

Computer Architecture Project

Evaluating Branch Prediction Strategies

Lulu Jiang
Ruotian Zhang
Junjie Feng

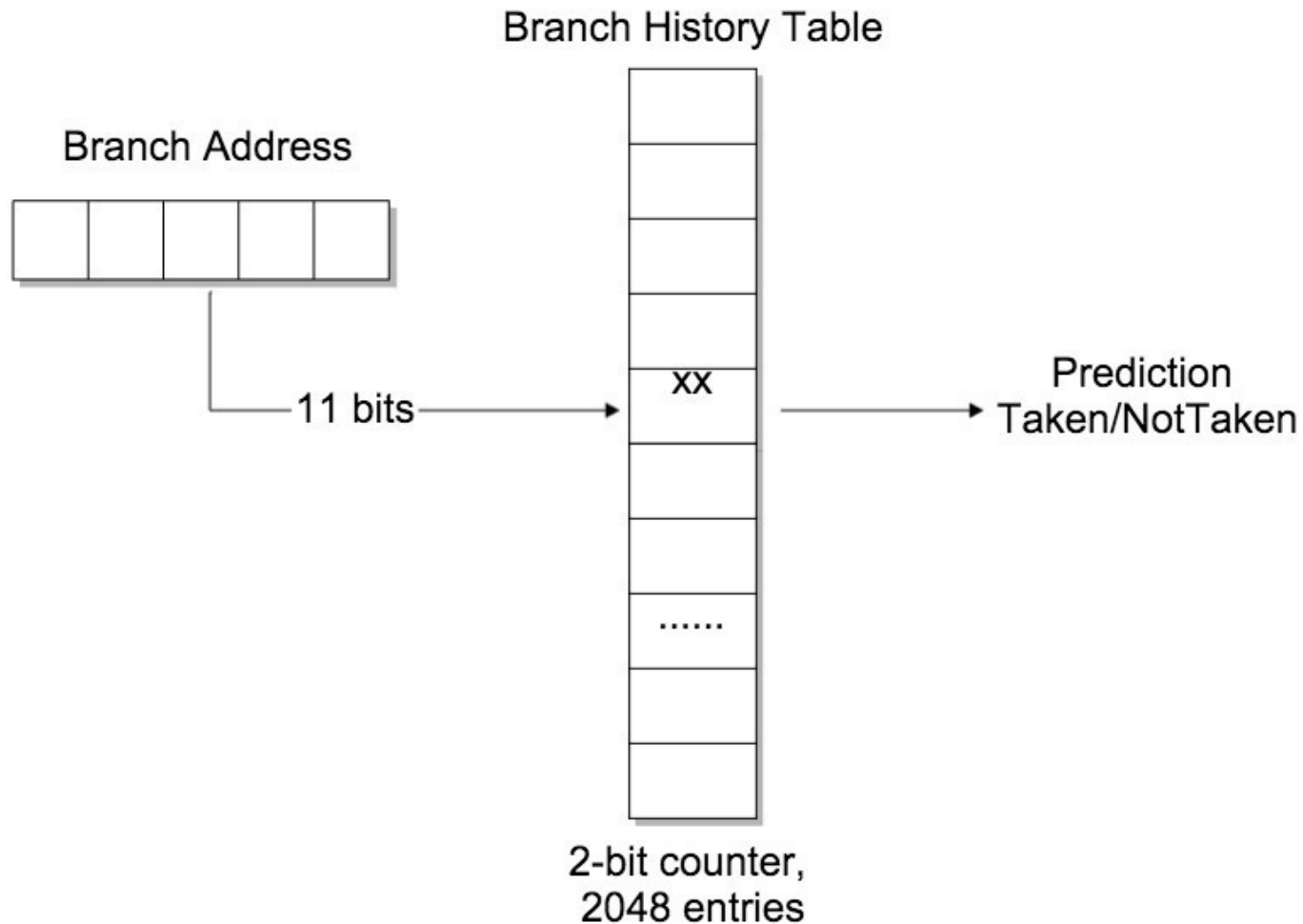
Simplescalar

- Simulation platform: Simplescalar simulator
- Benchmarks: SPEC95 benchmark suites
- In our project, we choose these benchmark:
- 1) apsi 2) ijpeg 3) perl 4) tomcatv 5) cc1
6) vortex

The default branch prediction strategies in SimpleScalar

- Taken: predict all the branches will be taken.
- Not-Taken: predict all the branches will be not taken.
- Bimod: 1) *use a branch history table, which contains 2048 entries.* 2) *Each entry of has 2-bit counter.* 3) *Using low-order 11-bit to index the entry.*

