ECE 586 FINAL PROJECT REPORT

Team 16 | Sai Kumar Reddy Pulagam | Reshwanth Sri Sai Sesham

Competitive Predictor:

Overview:

In this project we have implemented three competitive predictors considering different scenarios and references. We have implemented two hybrid predictors and one perceptron based predictor.

Hybrid Predictor :

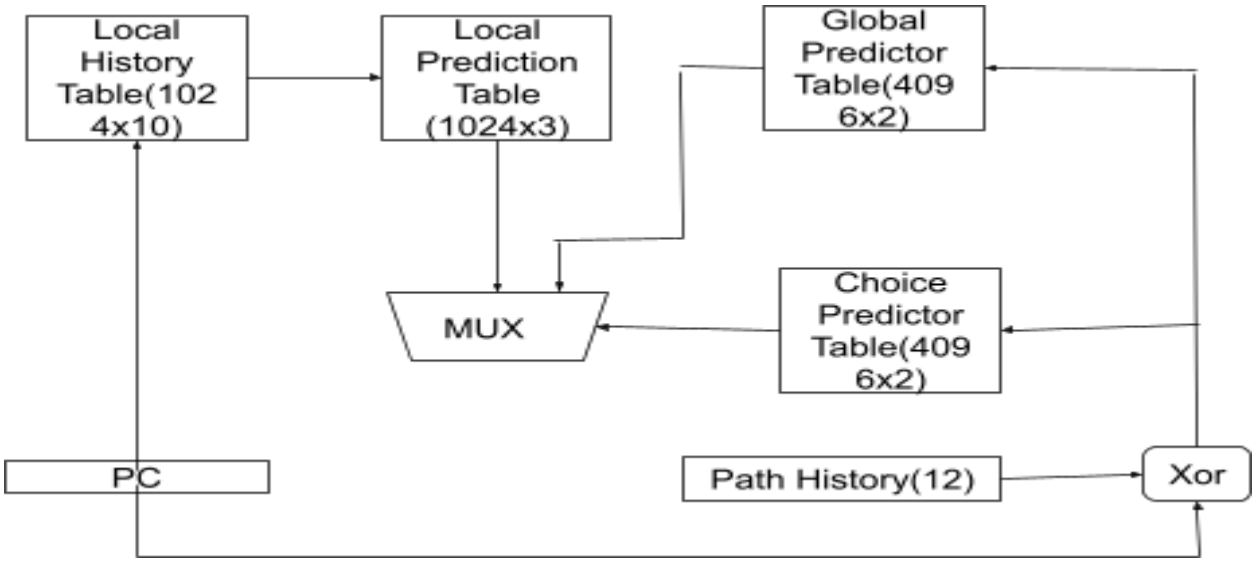
Data Structures or Tables:

Local History Table (1024x10)
Local Prediction Table (1024x3)
Global Prediction Table (4096x2)
Choice Prediction Table (4096x2)
Global History Bits(path history) (12)

Storage:

1024*10+1024*3+4096*2+4096*2+12= 29708/8 =3713.5 bytes= 3.7135 KB

Block Diagram:



Algorithm:

This predictor is similar to the Alpha Predictor.

Indexing and Prediction:

We have considered using the index of the global prediction table and choice predictor as hashing of PC index and path history bits.
global_idx=PCbits xor path_historybits
The local history table is indexed by PC bits[2:11], each entry consists of 10 history bits of a particular branch.
The local predictor table is indexed by 10 local history bits, predicts branch taken if value is greater than 3 else not taken
The choice predictor indexed by hashed result chooses between the local predictor and global predictor. If the value is 0,1 local predictor result is given out else global predictor result.

The global predictor indexed by hashed result predicts branch taken if the value is greater than 1 else not taken.

Used 2-bit Saturation counters in the global Predictor table and choice predictor table
Used 3-bit Saturation counter in Local Predictor Table.

Updation:

If the branch is conditional then comparing if global is predicted true and local prediction is false and choice prediction value is less than 3.
Increment the value
If the branch is conditional then comparing if global is predicted false and local prediction is true and choice prediction value is greater than 3.
Similarly, we update the local predictor table and global predictor table.
And we will update the local history table and global history with the outcome.

