The O-GEHL branch predictor

Optimized GEometric History Length

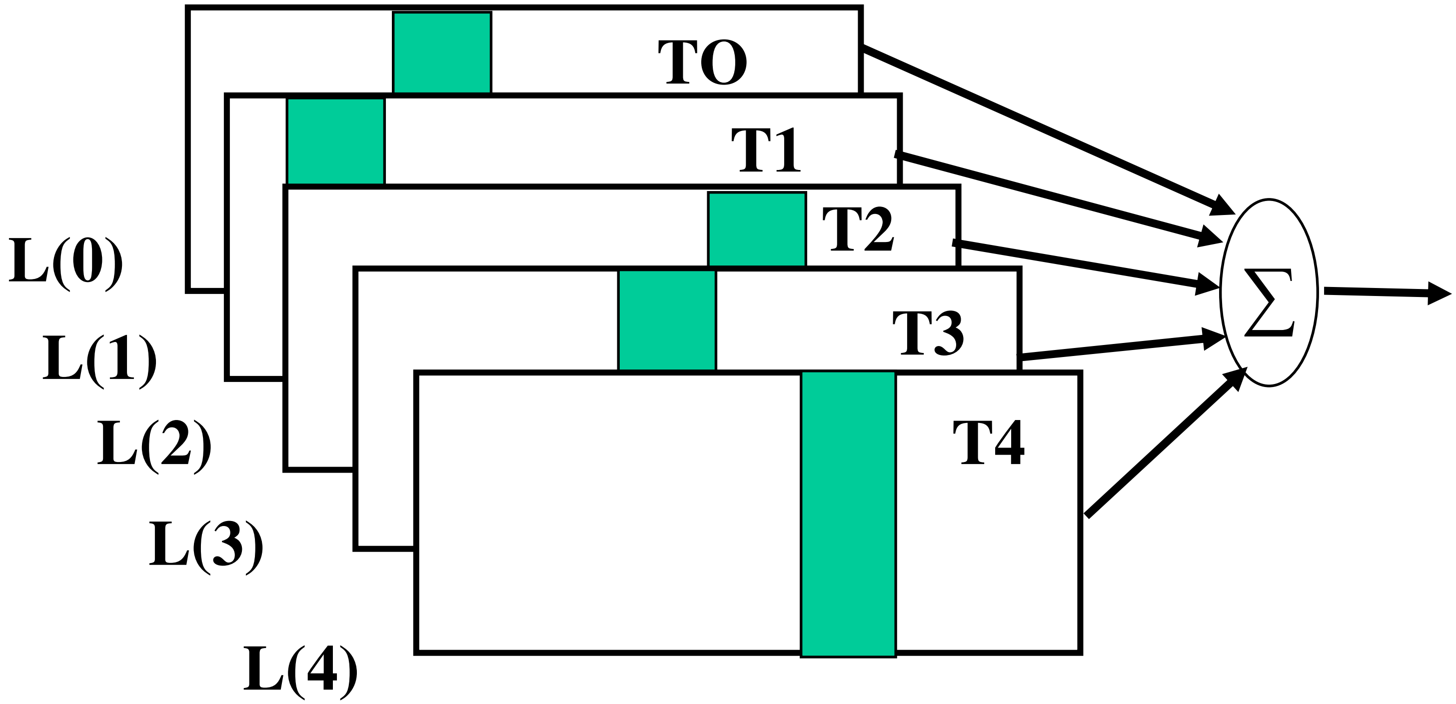
André Seznec
IRISA/INRIA/HIPEAC

What is classic ☺

- Global history based:
  - ➔ Yeh and Patt 91, Pan and So 91
- Use of multiple history lengths:
  - ➔ McFarling 93, Evers et al. 96
- Use an adder tree instead of a meta-predictor
  - ➔ Vintan and Iridon 99, Jimènez and Lin 01

