Lab2 Report

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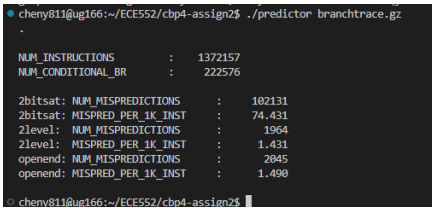
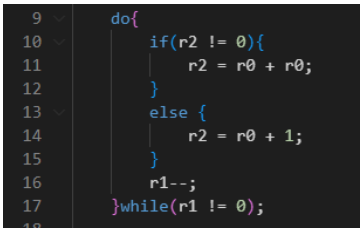
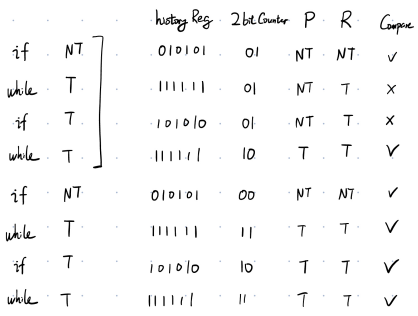
Microbenchmark

For the two-level GAg Predictor we wrote microbenchmark contained 2 Conditional branches one for if statement and one for while loop. By Calculate the percentage of misprediction it should be 0% and by inspecting the result of microbenchmark it is 1.490%. We use -0 flag for compilation, and iteration set to 100000 in order to prevent warming-up effect. 9 “nop” added to prevent branch access collision.



