Adaptive Information Processing: An Effective Way to Improve Perceptron Predictors

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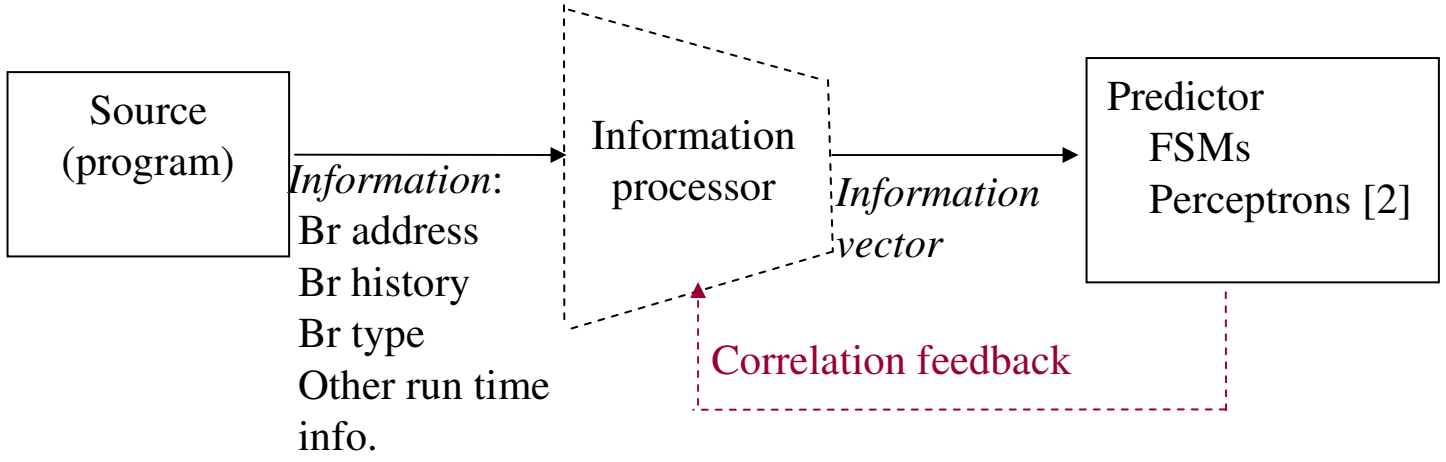
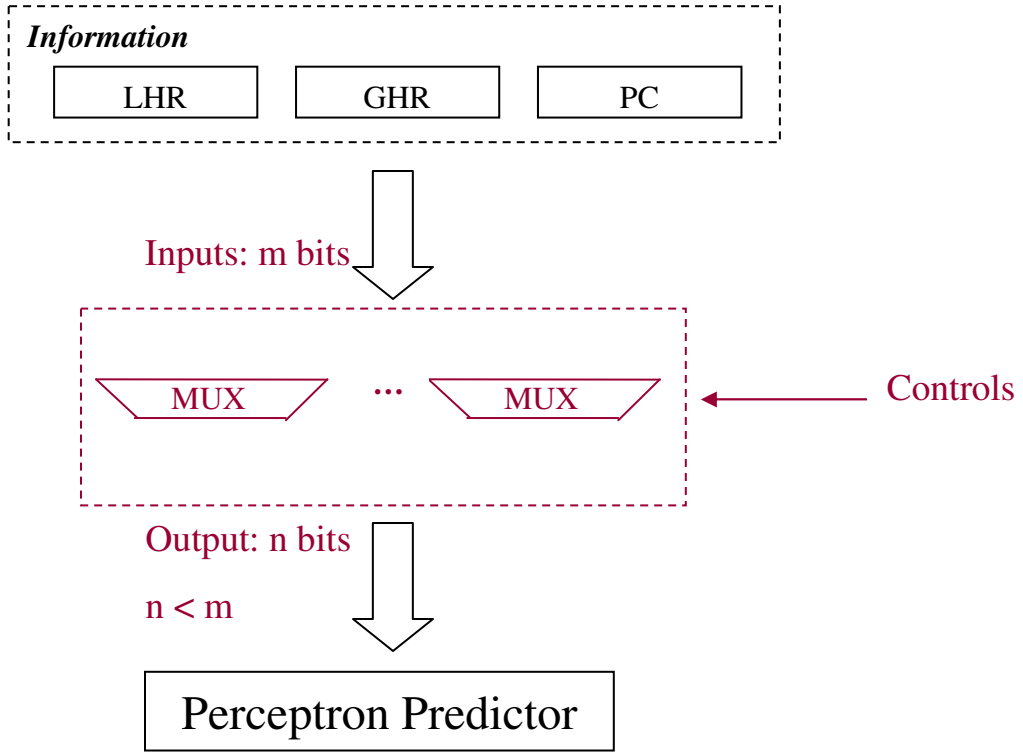
Information system model