André Seznec
Caps Team
Irisa

Multiple history length neural predictor



André Seznec
Caps Team
Irisa

GEometric History Length predictor

The set of history lengths forms a geometric series

$$L(0) = 0$$

$$L(i) = \alpha^{i-1} L(1)$$

{0, 2, 4, 8, 16, 32, 64, 128}

What is important: L(i)-L(i-1) is drastically increasing

André Seznec
Caps Team
Irisa

Updating the predictor

- Update on misprediction and under a threshold

8-bit counters and perceptron update threshold (29)

➔ **Would not have qualified for CBP-1 ☹**

André Seznec
Caps Team
Irisa

Dynamic update threshold fitting

On an O-GEHL predictor, best threshold depends on

- the application ☹
- the predictor size ☹
- the counter width ☹

By chance for the best fixed threshold,
updates on mispredictions ≈ updates on correct predictions

Monitor both numbers
and adapt the update threshold

8 components 8 bits counter would qualify for CBP-1 ☺

André Seznec
Caps Team
Irisa

Counter width on O-GEHL predictors

- 8 bits are just overkilling ☹
- 4 bits are sufficient ☺
- Mixing 5 bits for short histories and 4 bits for long histories is slightly better ☺
- 3 bits are not so bad !!

André Seznec
Caps Team
Irisa

Adaptative history length fitting
(inspired by Juan et al 98)

(½ applications: L(7) < 50)
≠
(½ applications: L(7) > 150)

Let us adapt some history lengths to the behavior of each application

- **8 tables:**
  - ➔ **T2: L(2) and L(8)**
  - ➔ **T4: L(4) and L(9)**
  - ➔ **T6: L(6) and L(10)**

André Seznec
Caps Team
Irisa

Adaptative history length fitting *(2)*

Intuition:

- ➔ if high degree of aliasing on T7, stick with short history

Implementation:

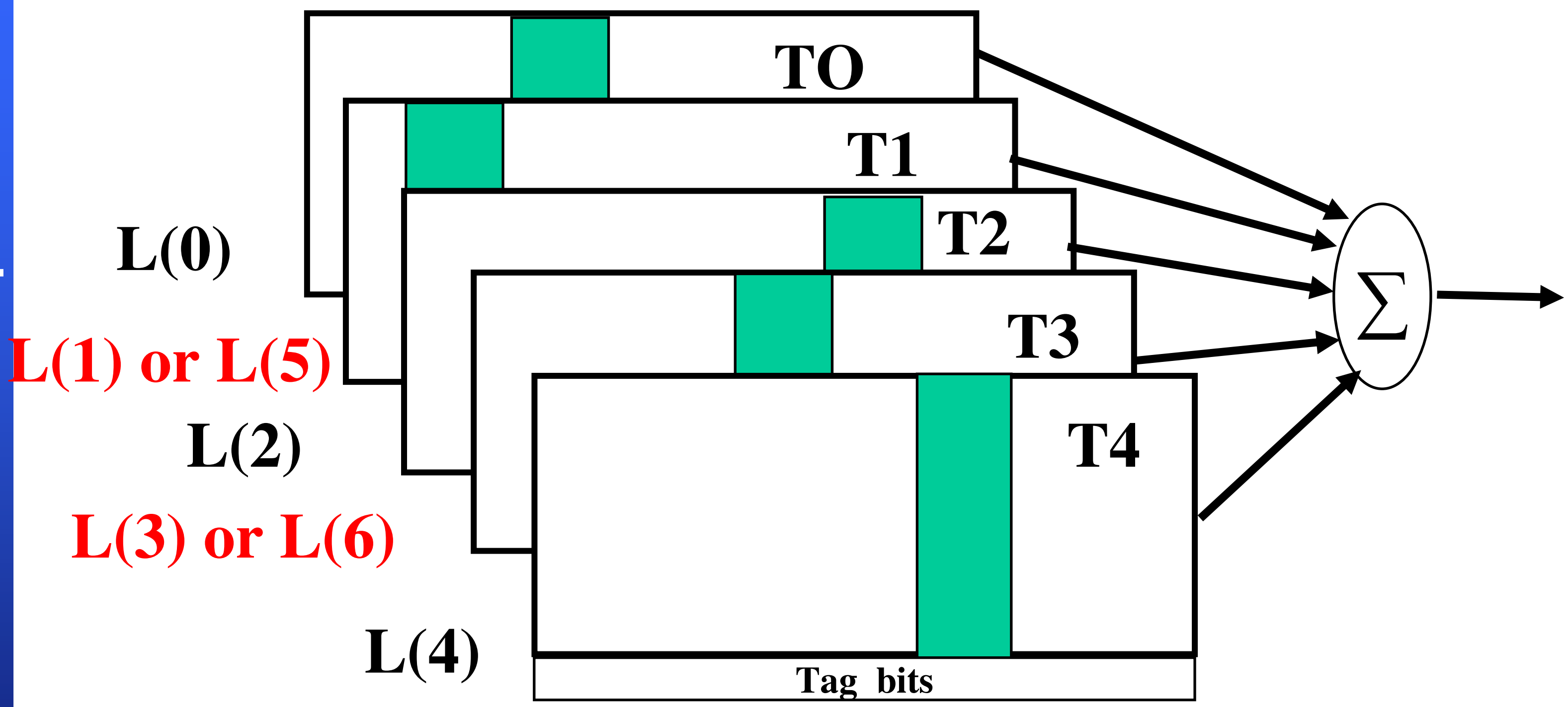
- ➔ monitoring of aliasing on updates on T7 through a tag bit and a counter

