NC State University

Department of Electrical and Computer Engineering

ECE 463/563: Fall 2018 (Rotenberg)

Project #2: Branch Prediction

by

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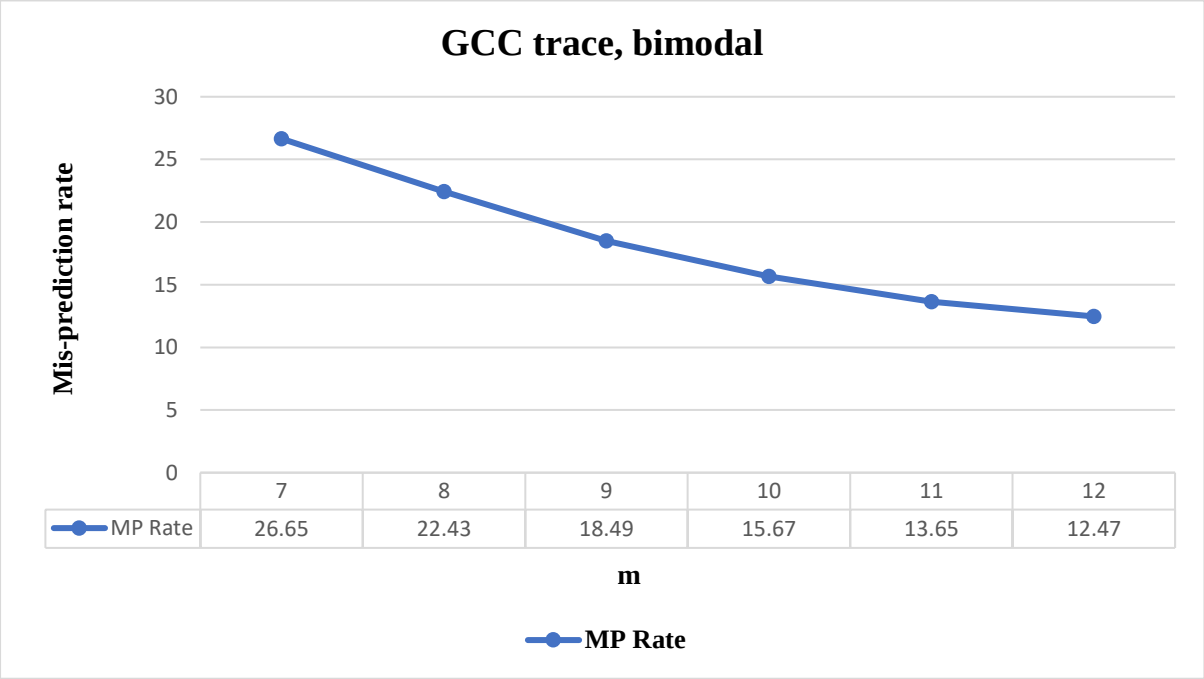
(sign by typing your name)

Course number: ECE 563

(463 or 563 ?)

BIMODAL PREDICTOR

GCC Trace:



DESIGN:

