Championship Branch Prediction Simulator

Project – II Report

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Q.1) Implement the PAg branch predictor described in "Alternative Implementations of Two Level Adaptive Branch Prediction," by Yeh & Pat, 1992. You will be testing 2 different configurations of this branch predictor, each with different sized structures (the per-address branch history table, PBHT, and the global pattern history table, GPHT), but using the same logic. The GPHT should be implemented with 2-bit saturating counters.

Configuration 1: PBHT size = 128 entries, with 8-bit branch history in each entry. Therefore, we will need a 256-entry GPHT.

Configuration 2: PBHT size = 512 entries, with 12-bit branch history in each entry. Therefore, we will need a 4096-entry GPHT.

For each trace in the trace directory, run a simulation for each configuration, PLUS the provided bimodal.bpred as a baseline, using 5 million warmup and 20 million simulation instructions.

(a) Include a table showing the branch prediction accuracy of the baseline bimodal predictor and each of the 2 PAg configurations, for each trace, plus an arithmetic mean of all traces for each case.

Traces	Prediction Accuracy Bimodal	Prediction Accuracy PAg (PBHT 128)	Prediction Accuracy PAg (PBHT 512)
astar_163B_50M	74.4939%	90.1207%	92.6884%
bwaves_1861B_50M	81.2193%	99.9014%	99.9502%
bzip2_183B_50M	90.2581%	86.2746%	88.8182%
gcc_13B_50M	92.3782%	93.4848%	96.5422%
GemsFDTD_109B_50M	99.5228%	99.5606%	99.5685%
lbm_94B_50M	98.753%	99.3951%	99.3951%
leslie3d_1116B_50M	98.2522%	98.1797%	98.6011%
libquantum_1210B_50M	85.6962%	98.5633%	99.9937%
mcf_46B_50M	87.1969%	92.0786%	93.0937%
milc_360B_50M	99.9982%	99.9991%	99.9991%
omnetpp_340B_50M	93.1968%	90.7941%	95.0742%
soplex_66B_50M	92.9669%	93.0347%	93.5831%
sphinx3_2520B_50M	95.9391%	95.9093%	96.1831%
wrf_1212B_50M	96.9415%	96.2368%	98.5878%
xalancbmk_748B_50M	96.8668%	92.3549%	97.2371%
Arithmetic Mean	92.2453%	95.0592%	96.6210%

(b) Include another table showing the IPC of the baseline bimodal predictor and each of the 2 PAg configurations, and % IPC improvement over the baseline bimodal predictor, for each trace, plus a geometric mean of all traces for each case.

Traces	IPC Bimodal	IPC PAg (PBHT 128)	IPC PAg (PBHT 512)	Percent Improvement (PBHT 128)	Percent Improvement (PBHT 512)
astar_163B_50M	0.331881	0.418594	0.438821	26.128%	32.222%
bwaves_1861B_50M	0.694852	0.725193	0.725433	4.367%	4.401%
bzip2_183B_50M	0.83362	0.751556	0.803032	-9.844%	-3.669%
gcc_13B_50M	0.18919	0.190959	0.194571	0.935%	2.844%
GemsFDTD_109B_50M	0.439453	0.439458	0.439487	0.001%	0.008%
lbm_94B_50M	0.494307	0.494347	0.494347	0.008%	0.008%
leslie3d_1116B_50M	0.707987	0.707445	0.707783	-0.077%	-0.029%
libquantum_1210B_50M	0.235601	0.435039	0.497377	84.651%	111.110%
mcf_46B_50M	0.0878508	0.103533	0.104569	17.851%	19.030%
milc_360B_50M	0.592034	0.592036	0.592036	0.000%	0.000%
omnetpp_340B_50M	0.242286	0.233343	0.250261	-3.691%	3.292%
soplex_66B_50M	0.339286	0.340117	0.34594	0.245%	1.961%
sphinx3_2520B_50M	0.737687	0.74091	0.744767	0.437%	0.960%
wrf_1212B_50M	0.544402	0.535366	0.552821	-1.660%	1.546%
xalancbmk_748B_50M	0.399627	0.374277	0.40364	-6.343%	1.004%
Geometric Mean	0.39544467	0.418342	0.431851	5.790%	9.206%

Q.2) Implement the gshare branch predictor described in "Combining Branch Predictors," by McFarling, 1993. You will be testing 2 different configurations of this branch predictor, each with different sized structures (the global predictor table, GPT), but using the same logic. The GPT should be implemented with 2-bit saturating counters.

