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Microbenchmark

The microbenchmark validates the correctness of the two-level branch predictor by testing it with different branch patterns. In the first case (commented out), a repeating pattern of size 7 (T T T T T T NT) should be totally covered by the 6-bit history. Result shows near-perfect prediction accuracy, as expected. In the active code, a repeating pattern of size 8 exists, which causes a significant increase in mispredictions (over 1 million). This drastic change demonstrates the predictor's sensitivity to the length of the branch history, behaving as expected. The code was compiled using the -O0 flag to prevent optimizations that might remove branches, and the -static flag to compile the branchtrace correctly.

MPKI Table

Benchmark	2-bit Sat		2-level PaP		Open-ended	
	num_mis	MPKI	num_mis	MPKI	num_mis	MPKI
astar	3695830	24.639	1785464	11.903	510448	3.403
bwaves	1182969	7.886	1071909	7.146	333846	2.226
bzip2	1224967	8.166	1297677	8.651	1153576	7.691
gcc	3161868	21.079	2223671	14.824	166009	1.107
gromacs	1363248	9.088	1122586	7.484	814590	5.431
hmmer	2035080	13.567	2230774	14.872	1949078	12.994
mcf	3657986	24.387	2024172	13.494	1404077	9.361
soplex	1065988	7.107	1022869	6.819	846992	5.647

Open-end: TAGE with 8 components

Our predictor implementation consists of a base predictor (bimodal) and 8 tagged components, with each component indexed with geometrically longer branch history lengths.Branch outcomes are stored in the global history register, which is used to compute both the index and the tag for each component. The components are used and searched in order of most specific (longer history) to least specific (shorter history). The useful counter (u) tracks the reliability of an entry, increasing with accurate predictions and decreasing with errors. If the provider's entry is newly allocated, the alternate provider can be used as a fallback to improve prediction accuracy. Probability model is used in entry allocation to deal with ping-pong phenomena. Note: Probability model introduces randomness, which may cause slight differences in results.

Storage Requirement:

Bimodal (base): (8192 entries * 2 bits) / 8 = 2048 bytes
GHR: 200 bits / 8 = 25 bytes
Component 1: 2048 entries * (3 ctr bits + 8 tag bits + 2 usefulness bits) / 8 = 3328 bytes
Component 2: 2048 entries * (3 ctr bits + 9 tag bits + 2 usefulness bits) / 8 = 3584 bytes
Component 3: 1024 entries * (3 ctr bits + 10 tag bits + 2 usefulness bits) / 8 = 1920 bytes
Component 4: 1024 entries * (3 ctr bits + 11 tag bits + 2 usefulness bits) / 8 = 2048 bytes

Component 5: 512 entries * (3 ctr bits + 12 tag bits + 2 usefulness bits) / 8 = 1088 bytes
Component 6: 512 entries * (3 ctr bits + 13 tag bits + 2 usefulness bits) / 8 = 1152 bytes
Component 7: 256 entries * (3 ctr bits + 13 tag bits + 2 usefulness bits) / 8 = 576 bytes
Component 8: 256 entries * (3 ctr bits + 13 tag bits + 2 usefulness bits) / 8 = 576 bytes
Total = 2048 + 25 + 3328 + 3584 + 1920 + 2048 + 1088 + 1152 + 576 + 576 = 16345 bytes

CACTI

2-level predictor	Area (mm^2)	Access latency (ns)	Leakage power (mW)	Modified based on	Param changed
Private history table	0.0010528	0.163585	0.195006	pureRAM	size (bytes)
private predictor	0.0010528	0.163585	0.195006	pureRAM	size (bytes)

open-end	Area (mm^2)	Access latency (ns)	Leakage power (mW)	Modified based on	Param changed
bimodal table open-ended-bpred-1.cfg	0.012718	0.279886	2.87418	pureRAM	size (bytes)
Component 1 open-ended-bpred-3.cfg	0.01354130	0.419944	3.14628	cache	size (bytes) tag size (b)
Component 2 open-ended-bpred-4.cfg	0.0168548	0.477051	3.95076	cache	size (bytes) tag size (b)
Component 3 open-ended-bpred-5.cfg	0.00880788	0.420538	1.96262	cache	size (bytes) tag size (b)
Component 4 open-ended-bpred-6.cfg	0.00880788	0.420538	1.96262	cache	size (bytes) tag size (b)
Component 5 open-ended-bpred-7.cfg	0.00653581	0.364766	1.30902	cache	size (bytes) tag size (b)
Component 6 open-ended-bpred-8.cfg	0.00791273	0.465168	1.77178	cache	size (bytes) tag size (b)
Component 7 open-ended-bpred-9.cfg	0.00427789	0.347284	0.828907	cache	size (bytes) tag size (b)
Component 8 open-ended-bpred-10.cfg	0.00427789	0.347284	0.828907	cache	size (bytes) tag size (b)

* GHR (200 bits) (open-ended-bpred-2.cfg) too small for CACTI to simulate

Work completed by each partner
Shawn: implemented 2-bit and 2-level, implemented open-ended and tuned parameters
Victor: did all CACTI work and benchmark, implemented open-ended and tuned parameters

Reference

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