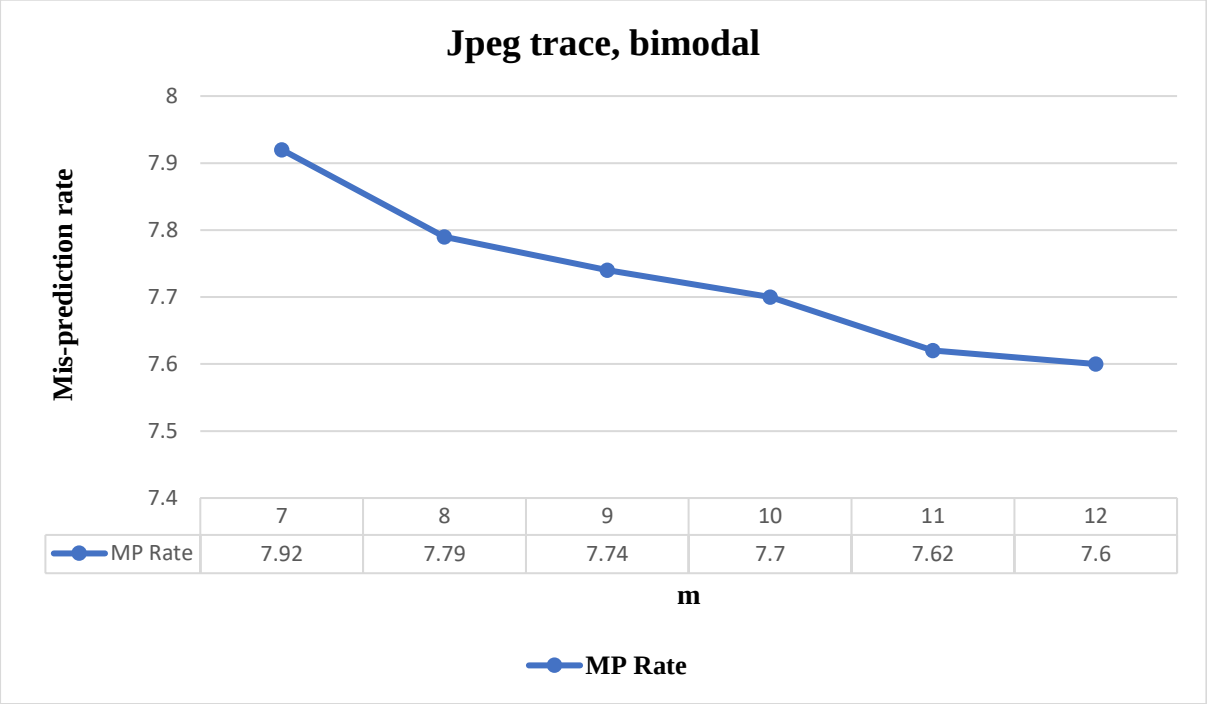
m	Misprediction Rate	m*Misprediction rate
7	26.65	186.55
8	22.43	179.44
9	18.49	166.41
10	15.67	156.7
11	13.65	150.15
12	12.47	149.64
13	11.72	152.36
14	11.37	159.18
15	11.30	169.5
16	11.21	179.36

We need to choose a bimodal predictor design that minimizes both misprediction rate and predictor cost in bits. Hence, we find the product of the two constraints and analyse for the trade-off between them to find the most efficient design.

For m = 12, the design product is found to be minimum and the corresponding size of branch history table is 2*2^12 = 8kilobits = 1kB.

The above method is followed for other traces in-order to design the best bimodal predictor for each case.

Jpeg Trace:



DESIGN:

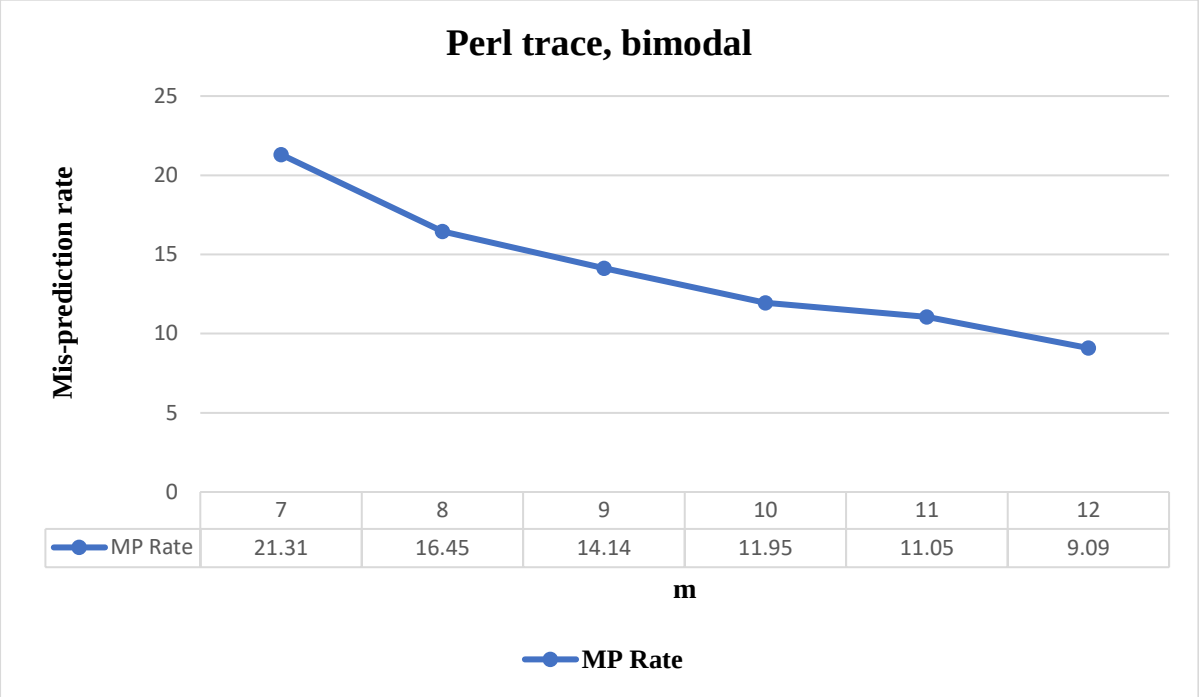
m	Misprediction Rate	m*Misprediction rate
7	7.92	55.44
8	7.79	62.32
9	7.74	69.66
10	7.70	77
11	7.62	83.82
12	7.60	91.2
13	7.59	98.67
14	7.59	106.26
15	7.59	113.85
16	7.59	121.44

For Jpeg trace, the most efficient design is found for m = 7 with a Misprediction rate of 7.92 and a design product of 55.44

Here, as the number of bits is increased, the product too seems to increase since the misprediction rate doesn't experience a large variation.

The size of branch history table for m = 7 is 2*2^7 = 256bits = 32B

Perl Trace:



DESIGN:

m	Misprediction Rate	m*Misprediction rate
7	21.31	149.17
8	16.45	131.6
9	14.14	127.26
10	11.95	119.5
11	11.05	121.55
12	9.09	109.08
13	8.92	115.96
14	8.82	123.48
15	8.82	132.3
16	8.83	141.28

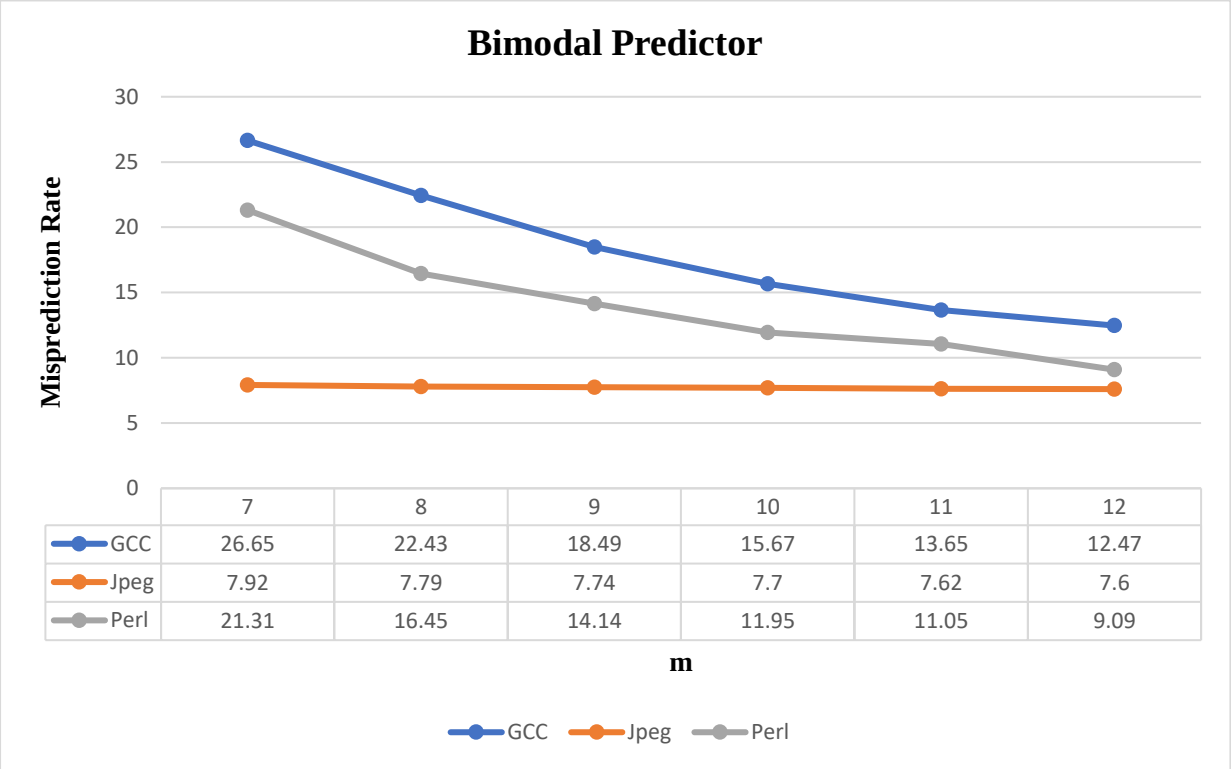
For Perl trace, the most efficient design is found for m = 12 with a Misprediction rate of 9.09 and a design product of 109.08