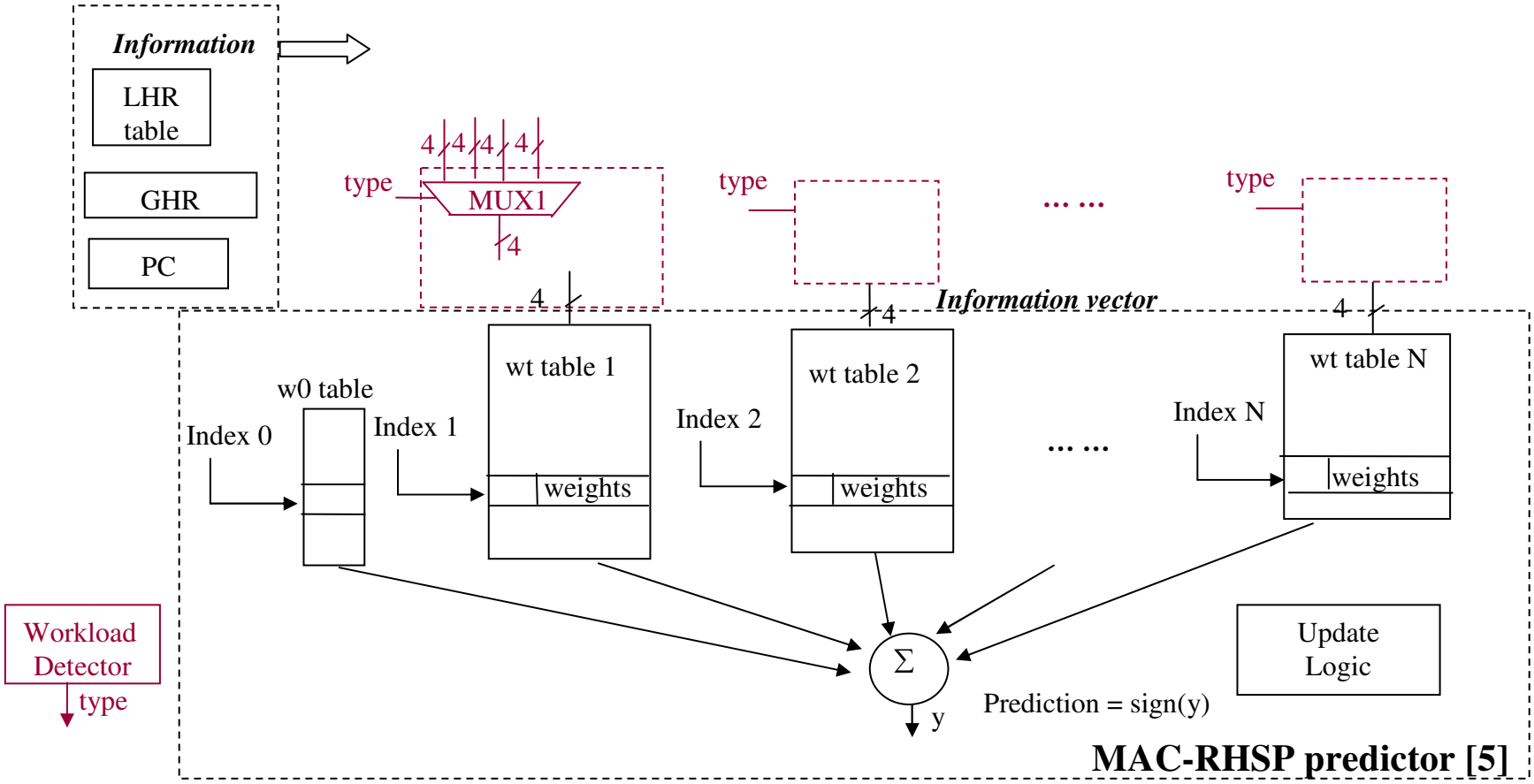
- Information system model by Chen et. al. [ASPLOS-VII].
- Key observations
  - Shortcomings:
    - Fixed information vector while different workloads/branches need different information data.
  - Perceptron weights ←→ Correlation
    - Assemble information vector to maximize correlation
- ***Our contribution***
  - Re-assemble the information vector based on correlation (weights)
  - Performed at a coarse grain, so it is not latency critical