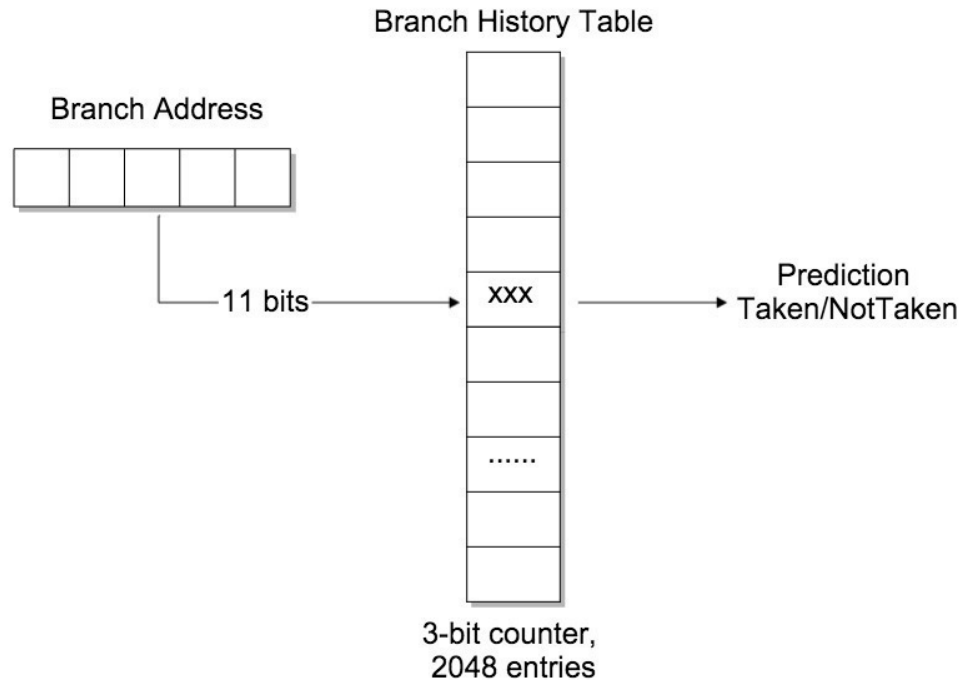
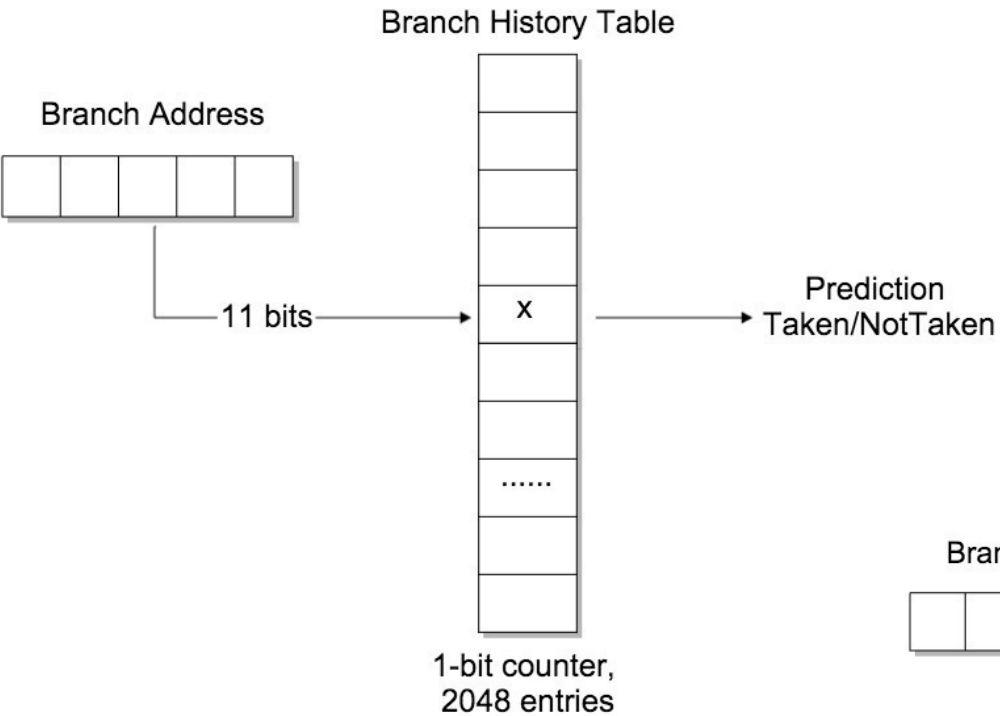
Bimod predictor