Alike GCC trace, this trace too portrays a similar performance with the value of misprediction rate decreasing significantly with increase in index bits.

The size of branch history table for m = 12 is 2*2^12 = 1kB

BIMODAL PREDICTOR:

ANALYSIS:



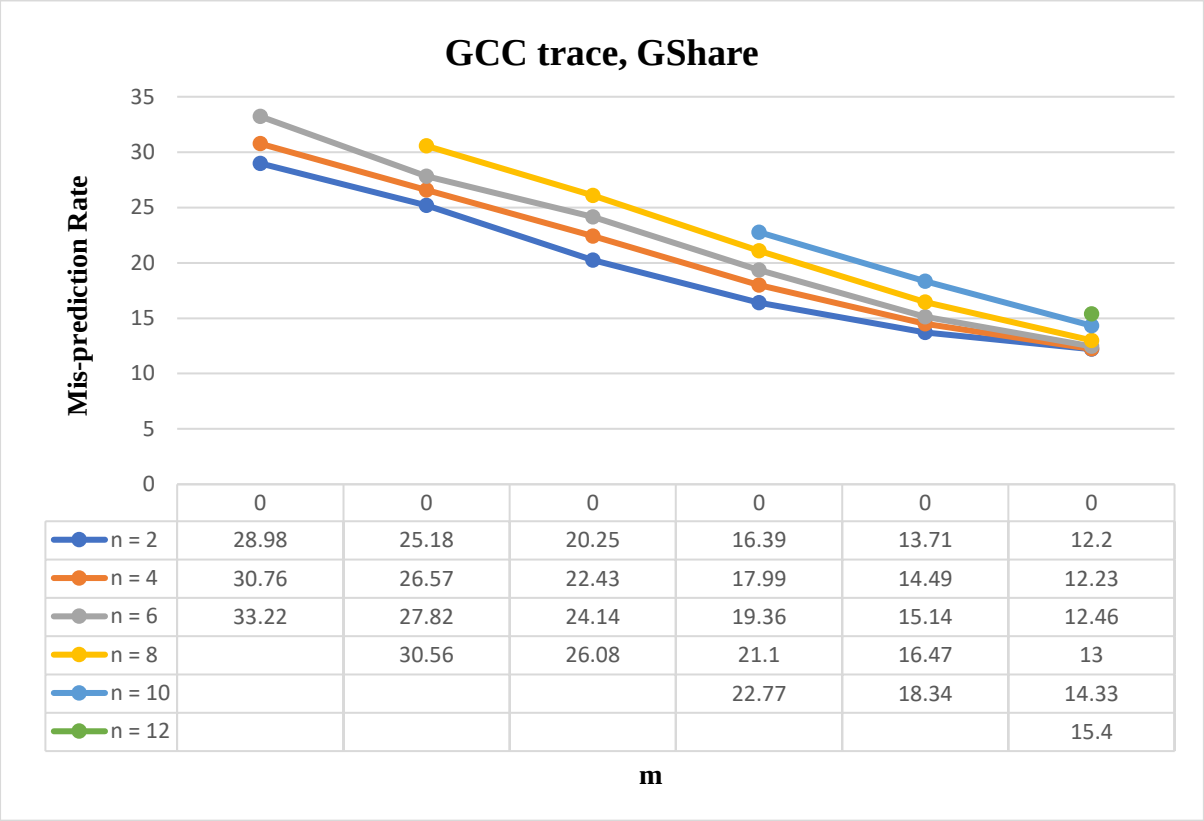
For every trace file, it is found that the misprediction rate decreases with increasing value of m, i.e.,

