E_E 524/CPT_S 561 PA3

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Introduction and Objective

This assignment focuses on the studying the varying effects of branch predictors parameters on five different benchmarks (401.bzip2, 429.mcf, 456.hmmer, 458.sjeng, 470.lbm).

Part 1: Set Up Gem5

I used the second proposed method of setting up gem5, which was to set up gem5 on my personal computer. I use a MAC, and the major challenge I had setting up gem5 was installing the dependencies required to build gem5. One observation I however noticed during the simulations for this assignment is that the runtime required reduced alot compared to the runtime of gem5 on the sig servers.

Part 2: Adding Branch Predictor Support to Timing Simple CPU

I used the command line option method for this part. Below is a screen shot of the *config.ini* file for **BiModeBP** . I have als attached the config.ini file as part of this assignment's deliverable [Part2_BiModeBP_config.ini].

Part 3: Calculate BTB Miss Rate and Branch Misprediction Rate From Stats.txt

BTB miss rate is defined as:

$$\text{BTBMiss } \% = \left(1 - \frac{\text{BTBHits}}{\text{BTBLookups}}\right) \times 100 \tag{1}$$

Where:
BTBHits = Total number of BTB Hits
BTBLookups = Total number of BTB references.

Similarly, branch misprediction rate is defined as:

$$\text{BranchMispredPercent} = \left(\frac{\text{numBranchMispred}}{\text{numBranches}}\right) \times 100 \tag{2}$$

Where:
numBranchMispred = Total number of mispredicted Branches
numBranches = Total number of branches fetched

By (1) and (2), we get table 1 for the BTB miss rates and the branch misprediction rate for the 11 predictions stated in the introduction.

Table 1: BTB Rates (BTBMR) and Branch Miss Rates (BMR)

Predictors	**Hits**	**Lookups**	**Mispredicted**	**Fetched**	**BTBMR**	**BMR**
LocalBP	245	372	493	1317	34.14	37.43
BiModeBP	119	227	583	1317	47.58	44.27
TournamentBP	217	404	523	1317	46.29	39.71
MultiperspectivePerceptron8KB	258	460	514	1317	43.91	39.03
TAGE_SC_L_8KB	287	436	481	1317	34.17	36.52
TAGE	279	389	489	1317	28.28	37.13
MultiperspectivePerceptron64KB	283	390	497	1317	27.44	37.74
MultiperspectivePerceptronTAGE8KB	291	406	479	1317	28.33	36.37
TAGE_SC_L_64KB	286	417	472	1317	31.41	35.84
LTAGE	279	392	495	1317	28.83	37.59
MultiperspectivePerceptronTAGE64KB	297	404	477	1317	26.49	36.22

Part 4:

Running the benchmarks with the changes and comparing the different Branch Predictors

Branch prediction units are key performance components in modern microprocessors as they are widely used with an attempt to address control hazards and minimize misprediction stalls. The table presents the performance of three different predictors (a local predictor, a BiMode predictor, and a Tournament predictor) for different benchmark. An important observation from these data points is how well the Tournament branch predictors performed. It appears that the Tournament branch predictor performed slightly well as compared to the others, and this is because the TPB uses multiple predictors, usually a global predictor and a local predictor, and choosing between them with a selector. Tournament predictors can achieve better accuracy at medium sizes (8K–32K bits) and also effectively use very large numbers of prediction bits [2].

1. **BTB Miss Rate:** With regards to all five benchmarks on average, 401.bzip2 performed the best accross the three branch predictors as we increase the localpredictor size in terms of BTB miss rates and amount of fetched branches. However, the 456.hmmer benchmark perfomed the worst with very high BTB miss rates.

2. **Branch Misprediction Rate:** With regards to the branch missprediction rate, there isn't any consistent pattern in effects of increasing the local predictor sizes. The three predictors performed well on the 429.mcf benchmark, although it had the highest fetched instructions across all other benchmarks.