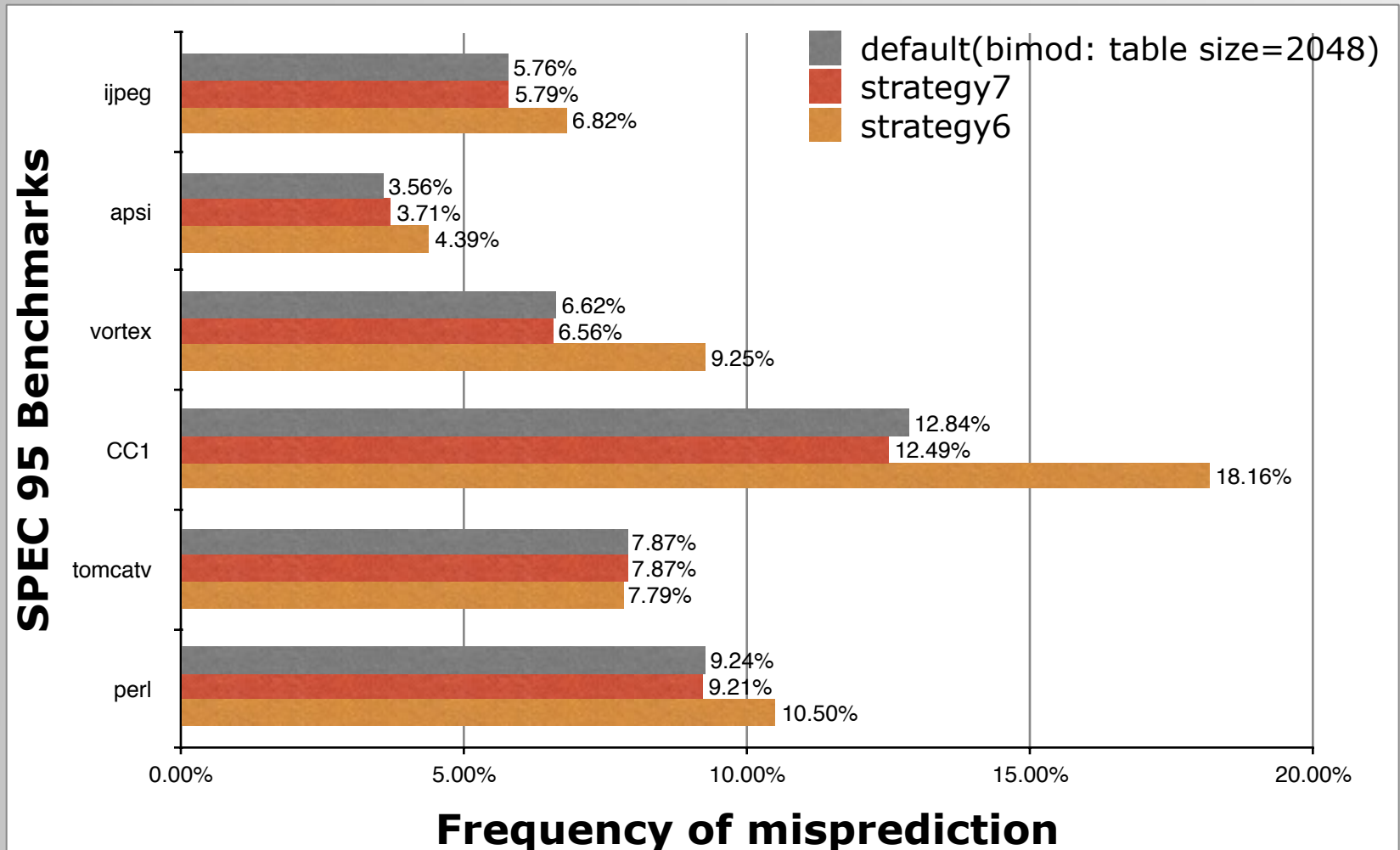
Strategy 6 & 7 form the paper

- From the paper *“A Study of Branch Prediction Strategies”*
- *Strategy 6: similar to bimod strategy*
- *The only difference: each entry has 1-bit counter instead of 2-bit.*
- *Strategy 7: similar to bimod strategy*
- *the only difference: each entry has 3-bit counter instead of 2-bit. If the sign bit is 0, predict as taken, otherwise, predict as not taken.*

Strategy 6 & strategy 7



Branch Prediction Results(1)



Strategy 6 & 7 form the paper

- » Why does the accuracy change?
- » `for(i=0;i<1000;i++)`
- » `{ for(j=0;j<100;j++)`
- » `{ /*code*/ }`
- » `}`
- » For instance, assuming that the initial prediction is not taken. Bimod strategy will only mis-predict one time. However, strategy 6 will miss every time when entry the inner loop.

New Branch Prediction Strategies

- 2-level adaptive predictor:
 - 1) Each branch has multiple 2-bit predictor,
 - 2) The preceding n branches' outcomes decide to use which 2-bit predictor.
- Some variations of 2-level predictor:
 - 1) Correlating Branch Predictor
 - 2) Gshare Branch Predictor

New Branch Prediction Strategies

- Why does the 2 level predictor could get accuracy sometimes?

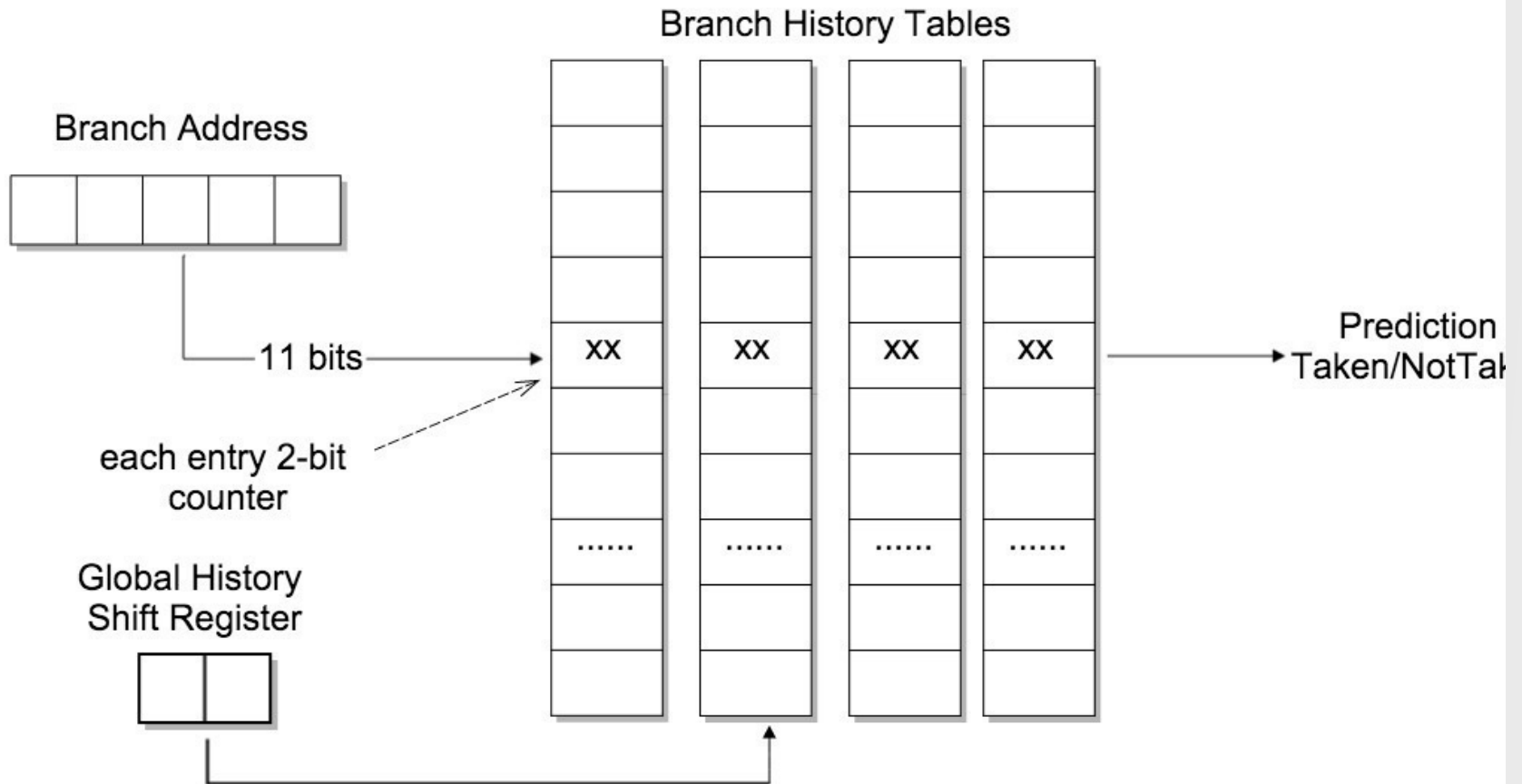
- ```
if (aa == 5)
 aa = 0;
if (bb == 5)
 bb = 0;
if (aa != bb) {}
```