Conclusions:

This Hybrid Predictor outperforms the tournament predictor in all standards INT, MM, FP, SERV. As per the statistics mentioned below in table 1, the misprediction rate of hybrid predictor is slightly lesser than the tournament predictor.

References:

This logic is inferred from the Tournament predictor, G-Share Predictor and tage hybrid predictor.
Lecture Slides

Perceptron Predictor:

Constraints Given : storage budget is no more than 4k+4 bytes
Given a fixed hardware budget, three parameters need to be tuned to achieve the best performance: the history length, the number of bits used to represent the weights, and the threshold.

Data Structures or tables:

Glocal History register: 28 //best history range as per the paper is 12 to 62
As per the paper the best history length for 4kB storage is 28.
Perceptron table:128 entries
Bits in weight : 8

Storage:

Size of predictor = 128*8*(28+1)= 29,696 bits =3.712 KB

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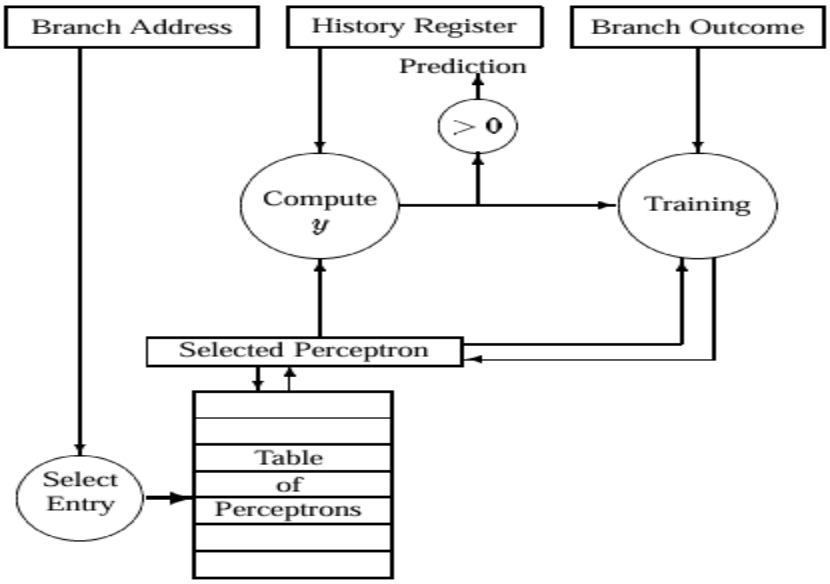

Algorithm:

As cited in the paper the best threshold for given history length is :1.93*hist_len+14.

1. The branch address is hashed to produce an index i 0::N 1 into the table of perceptrons.
2. The ith perceptron is fetched from the table into a vector register,P0::n ,of weights.
   (The Perceptron predictor finds an individual correlation factor for each bit position in the global history)
3. The value of y is computed as the dot product of P and the global history register.
4. The branch is predicted not taken when yi Negative,or taken otherwise.
5. Once The Actual Outcome Of The Branch Becomes Known,the training algorithm uses this outcome and the value of y to update the weights in P.
6. P is written back to the ith entry in the table.

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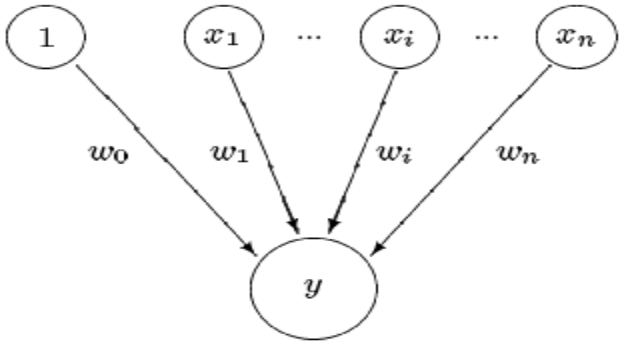

shows graphical model of a perceptron

$$y = w_0 + \sum_{i=1}^{n} x_i w_i.$$

Updating weights:

```
if sign(y_out) ≠ t or |y_out| ≤ θ then
        for i := 0 to n do
                w_i := w_i + t x_i
        end for
end if
```

Conclusions:

Unfortunately it could not perform well over tournament predictor or perceptron predictor in all the standards. This predictor performs the worst in the SERV standard.

