High Performance Computer Architecture (CS60003)

Tutorial 2 Solutions

Indian Institute of Technology Kharagpur

Probable Solutions

1. It is provided that ideally the processor has CPI 1. We have to decide which of the two predictors is better based on the execution time. Assume that clock period for the baseline processor is T.

   (a) `BatPredictor`:
   Cycle Time: $T \times (1 + 0.15) = 1.15T$
   Average CPI of non-branch instructions: $0.85 \times 1 = 0.85$
   Average CPI of branch instructions which are taken: $0.9 \times 1 = 0.9$
   Average CPI of branch instructions which are not-taken: $0.1 \times (1 + 2) = 0.3$
   Average CPI of the branch instructions: $0.15 \times (0.3 + 0.9) = 0.18$
   Average CPI of all the instructions: $0.85 + 0.18 = 1.03$
   Average execution time for each instruction: $1.03 \times 1.15T = 1.1845T$
   `SuperPredictor`:
   Cycle Time: $T \times (1 + 0.2) = 1.2T$
   Average CPI of non-branch instructions: $0.85 \times 1 = 0.85$
   Average CPI of branch instructions which are taken: $0.88 \times 1 = 0.88$
   Average CPI of branch instructions which are not-taken: $0.12 \times (1 + 2) = 0.36$
   Average CPI of the branch instructions: $0.15 \times (0.36 + 0.88) = 0.186$
   Average CPI of all the instructions: $0.85 + 0.186 = 1.036$
   Average execution time for each instruction: $1.036 \times 1.2T = 1.2432T$
   As $1.2432T > 1.1845T$, `BatPredictor` would be a better choice for this case.

   (b) `BatPredictor`:
   Cycle Time: $T \times (1 + 0.15) = 1.15T$
   Average CPI of non-branch instructions: $0.75 \times 1 = 0.75$
   Average CPI of branch instructions which are taken: $0.9 \times 1 = 0.9$
   Average CPI of branch instructions which are not-taken: $0.1 \times (1 + 2) = 0.3$
   Average CPI of the branch instructions: $0.25 \times (0.3 + 0.9) = 0.3$
   Average CPI of all the instructions: $0.75 + 0.3 = 1.05$
   Average execution time for each instruction: $1.05 \times 1.15T = 1.2075T$
   `SuperPredictor`:
   Cycle Time: $T \times (1 + 0.2) = 1.2T$
   Average CPI of non-branch instructions: $0.75 \times 1 = 0.75$
   Average CPI of branch instructions which are taken: $0.88 \times 1 = 0.88$
   Average CPI of branch instructions which are not-taken: $0.12 \times (1 + 2) = 0.36$
   Average CPI of the branch instructions: $0.25 \times (0.36 + 0.88) = 0.31$
   Average CPI of all the instructions: $0.75 + 0.31 = 1.06$
   Average execution time for each instruction: $1.06 \times 1.2T = 1.2720T$
   As $1.272T > 1.2075T$, again `BatPredictor` would be a better choice for this case.

2. (a)
$$CPI_{br} = 1 + (p_{br} + p_{btb}) \times T_{mp}$$
   (b)
$$CPI_{br} = 1 + (0.08 + 0.18) \times 10 = 3.6$$

3. (a) The global register stores 3-bit history. Therefore, the Pattern History Table (PHT) will have $2^3 = 8$ entries.

   (b) The table is filled up as discussed in the class. [**Note:** The updates in the PHT has been done in the next row, in a non-speculative manner. You can update the PHT in the same row as well.]

GR	**pred**	**Updated GR**	**act**	**Corr?**	**PHT**
000	N	000	T	No	00, 00, 00, 00, 00, 00, 00, 00
001	N	010	N	Yes	01, 00, 00, 00, 00, 00, 00, 00
010	N	100	N	Yes	01, 00, 00, 00, 00, 00, 00, 00
100	N	000	N	Yes	01, 00, 00, 00, 00, 00, 00, 00
000	N	000	T	No	01, 00, 00, 00, 00, 00, 00, 00
001	N	010	N	Yes	10, 00, 00, 00, 00, 00, 00, 00
010	N	100	N	Yes	10, 00, 00, 00, 00, 00, 00, 00
100	N	000	N	Yes	10, 00, 00, 00, 00, 00, 00, 00
000	T	001	T	Yes	10, 00, 00, 00, 00, 00, 00, 00
001	-	-	-	-	11, 00, 00, 00, 00, 00, 00, 00