The fact that the outcome of the branch depends not only on the branch address but also on the outcome of other recent branches. Behavior of longer sequence of branch execution history often provides more accurate prediction outcome.

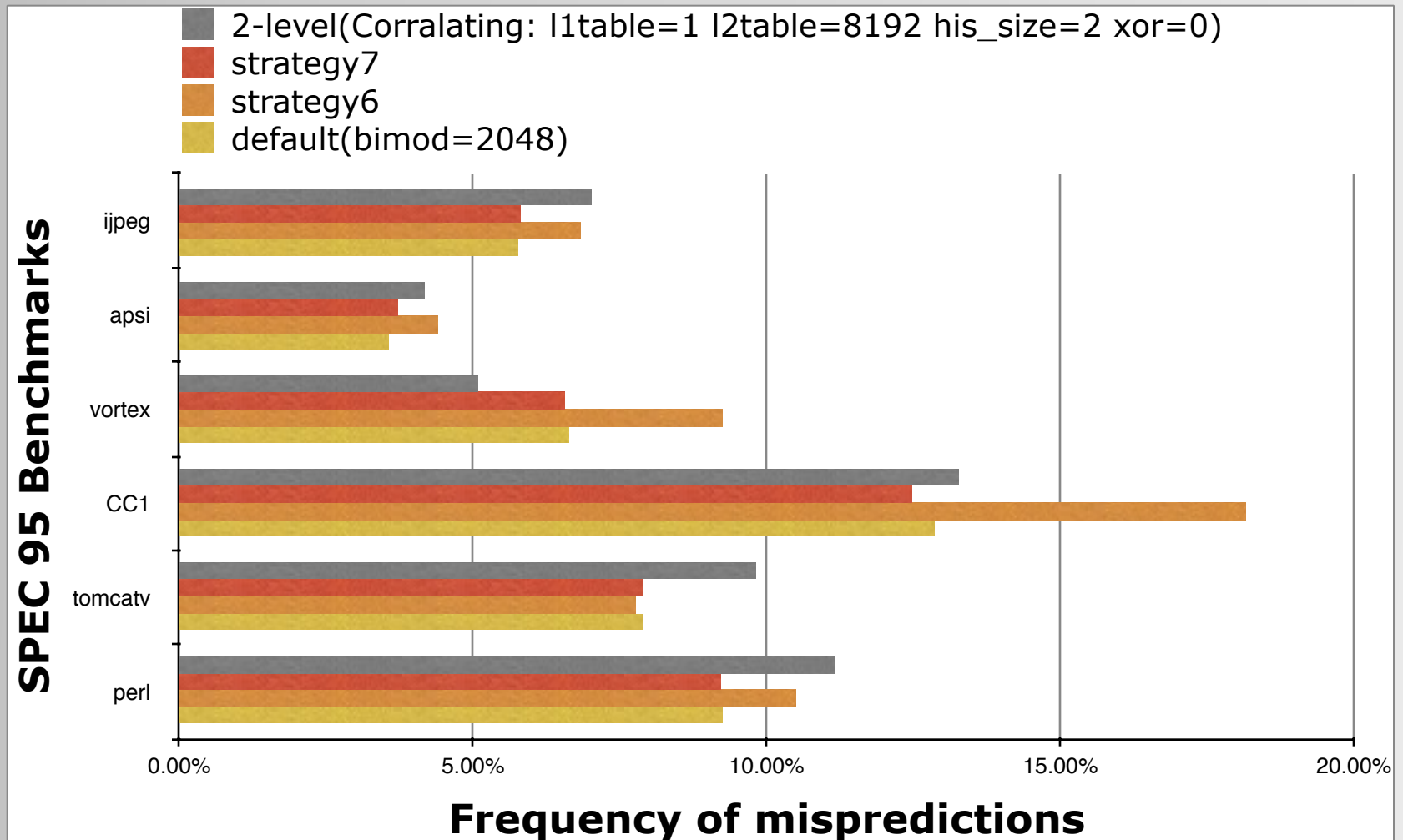
# Correlating Branch Prediction

- Using global history shift register which contains last 2 branch outcomes.
- Low-order 11 bits from branch address is used to choose the pattern history table.
- The global history bits is used to index the entry of the pattern history table. Each entry contains 2-bit counters.