Simple is sufficient:

- ➔ Flipping from short to long histories and vice-versa

André Seznec
Caps Team
Irisa

The O-GEHL branch predictor



André Seznec
Caps Team
Irisa

Information to be hashed

- Address + conditional branch history:
  - ➔ path confusion on short histories ☹
- Address + path:
  - ➔ Direct hashing leads to path confusion ☹

1. Represent all branches in branch history
2. Use also path history (1 bit per branch, limited to 16 bits)

André Seznec
Caps Team
Irisa

Configuration for CBP

- 8 tables:
  - ➔ 2 Kentries except T1, 1Kentries
  - ➔ 5 bit counters for T0 and T1, 4 bit counters otherwise
  - ➔ 1 Kbits of one bit tags associated with T7

10K + 5K + 6x8K + 1K = 64K

- L(1) =3 and L(10)= 200
  - ➔ {0,3,5,8,12,19,31,49,75,125,200}

André Seznec
Caps Team
Irisa

Hashing 200+ bits for indexing !!

- Need to compute 11 bits indexes :
  - ➔ Full hashing is unrealistic

1. Just regularly pick at most 33 bits in:
   address+branch history +path history
2. A single 3-entry exclusive-OR stage

André Seznec
Caps Team
Irisa

A case for the OGEHL predictor (1)

- High accuracy

- Robustness to variations of history lengths choices:
  - ➔ L(1) in [2,6], L(10) in [125,300]
  - ➔ misp. rate < 1.04 x reference misp. rate

- Geometric series: not a bad formula !!
  - ➔ best geometric L(1)=3, L(10)=223, REF-0.02 misp/KI
  - ➔ best overall {0, 2, 4, 9, 12, 18, 31, 54, 114, 145, 266} REF-0.04 misp/KI

André Seznec
Caps Team
Irisa

A case for the OGEHL predictor (2)

- Reduce counter width by 1 bit: 49 Kbits
  - ➔ would have been a finalist ☺
- 64 Kbits 4 components OGEHL predictor
  - ➔ would have been a finalist ☺
- 50 Kbits 4 components OGEHL predictor (3-bit)
  - ➔ would have been a finalist ☺
- 768 Kbits 12 components OGEHL predictor
  - ➔ 2.25 misp/KI

André Seznec
Caps Team
Irisa

A case for the O-GEHL predictor (3)

- O-GEHL predictor uses only global information
- Can be ahead pipelined
- Prediction computation logic complexity is low

(The End)

André Seznec
Caps Team
Irisa