The Inner Most Loop Iteration counter

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Projeto 3
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Article

Artigo: [MICRO48] The Inner Most Loop Iteration counter: a new dimension in branch history - Andre Seznec (INRIA/IRISA), Joshua San Miguel (University of Toronto), Jorge Albericio (University of Toronto)

Estado da Arte - Branch Predictor

Derived from 2 families:

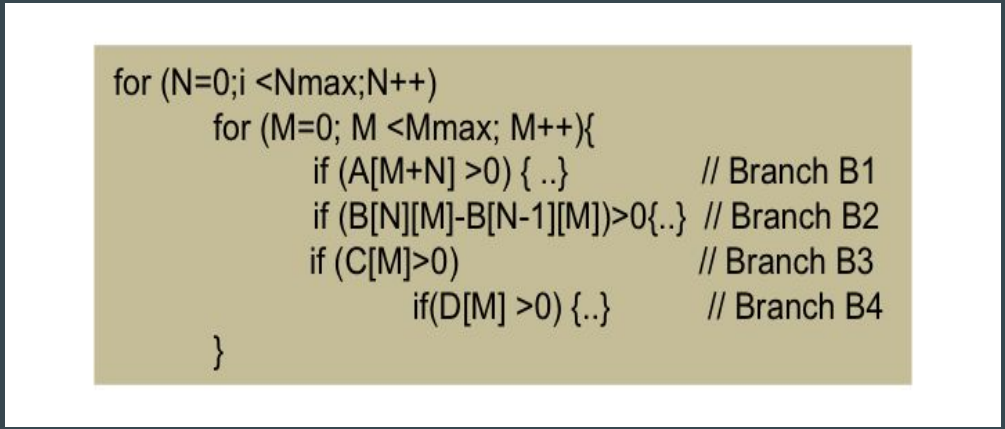
- Neural-inspired predictors
- TAGE-based predictos

Both works using a neural component, a large global history component and a small local history component

Branch Correlation

“(...) in many cases, the outcome of a branch is correlated with the outcome of a single past branch or the outcomes of a few past branches.”

“(...) in some cases, the outcome of a branch encapsulated in the inner most loop of a multidimensional loop is correlated with the outcomes of the same branch in neighbor iterations of the inner loop but within the previous outer loop iteration.”



Worm Hole Predictor

+ accuracy
- only for loops with constant number of iterations
- only for branches that are always executed on each iteration
- real hardware implementation

Inner Most Loop Iteration (IMLI)

For a dynamic branch: IMLI counter = iteration # of the loop encapsulating the branch

Two IMLI-based components:

- IMLI-SIC (Same Iteration Correlation)
  - IMLI-SIC prediction table indexed with the IMLI counter and the PC
- IMLI-OH (Outer History)
  - Same correlation as WH predictor
  - Prediction table
  - IMLI-OH table indexed with the PC and IMLI counter

IMLI Components

IMLI Counter:

IMLI count it's the number of times that the last encountered backward conditional branch has been consecutively taken

```
if (backward) {
        if (taken) IMLIcount++;
        else IMLIcount = 0;
}
```

IMLI Components

IMLI-SIC:

Add a single table (IMLI-SIC table) to the statistical corrector of TAGE-GSC and to GEHL. IMLI-SIC is indexed with a hash of the IMLI counter and the PC.

IMLI Components

IMLI-OH:

It consists of the IMLI-OH predictor table, which is incorporated in the SC part of the TAGE-GSC predictor or in the GEHL predictor. It also consists of two structures to store and retrieve the history of the previous outer loop iteration: the IMLI history table and the PIPE vector, described below.

The outcome of branches are stored in the IMLI history table. The outcome of a branch at address B is stored at address (B*64) + IMLIcount. This allows us to recover Out[N-1][M] when predicting Out[N][M]. However, when predicting the next iteration (i.e., Out[N][M+1]), Out[N-1][M] would have already been overwritten with Out[N][M]. Therefore, the PIPE (Previous Inner iteration in Previous External iteration) vector is used to intermediately store Out[N-1][M].