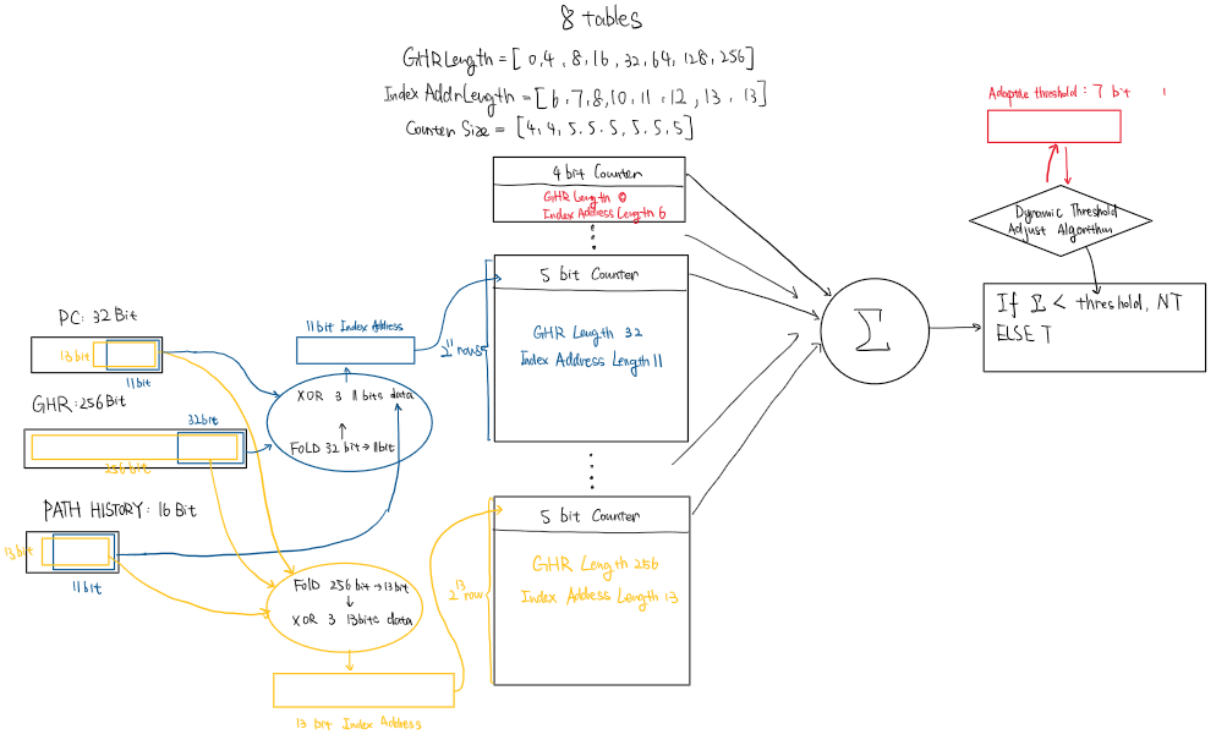




2-Level Branch Prediction

	2-bit MPB	2-bit MPKI	2-level MPB	2-level MPKI	open-end MPB	open-end MPKI
astar	3695830	24.639	1785464	11.903	506352	3.376
bwaves	1182969	7.886	1071909	7.146	215300	1.435
bzip2	1224967	8.166	1297677	8.651	1110479	7.403
gcc	3161868	21.079	2223671	14.824	130933	0.873
gromacs	1363248	9.088	1122586	7.484	768408	5.123
hmmer	2035080	13.567	2230774	14.872	1690557	11.270
mcf	3657986	24.387	2024172	13.494	1332083	8.881
soplex	1065988	7.107	1022869	6.819	661587	4.411
AVG		14.4899		10.649		5.3465

Open-ended Predictor Implementation



This implementation is based on **Analysis of the O-GEometric history length branch predictor [1]**

Prediction Tables: The diagram presents eight separate tables. Each table entry consists of a 5-bit prediction counter. The total number of rows (or index address sizes) varies based on the fetch length of the Global History Register (GHR). For each branch, the respective 5-bit counter from each table is shifted using the latest branch result.

GHR (Global History Register): With every branch instance, the GHR is shifted using the latest branch result. The number of bits extracted depends on the particular needs of each table.

(Simple Hash) FOLD & XOR Operations: Firstly, bits are retrieved from the GHR (examples include 32-bit or 256-bit) and are then folded to match the size of the index address length (like 11-bit or 13-bit). Following this, the folded value is XORed with both the PC and the PATH History, which have been fetched using the index address length (for instance, 11-bit or 13-bit).

PATH History Register: This is a 16-bit register that records previous PC values. Each time, it's shifted by 3 bits based on the least significant bits of prior PC.

Summation & Threshold: Compute the sum of the values from all 5-bit counters across the eight tables. This sum is then compared to a threshold value, which is adjusted dynamically based on preceding sums. If the summation is less than the threshold, the result is True; otherwise, it's False. We used an 7 bit Counter for Adaptive Threshold.

Total Size:

$$(4 \times (2^6 + 2^7) + 5 \times (2^8 + 2^{10} + 2^{11} + 2^{12} + 2^{13} + 2^{13}) + 256 + 16 + 7)bits$$
$$= 117.272Kbits = 14.659KBytes$$
$$8 \text{ Tables intotal with two 4-bit and six 5-bit counter}$$
$$256 \text{ Global History Bits}$$
$$16 \text{ Path History Bits}$$
$$7 \text{ Adaptive Threshold Counter}$$

Furthermore, we attempted to dynamically alter the bits fetched from the GHR and employed simulation annealing to identify optimal hyperparameters (namely GHR Fetch Length and Index Address Length). Despite these efforts, we did not observe a significant improvement in prediction performance. Thus we choose a set of fixed size GHR.

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2 Level Predictor:

The Private History table has 512 entries, each with a 6-bit counter. Additionally, there are 8 Private Predictor tables, each with 64 rows, where each row has a 2-bit counter. In the RAM configuration, both the 2-bit and 6-bit counters are upcast to 1 byte. Hence, the total memory used is 512 bytes for the History table plus 512 bytes for the Predictor tables, summing up to 1024 bytes.

$$512 \times 1Byte + (64 \times 8 \times 1Byte) = 1024Bytes$$

Therefore we modified size (bytes) to be 1024

Access Time	Area	Leakage Power
0.164342 ns	1.93x10^-3 mm	0.366395 mW

Open-ended Predictor:

Size structure is same as discussed above, In RAM configuration, all bits smaller than a Byte will be upcast to 1 Byte. Therefore

$$(1Byte \times (2^6 + 2^7 + 2^8 + 2^{10} + 2^{11} + 2^{12} + 2^{13} + 2^{13}) + 32Bytes + 2Bytes + 1Byte)$$
$$= 24035Bytes$$

Therefore we modified size (bytes) to be 24035

Access Time	Area	Leakage Power
0.38538 ns	0.03478 mm	7.64422 mW

Work Split

Work has been evenly divided between us, as we employ the peer coding method where one person writes the code and another person handles debugging.

Reference

1. A. Seznec, "Analysis of the O-GEometric history length branch predictor," 32nd International Symposium on Computer Architecture (ISCA'05), Madison, WI, USA, 2005, pp. 394-405, doi: 10.1109/ISCA.2005.13.