October 17, 2014

Lab 2: Dynamic Branch Prediction

Mehrad Khalesi 998694202
Hooman Haji 999615000

Micro Bench Mark for the 2 Level Predictor

In this micro benchmark we check the correctness of our 2-level predictor. A pattern of 19 1s and 1 zero is saved into an array. In a for loop of 10000 iterations, we call an if statement that has this pattern as its argument, thus 19 times taken and once untaken. As analyzed and explained in mb.c we expected 1/40 branch mispredictions from our predictor. In case of 10000 for loop, 500. The simulation result showed 583. The 83 extra mispredictions were due to the warm up stage of the predictor as explained in mb.c.

Performance Report

The performance of each 3 of the branch predictors, in terms of number of mispredicted instructions and MPKI, has been simulated using CBP-4 benchmarks.

Mispredictions

Predictor/Benchmark	astar	bwaves	bzip	gcc	gromacs	hmmer	mcf	soplex
2bitsat	3695830	1182969	1224967	3161868	1363248	2035080	3657986	1065988
2-level	1785464	1071909	1297677	2223671	1122586	2230774	2024172	1022869
open-end	464889	152728	1088613	101294	775533	169974 2	1370958	616964

MPKI

Predictor/Benchmark	astar	bwaves	bzip	gcc	gromacs	hmmer	mcf	soplex
2bitsat	24.639	7.886	8.166	21.079	9.088	13.567	24.387	7.107
2-level	11.903	7.146	8.651	14.824	7.484	14.872	13.494	6.819
open-end	3.099	1.018	7.257	0.675	5.170	11.332	9.140	4.113

Open Ended Predictor Design

The idea of our branch predictor is based upon *Analysis of the O-GEometric History Length branch predictor(O-GEHL)*[1]. The O-GEHL predictor has several predictor tables where each

tables is being indexed by independent functions of the global branch history, path history and branch address. The indexing process differentiates between different tables as some tables are being indexed using larger global history lengths and some use shorter ones to capture the correlation between very old branches as well as recent branch outcomes. The final answer whether a branch is taken or not takes into account results from all of the tables. We add all the counters read from the predictor tables. If the result is positive then the branch is predicted taken otherwise not taken.

Given size constraint(128Kbits) our design features 14 predictor tables of size 8Kbit (2K entries where each entry is a 4 bit saturating counter). In addition to predictor tables we use 384 bits to keep track of global branch histories and 16 bits for branch history path. Therefore, total number of storage required for this predictor would be:

*Storage = (2K * 4 * 14)(bits) + 384 (bits) + (16) (bits) = (14 KB) + (48 B) + (2 B) = 15 KB (approximately)*

Area, Access Latency and Leakage Power (CACTI)

To approximate the area, access latency and leakage power of the branch predictors, CACTI toolkit was used.

In order to get the closest simulation, the 2-stage predictor was broken down into two cache-like structures. The first level is a 512x6 block which had to be modeled with a 512x8 block due to simulators restrictions(rounded to the nearest multiple of 8). This model was compared to other alternatives models including a model with 6tag bits and a model with the same block size but with only I/O bus width of 6. However, the first of the alternatives showed more power leakage due to existence of the tags and the second alternative was fundamentally ambiguous to be correct, considering the simulator might have unknown behavior when bus width is not 8xblock-size. The second level is a 64x16 block. The alternative of 8 tables of 64x2 was not liable because it increased the area unreasonably.

The open-ended predictor was simulated with 14 2048x4 blocks, exactly as it was implemented. The details of the simulation is as follows:

table1: configuration

Block	Configuration	Cache size (bytes)	Block size (bytes)	I/O bus width
2-stage 512x6	*pureRAM*	*512*	*1*	*8*
2-stage 64x16	*pureRAM*	*128*	*2*	*16*
open-ended 2048x4	*pureRAM*	*2048*	*1*	*8*

table 2: results

Block	Access time(ns)	Power Leakage(mW)	Area (mm^2)
2-stage	*(0.164 + 0.142) = 0.306*	*(0.195 + 0.054) = 0.249*	*(0.000105 + 0.00035) = 0.000445*
open-ended	*0.206*	*14x0.834 = 11.676*	*14x(0.0036) = 0.0504*

Mehrad Khalesi: the Legendary open ended predictor, 2 level predictor

Houman Haji: 2 bit saturating counter, Micro benchmark, CACTI

Refrences:

1. Seznec, Andre´. "Analysis of the O-GEometric History Length branch predictor ." *http://www.irisa.fr/*. N.p., n.d. Web. 10 Nov. 2014. <http://www.irisa.fr/caps/people/seznec/ISCA05.pdf>.