Adaptive Information Processing

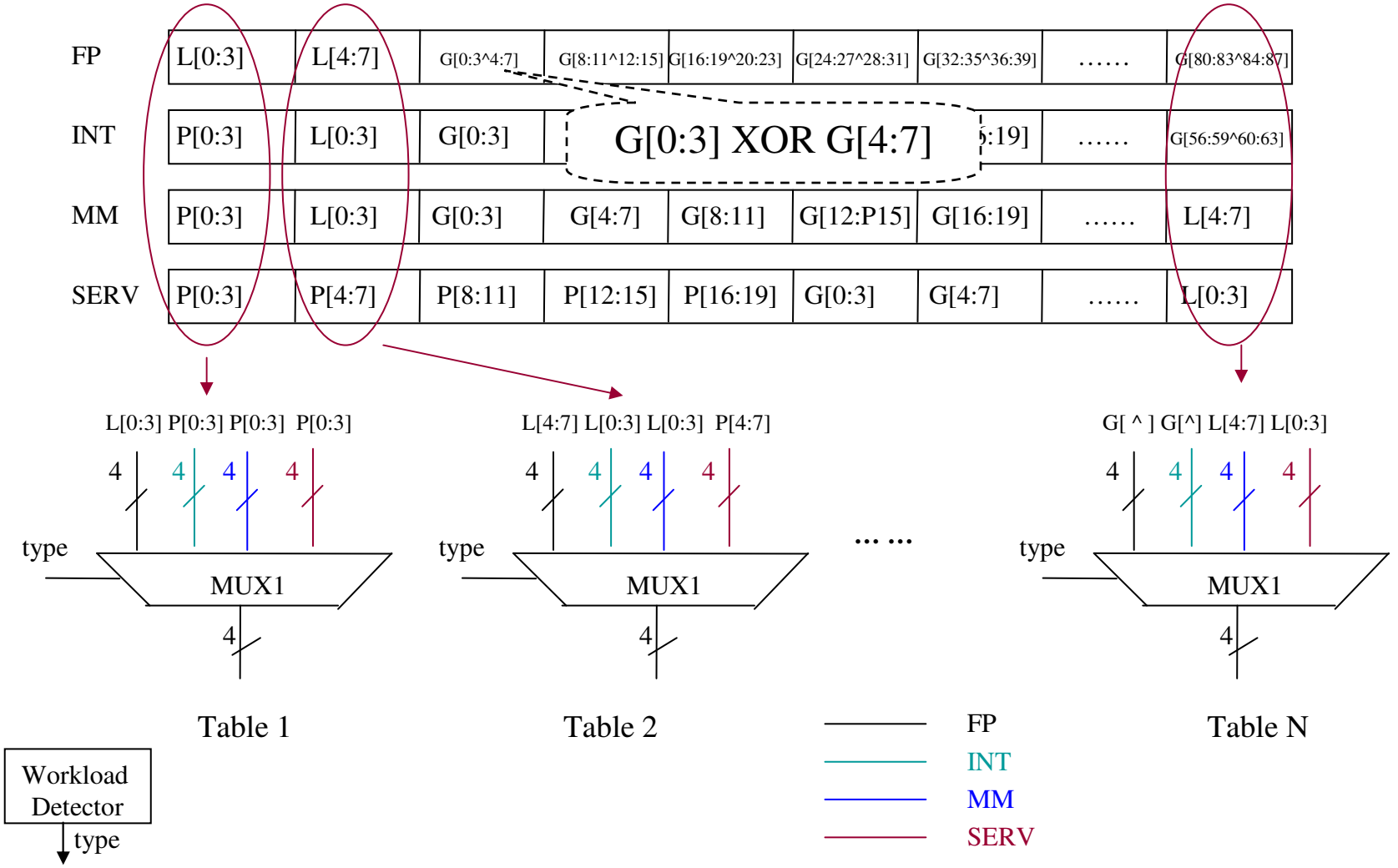


- Profile-directed adaptation
- Correlation-directed adaptation

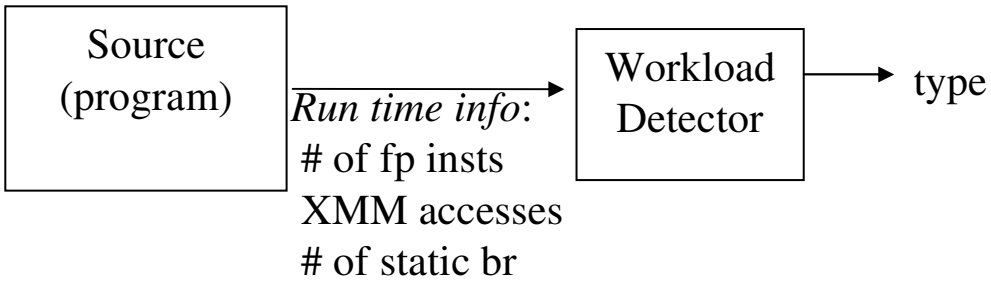
Profile-directed adaptation



Profile-directed adaptation

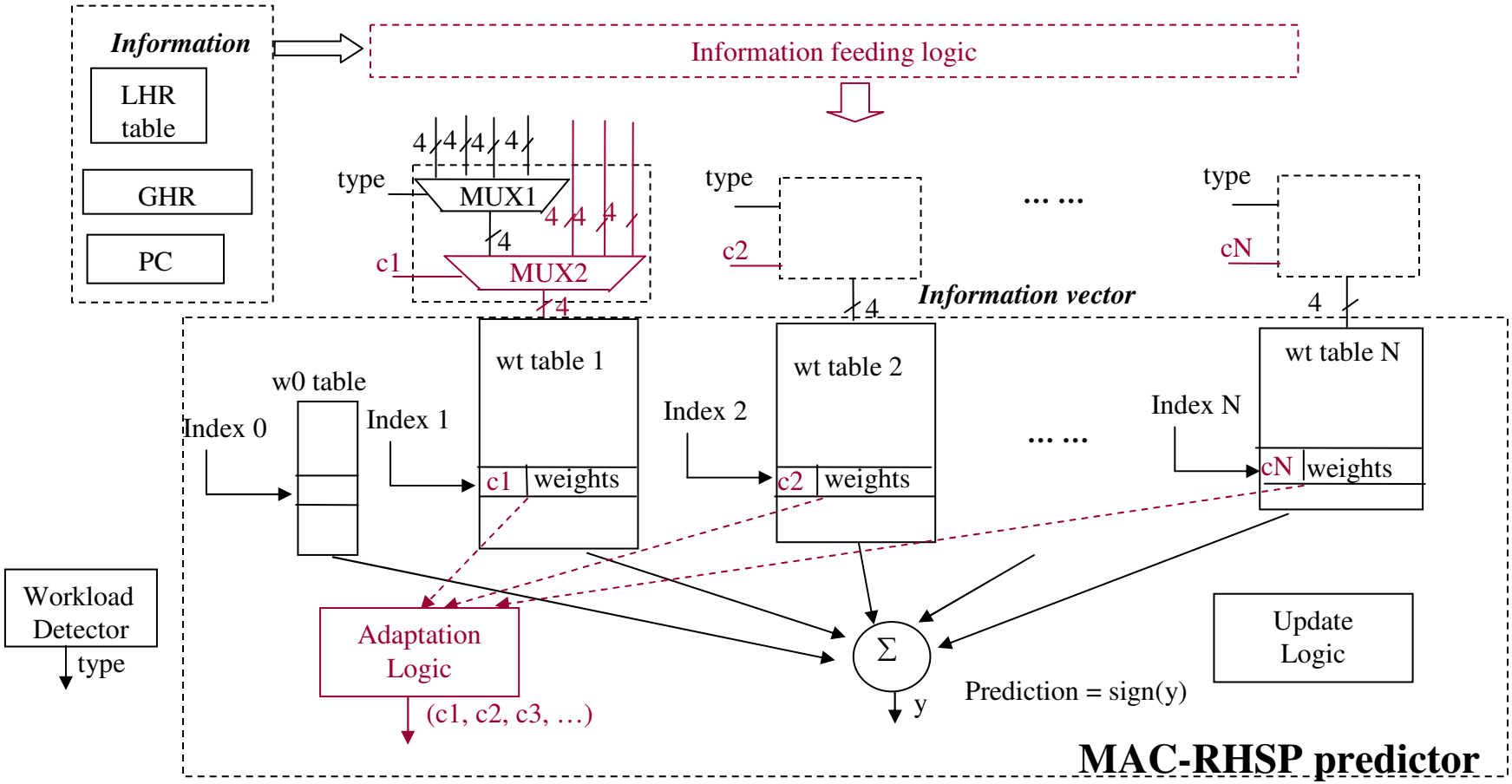