# Correlating Branch predictor



# Correlating Branch predictor



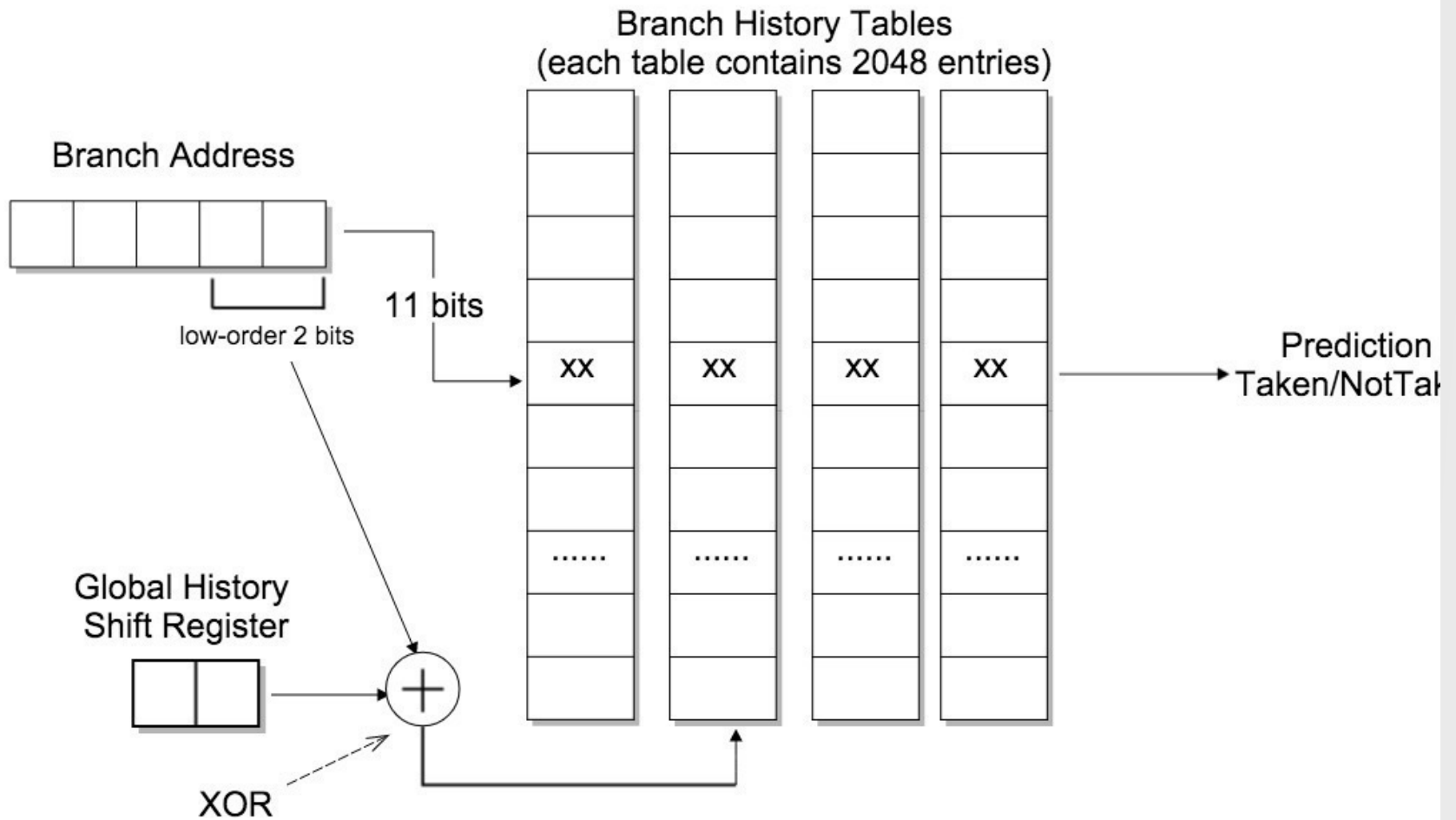
# Issues Affecting Accurate Branch Prediction

