

ALPHA Tournament Predictor:

Elements:

Local History Table (1024x10)

Local Prediction Table (1024x3)

Global Prediction Table (4096x2)

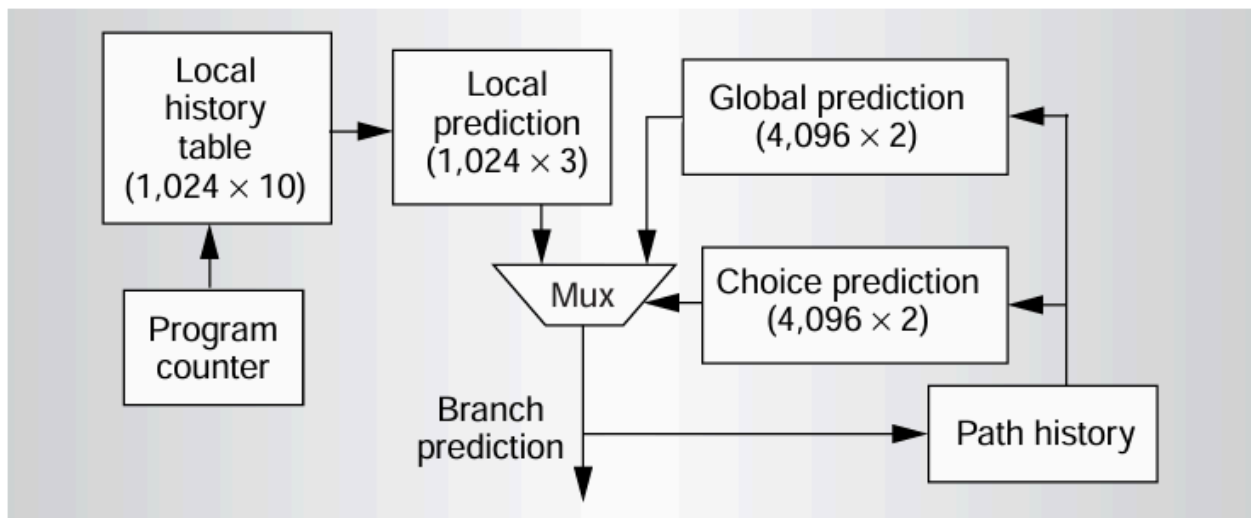
Choice Prediction Table (4096x2)

Global History Bits(path history) (12)

Storage:

$1024 \times 10 + 1024 \times 3 + 4096 \times 2 + 4096 \times 2 + 12 = 29708/8 = 3713.5 \text{ bytes} = 3.7135 \text{ KB}$

Considered Saturating counters for Global Predictor, Choice Predictor and Local Predictor.



IMG1:Represents the implementation of the Tournament 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:

$1024 \times 10 + 1024 \times 3 + 4096 \times 2 + 4096 \times 2 + 12 = 29708/8 = 3713.5 \text{ bytes} = 3.7135 \text{ KB}$

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.

$\text{global_idx} = \text{PCbits} \text{ xor } \text{path_historybits}$

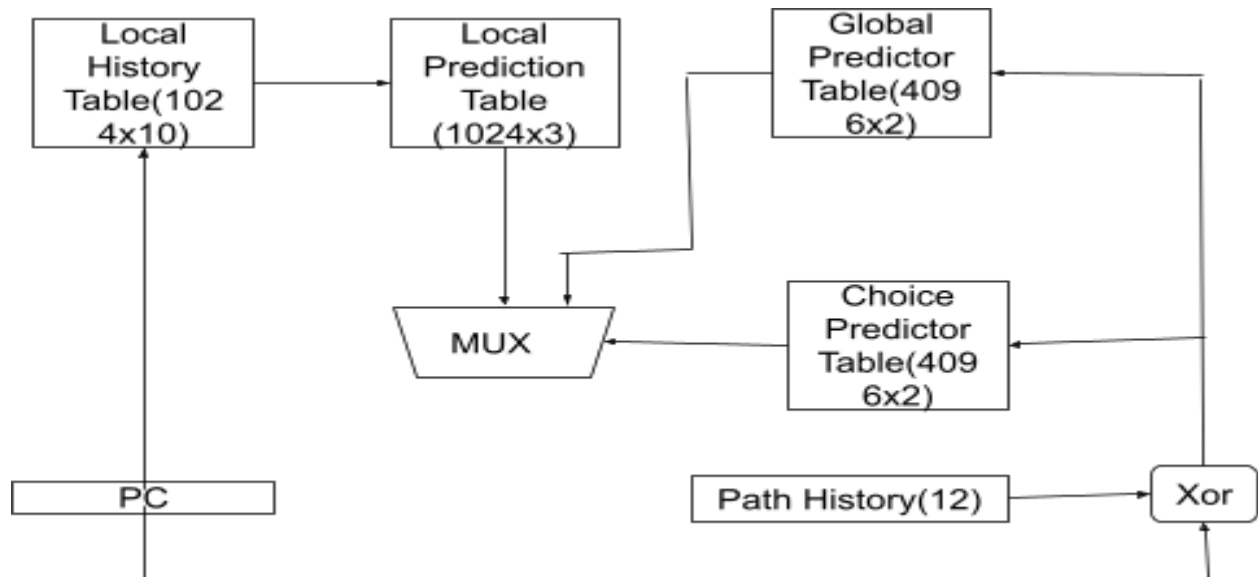
The local history table is indexed by PC bits[2:11], each entry consists of 10 history bits of a particular branch.