Finally, the contribution to CPI due to branches = number of cycles in between stages $\times$ the brach frequency.

		Parameters						
BenchMark	**Predictors**	**localPredictorSize**	**Hits**	**Lookups**	**Mispredicted**	**Fetched**	**BTBM**	**BMR2**
	LocalBP	4096	30779578	30780054	4800630	37843275	0.15%	12.69%
	LocalBP	8192	30775182	30775608	4800266	37843275	0.14%	12.68%
	BiModeBP	2048	31479549	31480044	3840296	37843275	0.16%	10.15%
	BiModeBP	8192	31467297	31467749	3829355	37843275	0.14%	10.12%
	TournamentBP	4096	33212605	33213940	2238543	37843275	0.40%	5.92%
401	TournamentBP	8192	33196295	33197583	2243718	37843275	0.39%	5.93%
	LocalBP	4096	49646711	49653271	9002194	97901023	1.32%	9.20%
	LocalBP	8192	49778467	49784938	8884657	97901023	1.30%	9.08%
	BiModeBP	2048	48459210	48462216	5487599	97901023	0.62%	5.61%
	BiModeBP	4096	49778467	49784938	8884657	97901023	1.30%	9.08%
	BiModeBP	8192	48445396	48446195	5404535	97901023	0.16%	5.52%
	TournamentBP	4096	48609740	48614508	4655347	97901023	0.98%	4.76%
429	TournamentBP	8192	48605844	48610406	4626295	97901023	0.94%	4.73%
	LocalBP	4096	20618433	20621405	3937910	27593168	1.44%	14.27%
	LocalBP	8192	20616209	20618882	3935773	27593118	1.30%	14.26%
	BiModeBP	2048	20652863	20659472	2445158	27593118	3.20%	8.86%
	BiModeBP	4096	20606727	20610685	1802759	27593118	1.92%	6.53%
	BiModeBP	8192	20620715	20626044	2401404	27593118	2.58%	8.70%
	TournamentBP	4096	20606727	20610685	1802759	27593118	1.92%	6.53%
458	TournamentBP	8192	20597831	20601754	1783398	27593118	1.90%	6.46%
	LocalBP	4096	50277741	50962017	7618733	69678397	134.27%	10.93%
	LocalBP	8192	50277741	50962017	7618733	69678397	134.27%	10.93%
	BiModeBP	2048	49962940	50524620	5610668	69678397	111.17%	8.05%
	BiModeBP	4096	48845671	49385235	5679154	69678397	109.26%	8.15%
	BiModeBP	8192	48871808	49341218	5906778	69678397	95.14%	8.48%
	TournamentBP	4096	48845671	49385235	5679154	69678397	109.26%	8.15%
456	TournamentBP	8192	49742351	50277787	4629359	69678397	106.50%	6.64%
	LocalBP	4096	6823667	6823904	1447551	18089614	0.35%	8.00%
	LocalBP	8192	6823663	6823884	1447551	18089614	0.32%	8.00%
	BiModeBP	2048	5482853	5483075	2826413	18089614	0.40%	15.62%
	BiModeBP	4096	6823663	6823884	1447551	18089614	0.32%	8.00%
	BiModeBP	8192	5482822	5483036	2826440	18089614	0.39%	15.62%
	TournamentBP	4096	6825264	6825623	1403189	18089614	0.53%	7.76%
470	TournamentBP	8192	6825113	6825473	1403284	18089614	0.53%	7.76%

References

[1] Petrovic, M., Tartalja, I., & Milutinovic, V. (1998, October). Two branch predictor schemes for reduction of misprediction rate in conditions of frequent context switches. In Proceedings Seventeenth IEEE Symposium on Reliable Distributed Systems (Cat. No. 98CB36281) (pp. 354-359). IEEE.

[2] Hennessy, J. L., & Patterson, D. A. (2011). Computer architecture: a quantitative approach. Elsevier.