- Aliasing: More than one branch may use the same Branch History Table entry

# Gshare Predictor

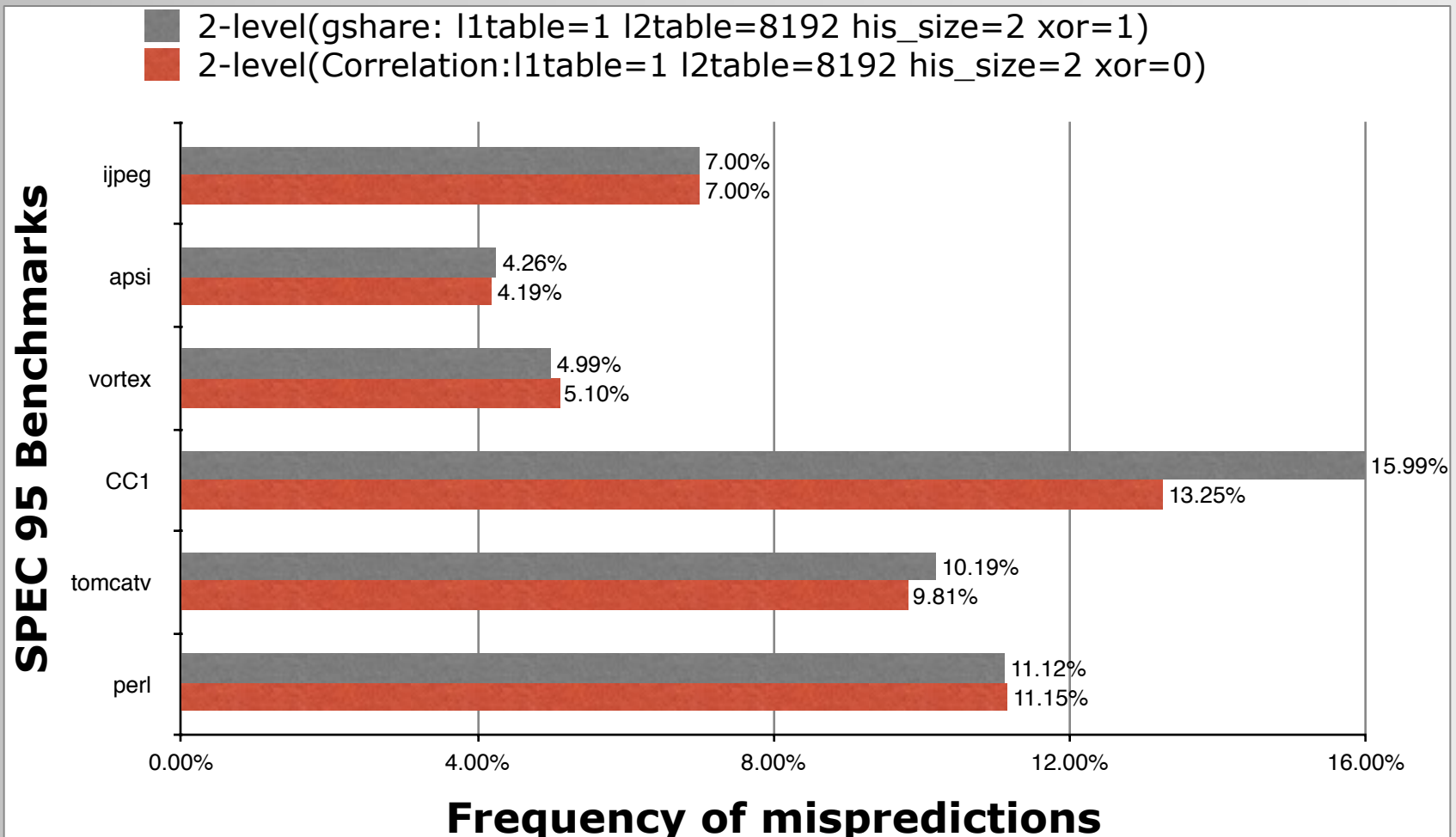
- Gshare is similar to the correlating branch predictor.
- The difference: using the result of low-order 2 bits XOR with 2-bits in the global history register as the index to address the entry.
- This strategy could effectively deal with aliasing.

# Gshare Predictor





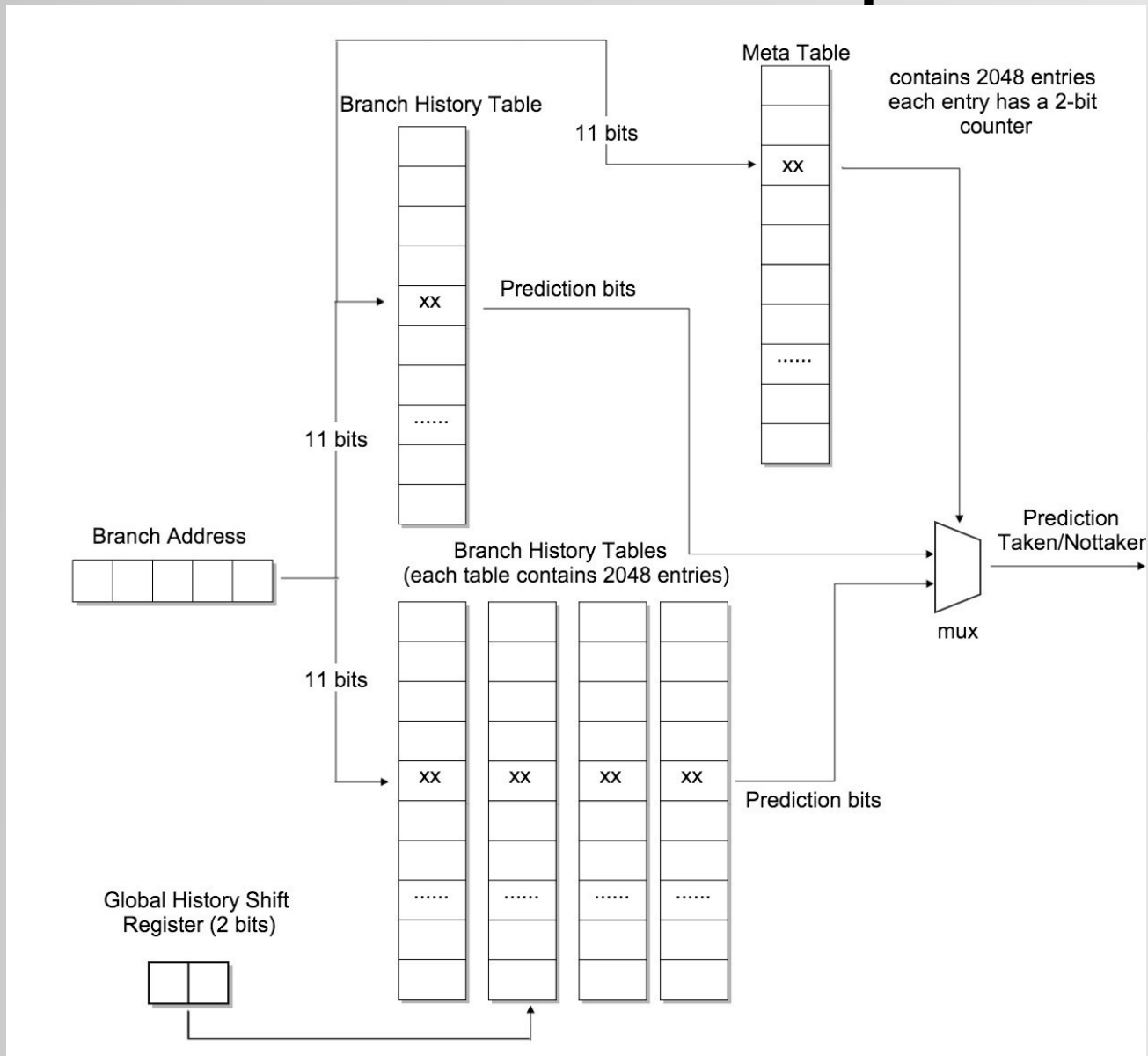
# Branch Prediction Results(2)



