Competitive Predictor:

Hybrid Predictor:

Elements:

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

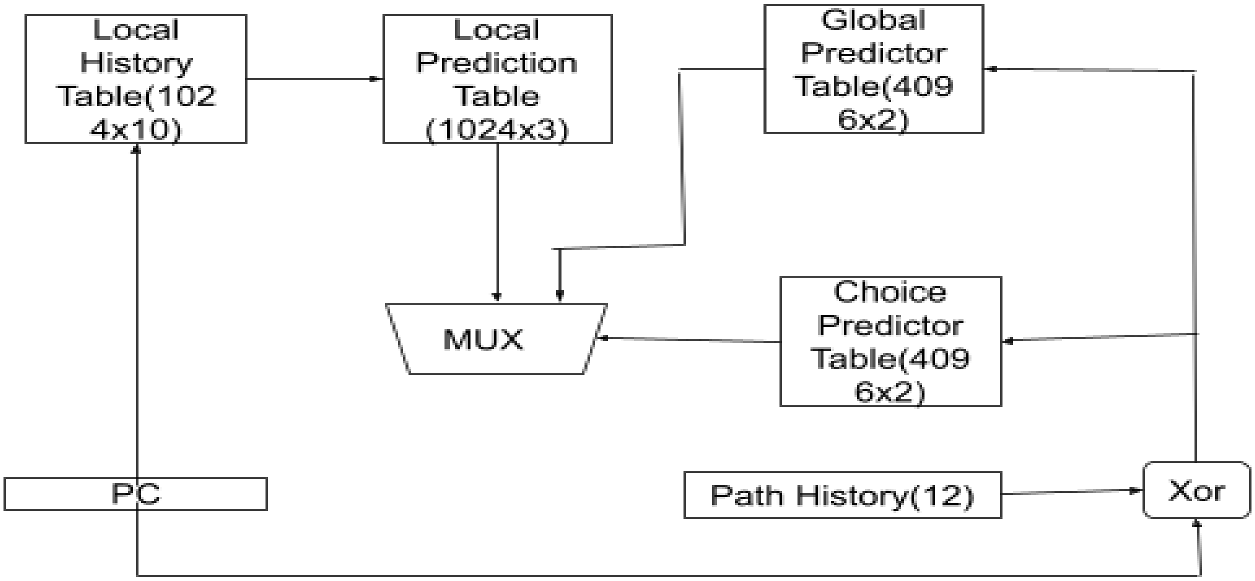
Storage:

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

Algorithm:

This predictor is similar to the Alpha Predictor.
I 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.

Represents the implementation of the Hybrid Predictor


Local History Table(1024x10)
Local Prediction Table (1024x3)
Global Predictor Table(4096x2)
MUX
Choice Predictor Table(4096x2)
PC
Path History(12)
Xor

Experimental Results:

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.

Elements:

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

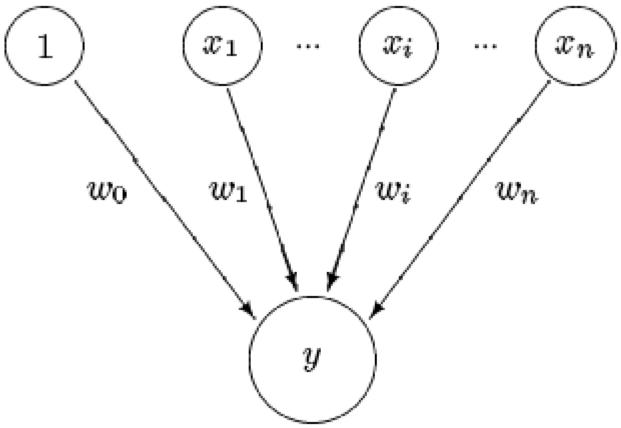
Storage:

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

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.



shows graphical model of a perceptron

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

Updating weights:

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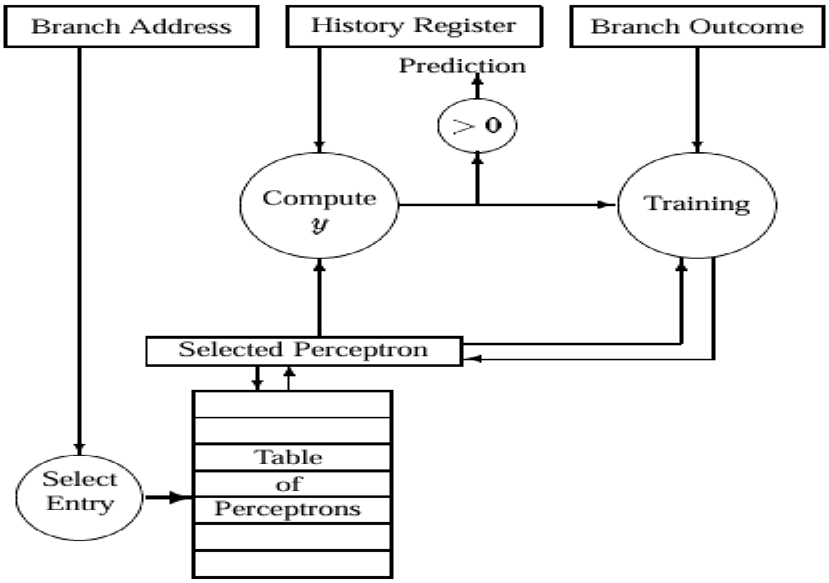
if sign($y_{out}$) $\neq t$ or $|y_{out}| \leq \theta$ then
        for $i := 0$ to $n$ do
                $w_i := w_i + t x_i$
        end for
end if
```



Perceptron Predictor Block Diagram

Limitations:

Unfortunately it could not perform well over tournament predictor or perceptron predictor in all the standards.

This predictor provides more efficiency for the linear separable data.

As, this is single level history .i.e; only depends on global history.

References:

Dynamic Branch Prediction with Perceptrons by Daniel A. Jim´ enez, Calvin Lin

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

Standards	Tournament Predictor	Hybrid Predictor	Perceptron Predictor	G-SHARE Predictor
INT-1	7.397	7.273(o)	7.964	8.593
INT-2	9.715	9.597(o)	11.175	9.105
INT-3	12.050	12.756	11.864(o)	15.191
INT-4	2.425	2.286(o)	3.252	2.624
INT-5	0.406	0.394(o)	0.378(o)	0.565
MM-1	8.299	7.991	7.572(o)	8.556
MM-2	10.970	10.766	9.792(o)	11.701
MM-3	2.021	1.800(o)	3.785	5.537
MM-4	2.165	2.034	1.618(o)	2.135
MM-5	6.436	6.115(o)	7.753	7.210
FP-1	3.286	3.080	2.497(o)	4.092
FP-2	1.317	1.135	1.101(o)	1.217
FP-3	0.518	0.473(o)	0.528	0.622
FP-4	0.266	0.265	0.210(o)	0.319
FP-5	1.397	0.336(o)	0.791	1.856
SERV-1	9.853	9.693(o)	17.844	7.247
SERV-2	10.299	10.228(o)	18.775	7.678
SERV-3	7.687	7.512(o)	11.117	7.580

SERV-4	9.492(o)	9.537	14.742	7.450
SERV-5	9.780	9.755(o)	15.759	7.781

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