Workload Detector

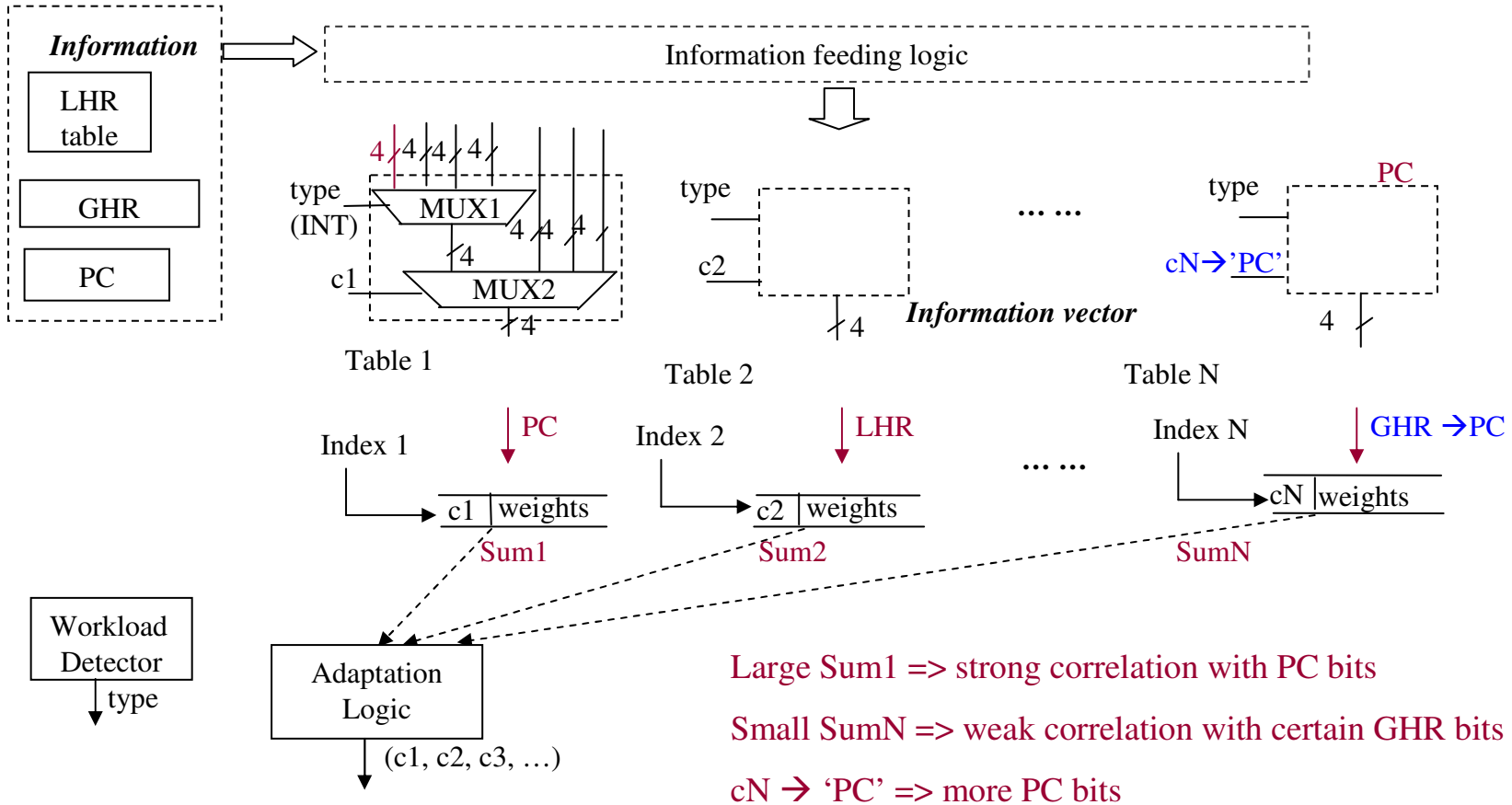


- Detection criteria
  - ***SERV***: a **large** number of **static branches**
  - ***FP***: a **small** number of **static branches**,
    a **high** number of **floating point operation**,
    and a **high** number of instructions using **XMM registers**
  - ***MM***: a **medium** number of **static branches**,
    a **medium** number of **floating point operation**,
    and a **medium** number of instructions using **XMM registers**
  - ***INT***: default