# New Branch Prediction Strategies

- Combination branch predictor has two component predictor: bimod predictor and correlating predictor.
- Why this strategy could get better accuracy of prediction?
- Different branches benefit from different types of history.

# Combination Branch predictor

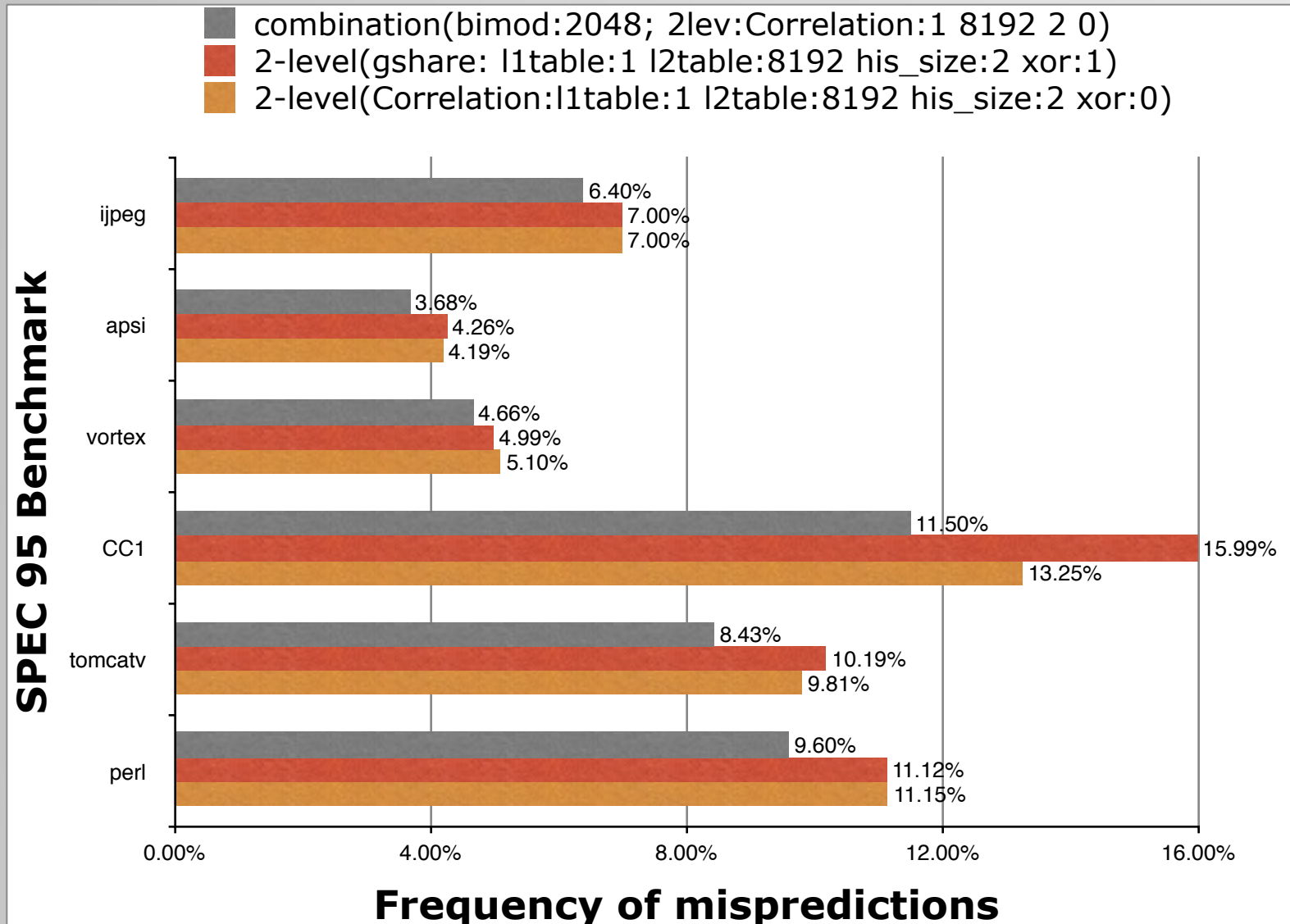


# Combination Branch Predictor

» How does this predictor update?

