

CS 3330 COMPUTER ARCHITECTURE, SPRING 2020

HW 4: BRANCH PREDICTION

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Assigned: Apr 6, 2020

Due: **Apr 13, 2020****1 Branch Prediction [60 points]**

Consider the following high level language code segment:

```

int array[1000] = { /* random values */ };
int sum1 = 0, sum2 = 0, sum3 = 0, sum4 = 0;

for (i = 0; i < 1000; i ++) // LOOP BRANCH
{
    if (i % 4 == 0) // IF CONDITION 1
        sum1 += array[i]; // TAKEN PATH
    else
        sum2 += array[i]; // NOT-TAKEN PATH

    if (i % 2 == 0) // IF CONDITION 2
        sum3 += array[i]; // TAKEN PATH
    else
        sum4 += array[i]; // NOT-TAKEN PATH
}

```

Your task is to find the prediction accuracy for the LOOP BRANCH (which is taken whenever the loop repeats, and not taken when the loop exits) and both of the IF CONDITION branches inside the loop (which are taken when the if-condition is *true*, and not taken when the if-condition is *false*), for different kinds of branch predictors.

Show all your work for credit.

- (a) What is the actual branch outcome for each individual branch? Use T to represent taken outcome and N for not-taken outcome. For example, one sample outcome can be represented as TTTN TTTN TTTN ... TTTN.

LOOP BRANCH:

--

IF CONDITION 1:

--

IF CONDITION 2:

- (b) What is the prediction accuracy for each individual branch using a per-branch last-time predictor (assume that every per-branch counter starts at “not-taken”) for the following branches?

LOOP BRANCH:

IF CONDITION 1:

IF CONDITION 2:

- (c) What is the prediction accuracy when a per-branch 2-bit saturating counter-based predictor is used (assume that every per-branch counter starts at “strongly not-taken”), for the following branches?

LOOP BRANCH:

IF CONDITION 1:

IF CONDITION 2:

- (d) What is the prediction accuracy of IF CONDITION 1 and IF CONDITION 2, when the counter starts at

(i) “weakly not-taken”?

IF CONDITION 1:

IF CONDITION 2:

(ii) “weakly taken”?

IF CONDITION 1:

IF CONDITION 2:

2 Branch Prediction [30 points]

Assume the following piece of code that iterates through a large array populated with **completely (i.e., truly) random** positive integers. The code has four branches (labeled B1, B2, B3, and B4). When we say that a branch is *taken*, we mean that the code *inside* the curly brackets is executed.

```

for (int i=0; i<N; i++) { /* B1 */
    val = array[i];      /* TAKEN PATH for B1 */
    if (val % 2 == 0) {  /* B2 */
        sum += val;     /* TAKEN PATH for B2 */
    }
    if (val % 3 == 0) {  /* B3 */
        sum += val;     /* TAKEN PATH for B3 */
    }
    if (val % 6 == 0) {  /* B4 */
        sum += val;     /* TAKEN PATH for B4 */
    }
}

```

- (a) Of the four branches, list all those that exhibit *local correlation*, if any.

- (b) Which of the four branches are *globally correlated*, if any? Explain in less than 20 words.

3 BONUS: Reading [20 points]

Read this papers and write a short summary (and pros and cons). Please follow these slides on how to critically analyze papers. <https://www.cs.virginia.edu/~smk9u/CS3330S20/reviewing.pptx>

- (a) McFarling, “Combining Branch Predictors”, WRL Technical Note TN-36, 1993. <https://www.cs.virginia.edu/~smk9u/CS3330S20/WRL-TN-36.pdf>

4 Handin

You should electronically hand in your homework (in pdf format) to Collab.