Correlation-directed adaptation



Correlation-directed adaptation

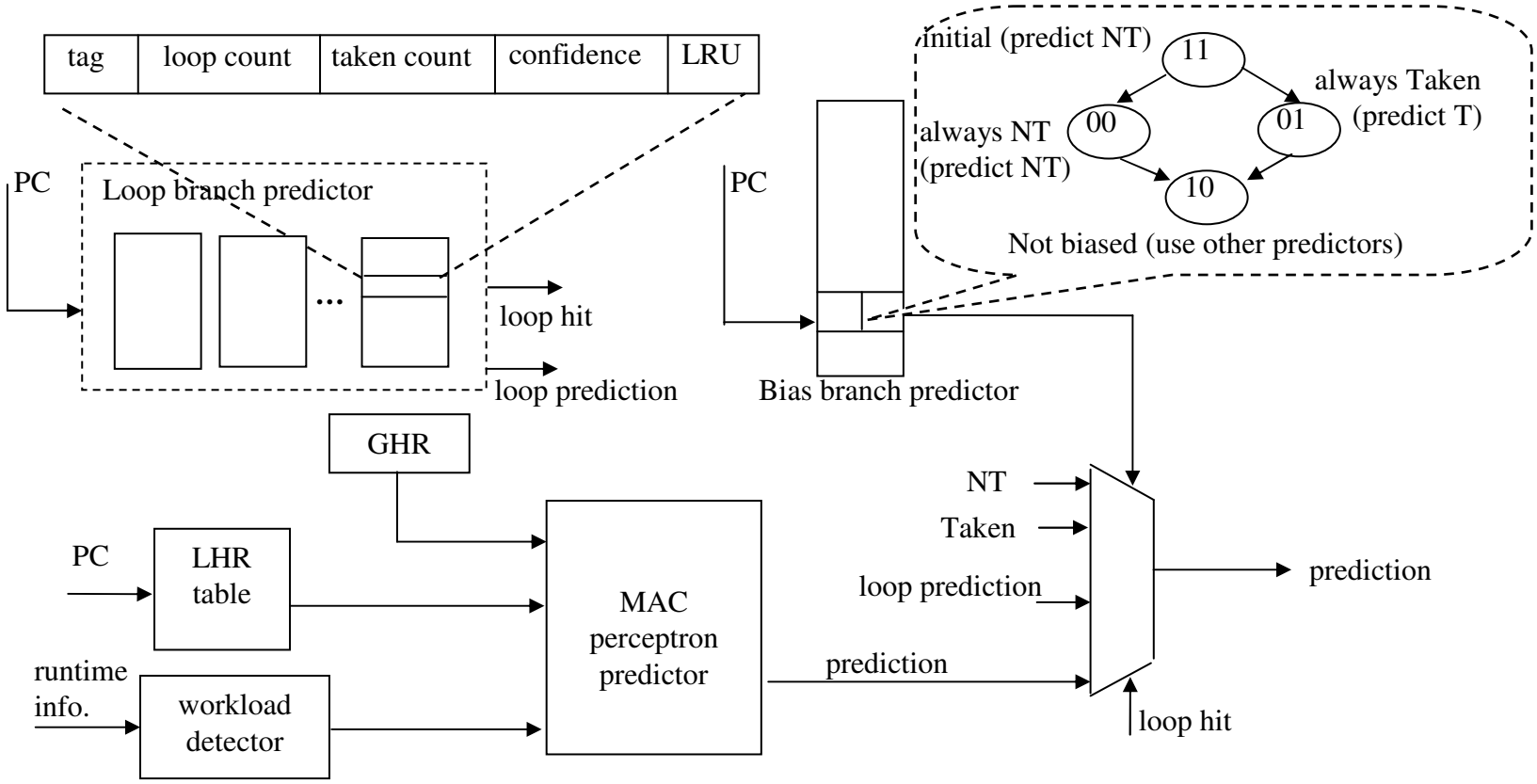


Large Sum1 => strong correlation with PC bits

Small SumN => weak correlation with certain GHR bits

cN → 'PC' => more PC bits

Overall scheme



Summary

- Observations
  - Different workloads/branches need different information.
  - Perceptron weights ←→ Correlation
- Contributions
  - Profile-directed adaptation
  - Correlation-directed adaptation
  - Reducing aliasing from bias and loop branches
- Result
  - Significant improvement

Thank you and Questions?

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References

[1] I. K. Chen, J. T. Coffey, and T. N. Mudge, "Analysis of branch prediction via data compression", *Proc. of the 7th Int. Conf. on Arch. Support for Programming Languages and Operating Systems* (ASPLOS-VII), 1996.

[2] D. Jimenez and C. Lin, "Dynamic branch prediction with perceptrons", *Proc. of the 7th Int. Symp. on High Perf. Comp. Arch* (HPCA-7), 2001.

[3] D. Jimenez and C. Lin, "Neural methods for dynamic branch prediction", *ACM Trans. on Computer Systems*, 2002.