References:

Dynamic Branch Prediction with Perceptrons by Daniel A. Jim´ enez, Calvin Lin
Link: https://www.cs.utexas.edu/~lin/papers/hpca01.pdf

Hybrid Predictor 1:

Data Structures or Tables:

Global Prediction Table(8192x2)
Local Prediction Table(4096x2)
Choice Prediction Table(4096x2)
Path history(13)

Storage:

Size of predictor = 8192*2+4096*2+4096*2+13=32781

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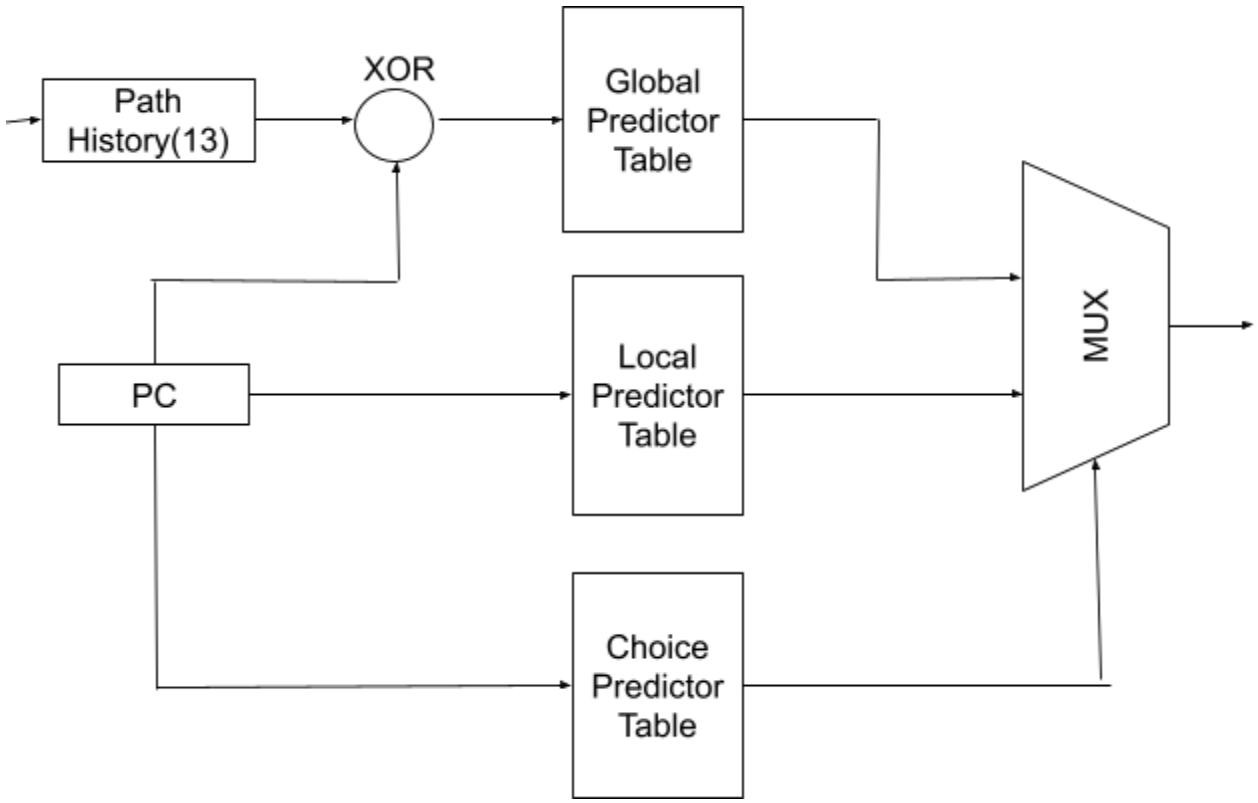
Block Diagram:



Algorithm:

Indexing:

In this, path history bits and PC 13 bits are xored to index the global predictor table.