Configuration 1: GPT size = 1024 entries, meaning we'll need 10 bits of global history register Configuration 2: GPT size = 4096 entries, meaning we'll need 12 bits of global history register For the indexing function, use the IP, XOR-ed with the global history register, and then mod by the size of the predictor table.

For example: int gpt_index = (ip^global_history) % GPT_SIZE; For each trace in the trace directory, run a simulation for each configuration, PLUS the provided bimodal.bpred as a baseline, using 5 million warmup and 20 million simulation instructions.

(a) Include a table showing the branch prediction accuracy of the baseline bimodal predictor and each of the 2 gshare configurations, for each trace, plus an arithmetic mean of all traces for each case.

Traces	Prediction Accuracy Bimodal	Prediction Accuracy GAg (GPT 1024)	Prediction Accuracy GAg (PBHT 4096)
astar_163B_50M	74.4939%	90.8024%	92.9464%
bwaves_1861B_50M	81.2193%	96.8277%	96.8274%
bzip2_183B_50M	90.2581%	86.5248%	87.7918%
gcc_13B_50M	92.3782%	96.0495%	96.4851%
GemsFDTD_109B_50M	99.5228%	94.3974%	99.5048%
lbm_94B_50M	98.753%	99.3951%	99.3943%
leslie3d_1116B_50M	98.2522%	97.6933%	98.1823%
libquantum_1210B_50M	85.6962%	92.8462%	94.6211%
mcf_46B_50M	87.1969%	92.8489%	94.1715%
milc_360B_50M	99.9982%	99.9964%	99.996%
omnetpp_340B_50M	93.1968%	91.7249%	95.2313%
soplex_66B_50M	92.9669%	93.0075%	93.3811%
sphinx3_2520B_50M	95.9391%	95.6296%	98.0373%
wrf_1212B_50M	96.9415%	97.144%	98.562%
xalancbmk_748B_50M	96.8668%	94.9157%	97.1886%
Arithmetic Mean	92.2453%	94.6536%	96.1547%

(b) Include another table showing the IPC of the baseline bimodal predictor and each of the 2 gshare configurations, and % IPC improvement over the baseline bimodal predictor, for each trace, plus a geometric mean of all traces for each case.

Traces	IPC Bimodal	IPC GAg (GPT 1024)	IPC GAg (GPT 4096)	Percent Improvement (GPT 1024)	Percent Improvement (GPT 4096)
astar_163B_50M	0.33188	0.418162	0.433306	25.998%	30.561%
bwaves_1861B_50M	0.69485	0.721411	0.721411	3.822%	3.822%
bzip2_183B_50M	0.83362	0.759457	0.782229	-8.896%	-6.165%
gcc_13B_50M	0.18919	0.190763	0.191893	0.831%	1.429%
GemsFDTD_109B_50M	0.43945	0.421412	0.43941	-4.105%	-0.010%
lbm_94B_50M	0.49431	0.494347	0.494346	0.008%	0.008%
leslie3d_1116B_50M	0.70799	0.706793	0.70709	-0.169%	-0.127%
libquantum_1210B_50M	0.2356	0.294549	0.32462	25.020%	37.784%
mcf_46B_50M	0.08785	0.104574	0.106284	19.036%	20.982%
milc_360B_50M	0.59203	0.592028	0.592028	-0.001%	-0.001%
omnetpp_340B_50M	0.24229	0.233262	0.248841	-3.725%	2.705%
soplex_66B_50M	0.33929	0.340504	0.343354	0.359%	1.199%
sphinx3_2520B_50M	0.73769	0.737624	0.747677	-0.009%	1.354%
wrf_1212B_50M	0.5444	0.543351	0.552833	-0.193%	1.549%
xalancbmk_748B_50M	0.39963	0.388027	0.400504	-2.903%	0.219%
Geometric Mean	0.395445	0.408083	0.418056	3.196%	5.718%

Q.3) Show a table with the storage overhead for each branch predictor and each configuration from this assignment, i.e., the bimodal predictor, 2 PAg configurations, and 2 gshare configurations. Count the storage overhead as it would appear in real hardware, not as you happened to have implemented it in the simulation. For example, if you implement a 2-bit saturating counter as a 32-bit integer, this should only count as 2 bits, and not 32 bits, for this purpose.

Predictors	Bimodal	PAg (128)	PAg (512)	GAg (1024)	GAg (4096)
Branch History Table	0	8 x 128	12 x 512	1 x 10	1 x 12
Pattern History Table	2 x 16384	2 x 256	2 x 4096	2 x 1024	2 x 4096
Total	32768 bits	1536 bits	14336 bits	2058 bits	8204 bits
	32Kb	1.5Kb	14Kb	~2Kb	~8Kb