not all curves have the same number of datapoints; see the listing below for the number of datapoints for each of the 14 curves, $m=7$ through $m=20$. The rationale for this graph is to study the effect of global history length for each predictor size.

...

m=20 curve has 21 datapoints: $0 \leq n \leq 20$

[illegible]



[5 points] Analysis:

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 global history length (n) that yields the lowest misprediction rate, indicate what that lowest misprediction rate is, and indicate the misprediction rate for bimodal. **Fill in the table below.**

m	Global history length (n) that yields the lowest misprediction rate	Lowest misprediction rate	Bimodal misprediction rate (<i>i.e.</i> , for $n=0$)
7	0	26.65%	26.65%
8	0	22.43%	22.43%
9	0	18.49%	18.49%
10	0	15.67%	15.67%
11	1	12.04%	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 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 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**.

PART 3: HYBRID PREDICTOR (ECE563 students only)

[ECE563: 20 points] Gradescope will evaluate your simulator on the two validation runs “val_hybrid_1.txt” and “val_hybrid_2.txt” posted on the website for the HYBRID PREDICTOR. Gradescope will also evaluate your simulator on two hybrid predictor mystery runs. Each validation run and mystery run is worth $\frac{1}{4}$ of the points for this part (5 points each).