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.

IMG2:Represents the implementation of the Hybrid Predictor



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 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:

Global 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

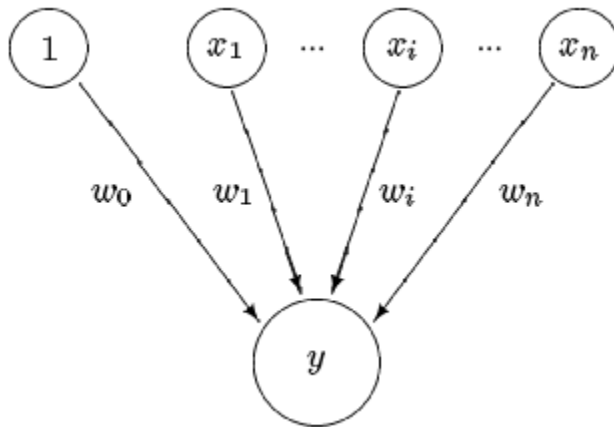
Storage:

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

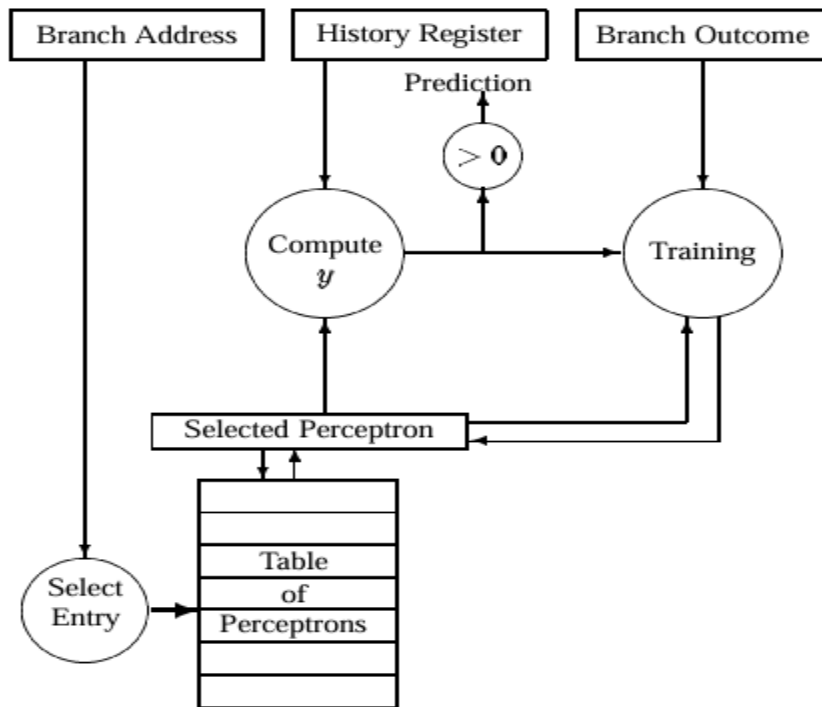
Algorithm:

As cited in the paper the best threshold for given history length is : $1.93 * \text{hist_len} + 14$.

1. The branch address is hashed to produce an index i $0::N-1$ into the table of perceptrons.
2. The i th perceptron is fetched from the table into a vector register, $P_{0::n}$, of weights.
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 y is 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 i th entry in the table.



shows graphical model of a perceptron



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.

References:

Dynamic Branch Prediction with Perceptrons by Daniel A. Jimenez, 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