IMLI Components

IMLI-OH:

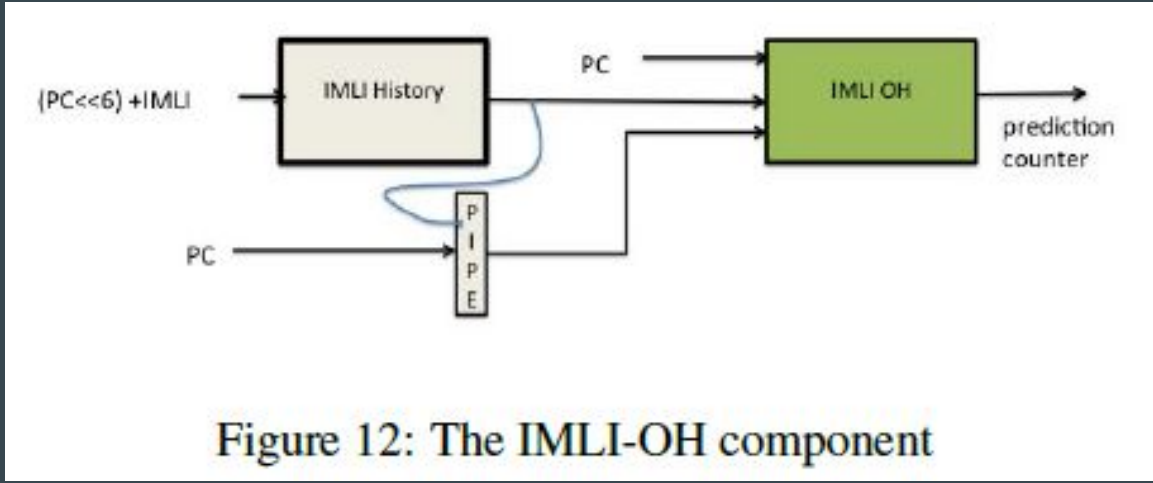


Figure 12: The IMLI-OH component

Implementation TAGE-GSC

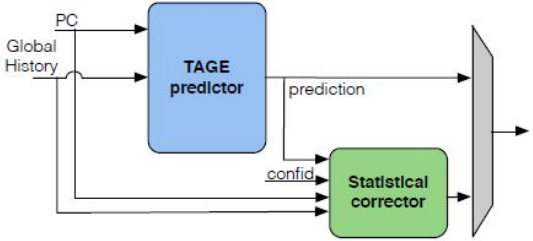


Figure 4: The TAGE-GSC predictor: a TAGE predictor backed with a Global history Statistical Corrector predictor

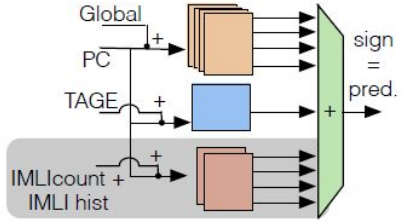


Figure 5: The Statistical Corrector predictor for TAGE-GSC with IMLI-based components

