The Frankenpredictor

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Design Objectives

- Capacity
  - SERV has large branch footprint
- Long history length correlation
  - INT and MM benefit from this
- 8KB makes interference a big issue
- … and don’t mess up FP
Overview

Perceptron Table

Global BHR

Path-Neural:
Long History
Fusion

Gskew-Agree:
Capacity

Ideas from:
static branch prediction,
gskewed, agree,
perceptron, path-based
neural, 2bcgskeew,
fusion, MAC-RHSP,
machine learning

Misc Other Ideas
Gskew-Agree Lookup

Global BHR

PC

Target

BIM

\( h_0 \)

\( h_1 \)

\( h_2 \)

\( G_0 \)

\( G_1 \)

Target

\( BTFNT \)

\( x_{g0} \)

\( x_{g1} \)

\( x_{g2} \)

\( x_{gM} \)

\( >? \)

\( =? \)

\( =? \)

\( =? \)

\( =? \)

MAJ
Gskew-Agree Update

- **Shared Hysteresis**
  - Every two counters share one hyst. bit

- **Partial Update**
  - Modified from 2bwcskew (no meta rules)
  - On mispred, update all three tables
  - If correct:
    - If all agree, do nothing
    - Else update the two correct tables
Path-Based Perceptron

Bias, Pseudotag, Recent History

Old History

Gskew-Agree

84 rows, 8-bit weights

42 rows, 7-bit weights

168 rows, 8-bit weights
Redundant Indexing

Bias, Pseudotag, Recent History

Old History

Gskew-Agree
Non-Linear Learning Curves

• Slow start:
  – avoids transient/coincidental correlation

• Steep End:
  – quick unlearning
Synergistic Reinforcement

BIM → hash → Global BHR

PC → hash → $G_0$

BTFNT

$=\?$

$=\?$

$X_{g0}$

$=\?$

$X_{g1}$

$\sim 1$

To Summation

sign

$=\?$

$=\?$

$=\?$

sign
Notes on Initialization

• All neural weights initialized to zero except those corresponding to $x_{gM}^g$  
  – The perceptron will use the gskew-agree prediction until other correlations are established

• All PHT banks initialized to “Weakly Agree”  
  – gskew-agree provides a BTFNT prediction at start of program
Unconditional Branches

- Always predict taken, of course
- No update to PHTs, neural weights, path
- Update global BHR:

  Call: 00000000 xor
  Return: 11111111 xor
  Other: 01010101 xor

PC
“Path” History Update

Outcome

Branch Address

Global BHR

Shift registers

PC

Path1
Path2
Path3
Path4
Path5
Path6
Path7
Path8
Path9
Path10
Index Generation

Path History

Primary Index:

PC

3 LSB

Redundant Index:

6 most recent BHR bits
Implementation Issues

• Frankenpredictor optimized for state
• Neural table sizes not power-of-two
• Redundant indexing biggest challenge
  – Many hash functions
  – Many ports
  – Huge adder tree
Summary

- Gskew for capacity, Neural for long-history
  - Neural also for fusion
- Gskew-Agree
  - Skewing for interference-avoidance
  - Agree-prediction for interference-tolerance

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