$$\text{Misprediction Rate} \propto \frac{1}{m}$$

The misprediction rate variation is similar for GCC & Perl traces, and the lowest for Jpeg trace. This may be due to lower number of unique branch addresses or has a high-looping structure. Thus, the predictor gets trained and results in lower probability of misprediction.

GSHARE PREDICTOR

GCC Trace:



DESIGN:

m	7	8	9	10	11	12	13	14	15	16
n = 2 Rate	28.98	25.18	20.25	16.39	13.71	12.2	11.11	10.42	10.13	9.93
n = 2 Product	202.86	201.44	182.25	163.9	150.81	146.4	144.43	145.88	151.95	158.88
n = 4 Rate	30.76	26.57	22.43	17.99	14.49	12.23	10.57	9.69	9.13	8.77
n = 4 Product	215.32	212.56	201.87	179.9	159.39	146.76	137.41	135.66	136.95	140.32
n = 6 Rate	33.22	27.82	24.14	19.36	15.14	12.46	10.59	9.08	8.3	7.89
n = 6 Product	232.54	222.56	217.26	193.36	166.54	149.52	137.67	127.12	124.5	126.24
n = 8 Rate		30.56	26.08	21.1	16.47	13	11	9.34	8.22	7.57
n = 8 Product		244.48	234.72	211	181.17	156	143	130.76	123.3	121.12
n = 10 Rate				22.77	18.34	14.33	11.68	9.83	8.46	7.61