Implementation GEHL

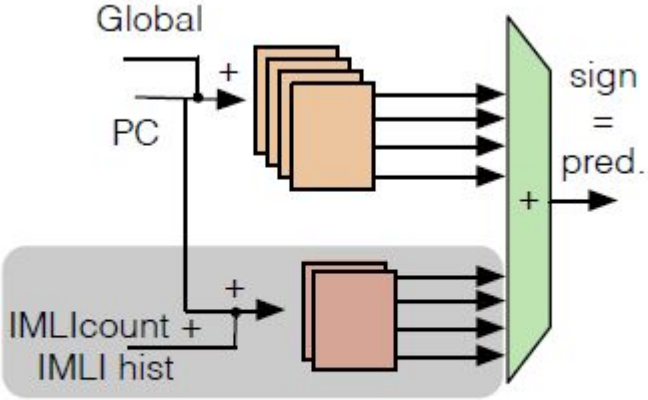


Figure 6: GEHL augmented with IMLI-based components

Results

Figure 8: IMLI-induced MPKI reduction on the 80 benchmarks; TAGE-GSC predictor

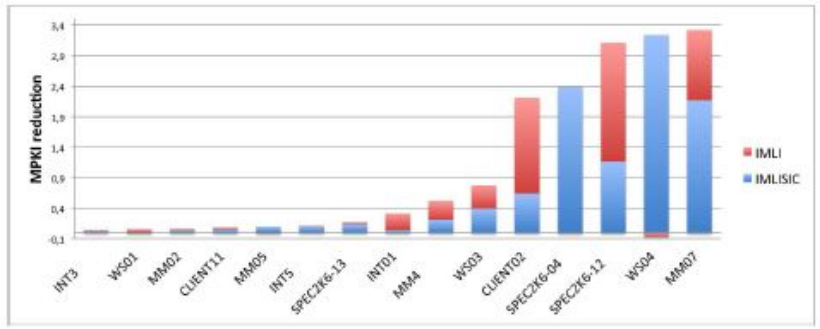


Figure 9: IMLI-induced MPKI reduction on the 15 most benefitting benchmarks; TAGE-GSC predictor

For TAGE-GSC, the misprediction rate is improved by 6.8 % from 2.473 MPKI to 2.313 MPKI on CBP4 traces and by 6.1 % from 3.902 MPKI to 3.649 MPKI on CBP3 traces.

Results

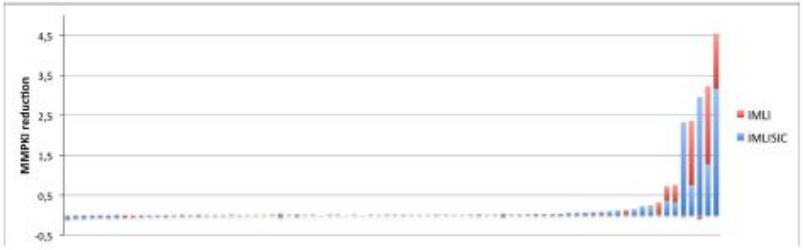


Figure 10: IMLI-induced MPKI reduction on the 80 benchmarks; GEHL predictor

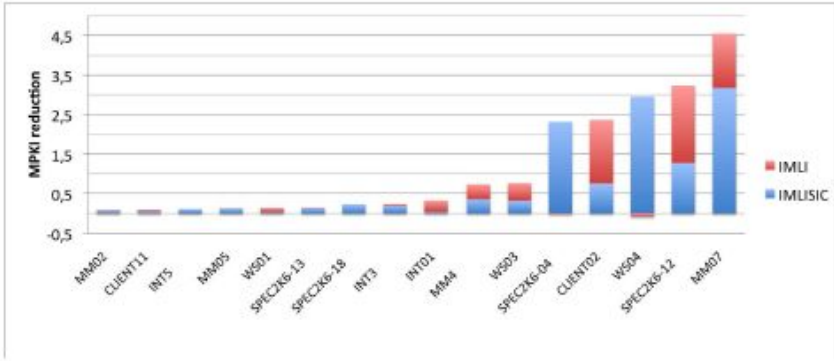


Figure 11: IMLI-induced MPKI reduction on the 15 most benefitting benchmarks; GEHL predictor

For the GEHL predictor, the misprediction rate is improved by 6.0 % from 2.864 MPKI to 2.694 MPKI on CBP4 traces and 6.5 % from 3.902 MPKI to 3.649 MPKI on CBP3 traces.

Project3

Goal: Try to reproduce figures 9 and 11 for SPEC benchmarks

Bibliography

[MICRO48] The Inner Most Loop Iteration counter: a new dimension in branch history - Andre Seznec (INRIA/IRISA), Joshua San Miguel (University of Toronto), Jorge Albericio (University of Toronto) - http://dx.doi.org/10.1145/2830772.2830831