Checkpoint - 1A: Branch Prediction Simulation using PIN

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Task 1:

Different types of brach predictors namely one bit predictor, two bit predictor, Two level GAg predictor and two level PAg predictors were simulated by using PIN tool. Their prediction accuracies were tested and compared using SPEC benchmarks. Different spec2006 benchmarks used are 403.gcc, 456.hmmer, 464.h264ref and bzip.

One bit predictor and two bit predictor are constructed using 1024 entry branch target buffer (BTB). In addition to BTB table, GAg and PAg predictor use 12 bit history tables for branch prediction. Prediction accuracies were computed for the given SPEC2006 benchmarks as shown in the following table 1.

Prediction accuracy is calculated from *count correct* and *count taken* as follows

$$Prediction\ Accuracy = \frac{Correct\ Count}{Seen\ Count} \times 100$$

Correct Count– Number of correct branch predictions

Seen Count –Total number of branches seen

Benchmark	Prediction Accuracy (%)			
	1-Bit predictor	**2-Bit predictor**	**GAg**	**PAg**
403.gcc	91.2562	69.4325	81.215	69.4408
456.hmmer	90.0261	83.4043	85.3816	83.3706
464.h264ref	86.0715	83.259	85.0286	82.4949
bzip	97.7989	68.9831	98.5984	68.8438

Table 1: Prediction Accuracy (%) for 1-Bit, 2-Bit, GAg, PAg branch predictors
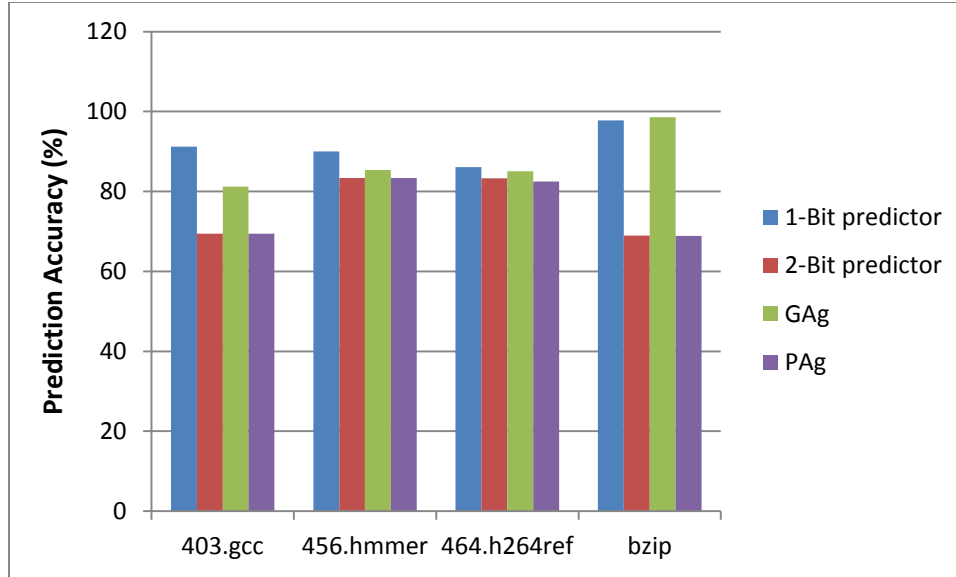
Figure 1: Prediction Accuracy (%) for 1-Bit, 2-Bit, GAg, PAg branch predictors

Figure 1 shows prediction accuracies after 2,000,000 instructions for four different predictors. It is seen that PAg has the highest prediction accuracy while 1-Bit predictor has the lowest accuracy. This is due to the fact that PAg is using two level prediction technique which uses branch history table. 1-bit predictor has the lowest prediction accuracy as it uses only one level branch predictor.

Task: 2

New branch predictor called Hybrid predictor has been developed to further improve the branch prediction accuracy.

This Hybrid predictor deploys the information gathered from both PAg and the two-bit counter. The PAg history table gives the history of the present branch whereas the two bit predictor gives the advantage of less number of mispredictions. Combination of the both helps to predict branch more accurately.

The results from Table 2 and Figure 2 show that the Hybrid predictor has higher prediction accuracy compared with other branch predictors.

Benchmark	Prediction Accuracy (%)				
	1-Bit predictor	**2-Bit predictor**	**GAg**	**PAg**	**Hybrid**
403.gcc	91.2562	69.4325	81.215	69.4408	93.638
456.hmmer	90.0261	83.4043	85.3816	83.3706	91.8738
464.h264ref	86.0715	83.259	85.0286	82.4949	92.1695
bzip	97.7989	68.9831	98.5984	68.8438	98.4136

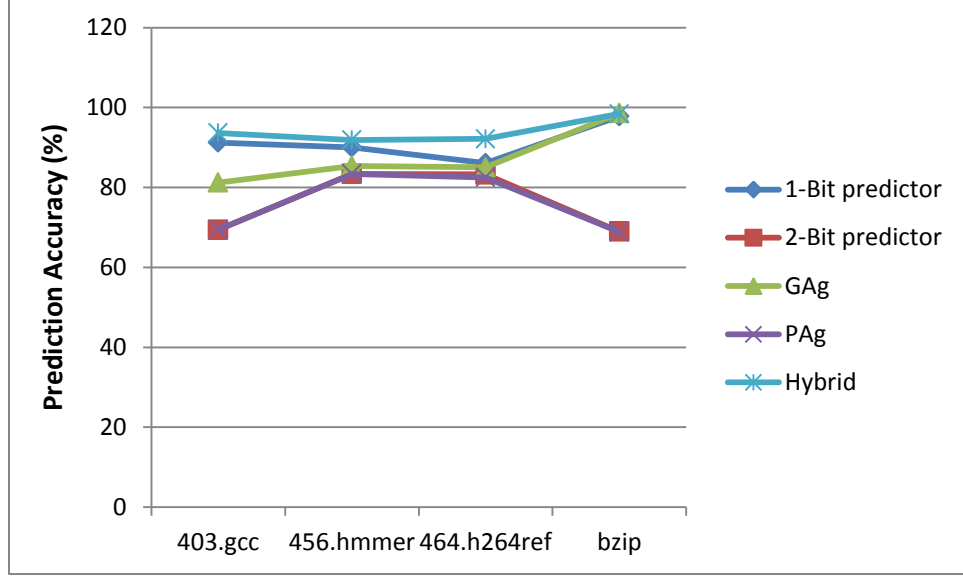Table 2: Prediction Accuracies along with Hybrid predictor