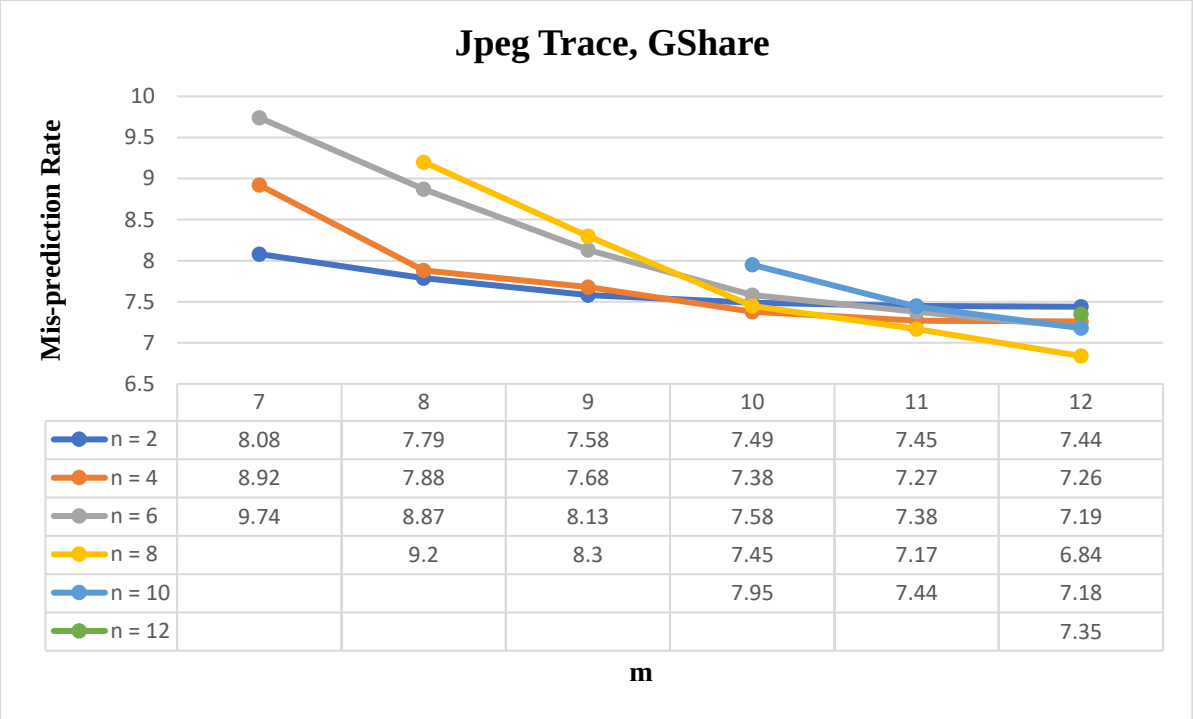
n = 10 Product				227.7	201.74	171.96	151.84	137.62	129	121.76
n = 12 Rate						15.4	12.68	10.48	9.01	7.86
n = 12 Product						184.8	164.84	146.72	135.15	125.76
n = 14 Rate								11.13	9.48	8.34
n = 14 Product								155.82	142.2	133.44
n = 16 Rate										8.75
n = 16 Product										140

For GCC trace – Gshare predictor, the most efficient design is found for n=8, m=16 with a Misprediction rate of 7.57 and a design product of 121.12

The corresponding size of branch history table for n = 8, m = 16 is

$$8 + (2*2^{16}) \approx 128 \text{ kilobits} = 16\text{kB}$$

Jpeg Trace:



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

DESIGN:

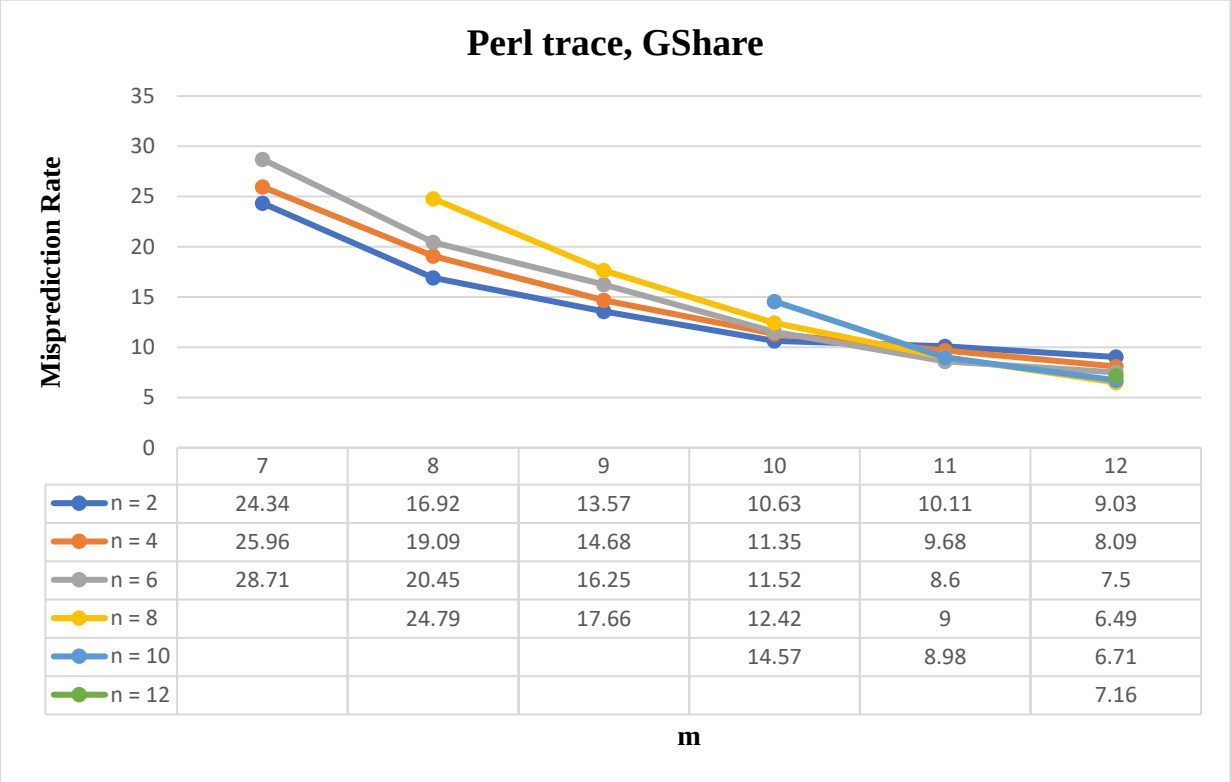
m	7	8	9	10	11	12	13	14	15	16
n=2 Rate	8.08	7.79	7.58	7.49	7.45	7.44	7.33	7.32	7.31	7.31
n=2 Product	56.56	62.32	68.22	74.9	81.95	89.28	95.29	102.48	109.65	116.96
n=4 Rate	8.92	7.88	7.68	7.38	7.27	7.26	7.24	7.17	7.13	7.13
n=4 Product	62.44	63.04	69.12	73.8	79.97	89.28	94.12	100.38	106.95	114.08
n=6 Rate	9.74	8.87	8.13	7.58	7.38	7.19	7.16	7.14	7.09	7.08
n=6 Product	68.18	70.96	73.17	75.8	81.18	86.28	93.08	99.96	106.35	113.28
n=8 Rate		9.2	8.3	7.45	7.17	6.84	6.83	6.69	6.69	6.65
n=8 Product		73.6	74.7	74.5	78.87	82.08	88.79	93.66	100.35	106.4
n=10 Rate				7.95	7.44	7.1	7.02	6.84	6.72	6.7
n=10 Product				79.5	81.84	86.16	91.26	95.76	100.8	107.2
n=12 Rate						7.35	7.17	6.84	6.7	6.66
n=12 Product						88.2	93.21	95.76	100.5	106.56
n=14 Rate								6.93	6.67	6.57
n=14 Product								97.02	100.05	105.12
n=16 Rate										6.68
n=16 Product										106.88

For Jpeg trace – Gshare predictor, the most efficient design is found for n=2, m=7 with a Misprediction rate of 8.08 and a design product of 56.56

The corresponding size of branch history table for n = 2, m = 7 is

$$2 + (2*2^{\wedge}7) \approx 256 \text{ bits} = 32B$$

Perl Trace:



DESIGN:

m	7	8	9	10	11	12	13	14	15	16
n = 2 Rate	24.34	16.92	13.57	10.63	10.11	9.03	9.23	8.07	8.02	8.04
n = 2 Product	170.38	135.36	122.13	106.3	111.21	108.36	119.99	112.98	120.3	128.64
n = 4 Rate	25.96	19.09	14.68	11.35	9.68	8.09	7.27	7.35	7.28	6.54
n = 4 Product	181.72	152.72	132.12	113.5	106.48	97.08	94.51	102.9	109.2	104.64
n = 6 Rate	28.71	20.45	16.25	11.52	8.6	7.5	6.09	5.43	5.71	5.07
n = 6 Product	200.97	163.6	146.25	115.2	94.6	90	79.17	76.02	85.65	81.12
n = 8 Rate		24.79	17.66	12.42	9	6.49	5.26	4.51	4.13	4.12
n = 8 Product		198.32	158.94	124.2	99	77.88	68.38	63.14	61.95	65.92
n = 10 Rate				14.57	8.98	6.71	4.92	3.8	3.58	3.84
n = 10 Product				145.7	98.78	80.52	63.96	53.2	53.7	61.44
n = 12 Rate						7.16	5.09	4.3	3.35	3.53