Local predictor table and choice predictor table is indexed by 12 PC bits.

Prediction:

In the global predictor table and local predictor table, we are using a 2-bit saturating counter, the prediction is true if the value is greater than 1 else false.

In Choice predictor, we used 2-bit saturating counter, where we choose local prediction if value is less than 2 else global prediction.

Updation:

The path history or global history is updated using the prediction.

The prediction tables are updated similarly, depending on the value in the predictor tables and features of the saturating counter.

References:

Analysis and Optimization of the Branch Prediction Unit of SweRV EH1
https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9996038

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Experimental Results:

The table represents the mispredicts / 1000 instructions of different predictors for various standards.

Standards	Tournament Predictor	Hybrid Predictor 0	Perceptron Predictor	G-SHARE Predictor	Hybrid Predictor 1
INT-1	7.397	7.273(o)	7.964	8.593	8.829
INT-2	9.715	9.597(o)	11.175	9.105	8.834
INT-3	12.050	12.756	11.864(o)	15.191	13.728
INT-4	2.425	2.286(o)	3.252	2.624	2.778
INT-5	0.406	0.394	0.378(o)	0.565	0.496
MM-1	8.299	7.991	7.572(o)	8.556	8.639
MM-2	10.970	10.766	9.792(o)	11.701	10.707
MM-3	2.021	1.800(o)	3.785	5.537	5.480
MM-4	2.165	2.034	1.618(o)	2.135	2.059
MM-5	6.436	6.115	7.753	7.210	5.841(o)
FP-1	3.286	3.080	2.497(o)	4.092	4.554
FP-2	1.317	1.135	1.101(o)	1.217	1.208
FP-3	0.518	0.473(o)	0.528	0.622	0.514
FP-4	0.266	0.265	0.210(o)	0.319	0.303
FP-5	1.397	0.336(o)	0.791	1.856	1.698
SERV-1	9.853	9.693	17.844	7.247	6.094(o)
SERV-2	10.299	10.228	18.775	7.678	6.359(o)
SERV-3	7.687	7.512	11.117	7.580	6.349(o)
SERV-4	9.492	9.537	14.742	7.450	6.238(o)
SERV-5	9.780	9.755	15.759	7.781	6.365(o)