Table 2: Prediction Accuracy for Hybrid predictor

This Hybrid predictor gives highest prediction of 96.3971% for bzip benchmark. But this predictor requires lots of memory for its execution. This additional complexity increases the latency as well as hardware cost for its implementation.

Task 3:

1. Prediction accuracies for one Bit, two bit, GAg, PAg predictor which were run on 403.gcc, 456.hmmer, 464.h264ref, bzip benchmarks are tabulated as follows

Benchmark	Prediction Accuracy (%)			
	1-Bit predictor	**2-Bit predictor**	**GAg**	**PAg**
403.gcc	91.2562	69.4325	81.215	69.4408
456.hmmer	90.0261	83.4043	85.3816	83.3706
464.h264ref	86.0715	83.259	85.0286	82.4949
bzip	97.7989	68.9831	98.5984	68.8438

Table 3: Prediction Accuracy (%) for 1-Bit, 2-Bit, GAg, PAg branch predictors

The analysis of the information inferred from the above table is same as in Task 1.

2. The missed rate is calculated from count missed and count seen as follows

$$Missed\ rate\ (\%) = \frac{Missed\ Count}{Seen\ Count} \times 100$$

Following table shows the missed rate of each predictor for each benchmark application.

Benchmark	Missed Rate (%)			
	1-Bit predictor	**2-Bit predictor**	**GAg**	**PAg**
403.gcc	1.9841	1.9841	7.26995	0.58025
456.hmmer	0.83265	0.83265	2.97455	0.7587
464.h264ref	2.11705	2.11705	6.14115	0.27875
bzip	0.09835	0.09835	0.2776	0.06395

Table 4: Missed rate for 1-Bit, 2-Bit, GAg, PAg branch predictors

3. The length of the global history register for the GAg predictor was varied and run on all benchmark application and the prediction accuracies were tabulated in the following table.

Benchmark	Prediction Accuracy (%)		
	8 Bit	**10 Bit**	**12 Bit**
403.gcc	81.215	82.5159	85.7469
456.hmmer	85.3816	88.253	89.5001
464.h264ref	85.0285	85.9896	87.899
Bzip	98.5984	98.5911	98.7323

Table 5: Prediction Accuracies for GAg predictor for different history register lengths.

It is observed that the prediction accuracy increase when the length of the history register is increased. 12 Bit GAg has the better performance as compared with 8 Bit GAg branch predictor. From the table it is observed that beyond certain bit length limit, the prediction accuracy rate saturates.
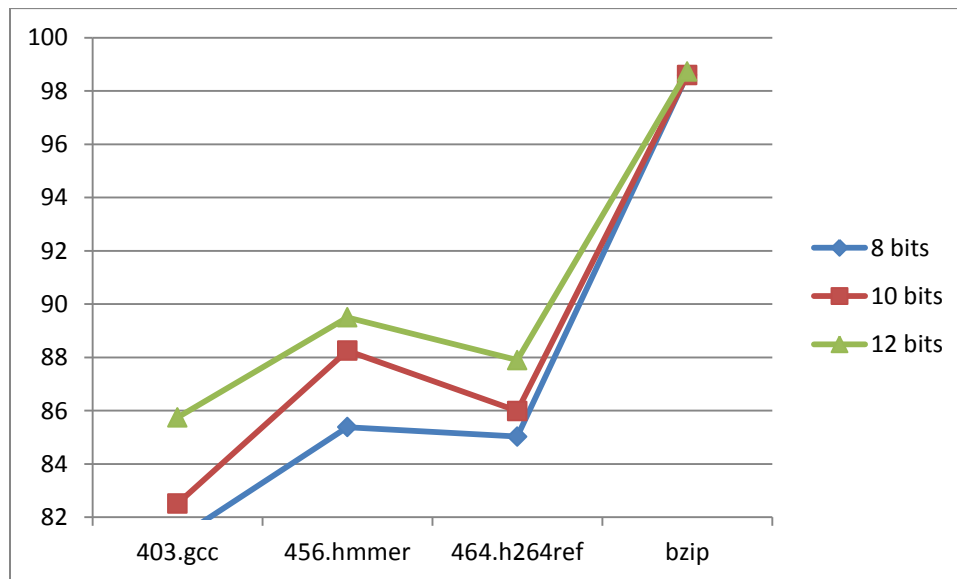

Figure 3: Prediction accuracy of GAg for 8,10,12 bit history register

4. The GAg branch predictor uses the global history register for branch prediction. The application with the most global correlation will have the consistently accurate prediction accuracy. It is observed from the table 3 that the prediction accuracy for benchmark application bzip persistently increases. Therefore, we can conclude that the bzip application has most global correlation from among all the others compared in this assignment. In this case, it exploits the global redundancy.