[4] S. MacFarling, "Combining branch predictors", *Technical Report*, DEC, 1993.

[5] A. Seznec, "Revisiting the perceptron predictor", *Technical Report*, IRISA, 2004.

[6] T.-Y. Yeh and Y. Patt, "Alternative implementations of two-level adaptive branch prediction", *Proc. of the 22nd Int. Symp. on Comp. Arch* (ISCA-22), 1995.

Predictor configuration

COMPONENT	CONFIGURATION	COST
Bias branch predictor	2293 entries	2293 x 2 = 4586 bits.
Loop branch predictor	24 entries, 8-way set associative	1344 bits
Information	PC GHR: 100 bits LHR: 8 bits, 63 entries	32 + 100 + 8 * 63 = 636 bits
MAC perceptron predictor	**W0 table**: 61 entries, 8 bits each Other table sizes: 63, 55, 53, 53, 51, 49, 43, 41, 41, 39, 37, 37, and 35. **Total MAC entries**: 597 Each entry: 16 weights, 6 bits each **Control bits**: 2 bits each entry	61 * 8 + 597 * 16 * 6 + 597 * 2 = 58994 bits
Adaptation	Adaptation interval : 100000 * 2 conditional branches	22 bits
Workload detection	Interval: 10000 (instructions / conditional branches)	82 bits
		Total : 65649 bits (less than 64 x 1024 + 256 = 65792 bits)