(o)-represents which predictor performs best in particular standard traces

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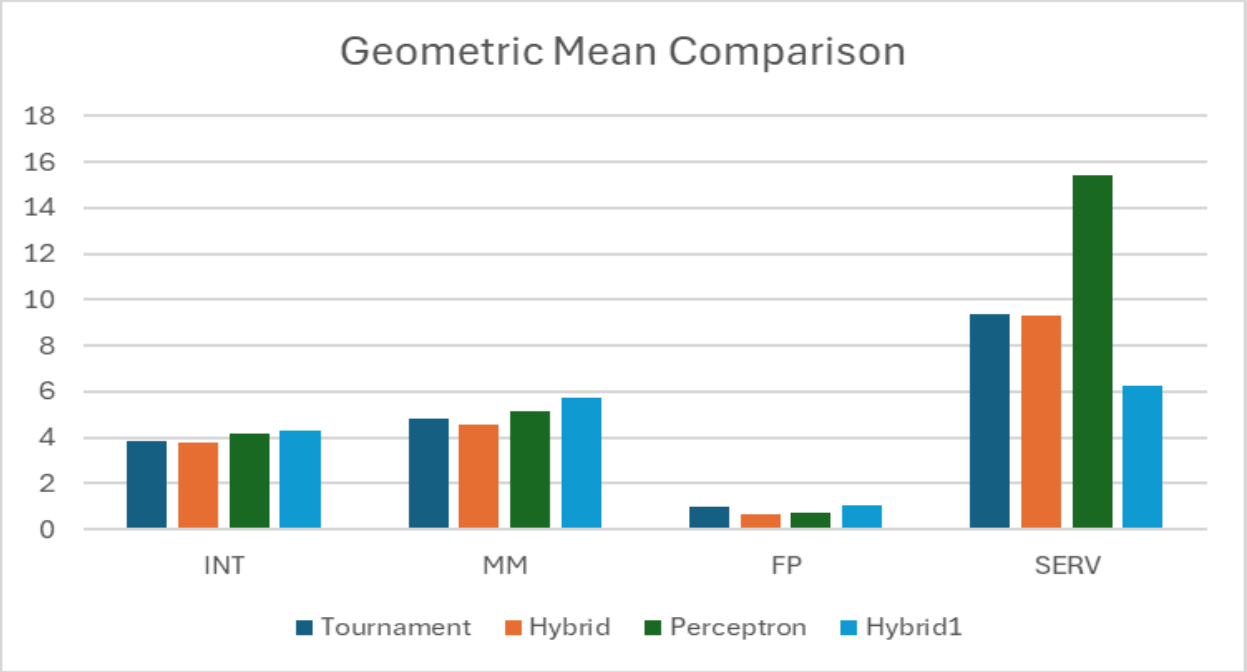
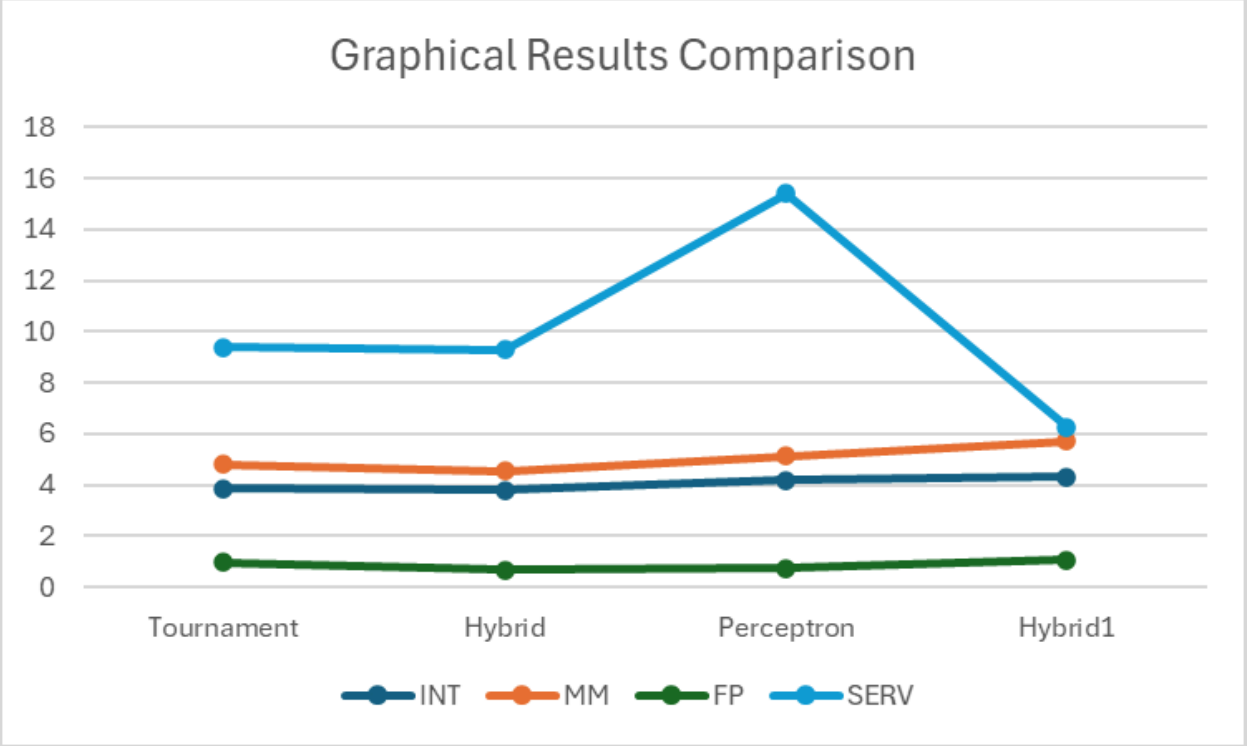


Bar Graph represents the geometric means for different predictors on INT, MM, FP, SERV standards



Plottinging represents the geometric means for different predictors on INT, MM, FP, SERV standards