| <i><b>Bimod</b></i>     | <i><b>Share</b></i>     | <i><b>Meta table</b></i>         |
|-------------------------|-------------------------|----------------------------------|
| <i><b>Correct</b></i>   | <i><b>Correct</b></i>   | <i><b>No change</b></i>          |
| <i><b>Correct</b></i>   | <i><b>Incorrect</b></i> | <i><b>Increment<br/>(+1)</b></i> |
| <i><b>Incorrect</b></i> | <i><b>Correct</b></i>   | <i><b>Decrement<br/>(-1)</b></i> |
| <i><b>Incorrect</b></i> | <i><b>Incorrect</b></i> | <i><b>No change</b></i>          |

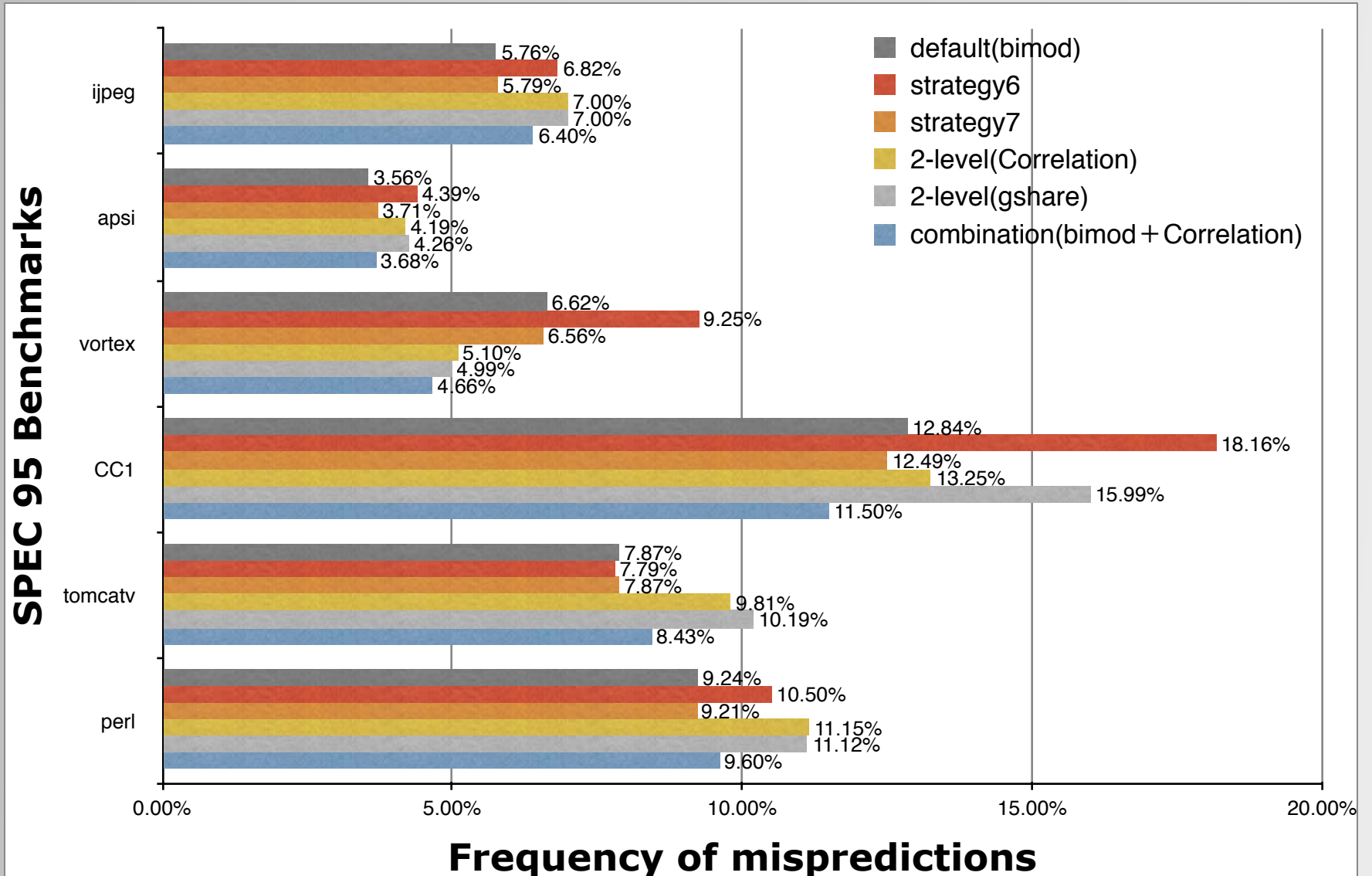
# Branch Prediction Results(3)



# Combination Branch predictor

- » Why does combination predictor could get better performance?
- » The greater the bits in meta table, the more accuracy of prediction the bimod predictor. Otherwise, the more accuracy of prediction the correlate predictor.

# Summary



Thank You