n = 12 Product						85.92	66.17	60.2	50.25	56.48
n = 14 Rate								3.75	3.58	3.01
n = 14 Product								52.5	53.7	48.16
n = 16 Rate										2.91
n = 16 Product										46.56

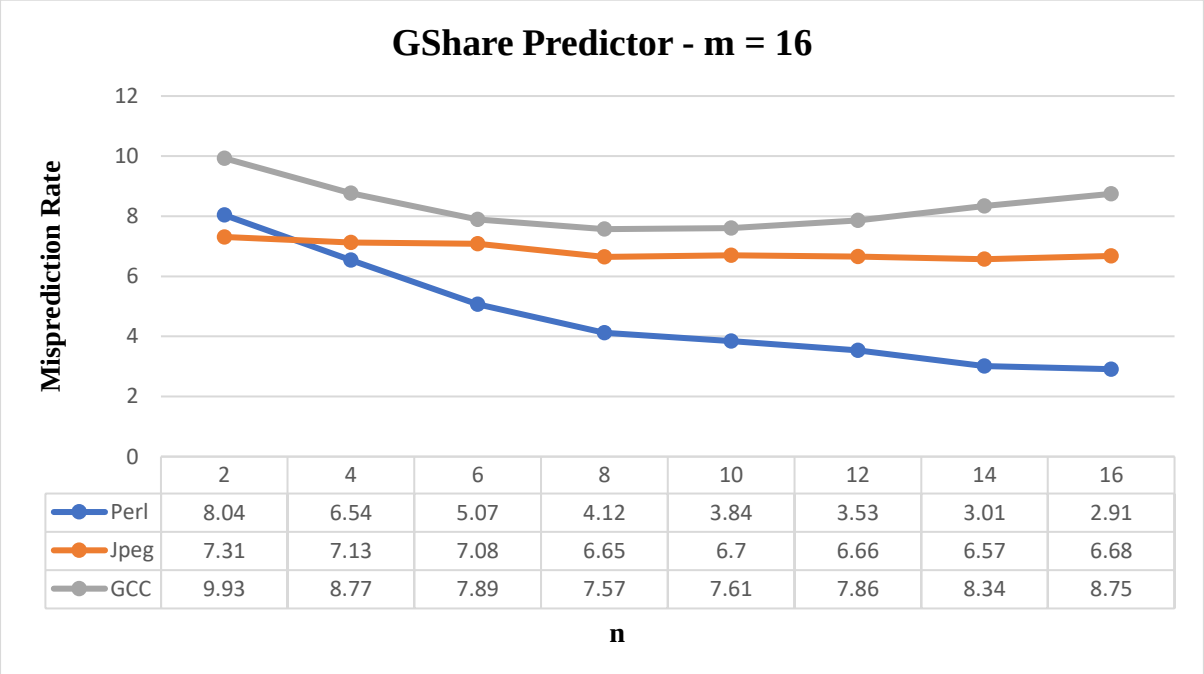
For Perl trace – Gshare predictor, the most efficient design is found for n=16, m=16 with a Misprediction rate of 2.91 and a design product of 46.56

The corresponding size of branch history table for n = 16, m = 16 is

$$16 + (2*2^{16}) \approx 128 \text{ kilobits} = 16\text{kB}$$

GSHARE PREDICTOR:

ANALYSIS:



The graph is plotted for m = 16. Analysing the performance of GShare predictor across the three traces, it is found that the GShare predictor displays similar performance to that of bimodal predictor with misprediction rate decreasing with increasing value of m. The lowest design product obtained using the GShare predictor is lower than that of bimodal due to the use of better indexing strategy.