

## CS2323 Computer Architecture 2019

### Homework 3

**Important:** Your submission should be named as RollNumber\_CA\_HW3.pdf. For example, if your roll number is cs16mtech11075, then your submission should be cs16mtech11075\_CA\_HW3.pdf. Except pdf, no other format is acceptable. **10 marks will be deducted for not following these instructions or if you submit a zipped file.**

To reduce TA efforts, please answer the questions in the order in which they are given. There is no latex bonus.

1. (4 mark) Assume a neural predictor entry has the weight vector as [20, -14, 29, -12, 4] (bias weight is the last one) and branch history register as [1, -1, 1, 1]. Find its prediction. Assume that the outcome is taken, show updated weights and second prediction.

2. (1 mark) Write a minimal sequence of instructions which shows WAR hazard.

3. (1 mark) Write a minimal sequence of instructions which shows control hazard.

4. (3 marks) Consider the following instructions:

```
add  r11, r11, 5
```

```
mul  r2, r11, 90
```

```
add  r8,  r8,  r2
```

```
sub  r9,  r9,  5
```

```
ld   r0, 55(r9)
```

Assume the pipeline has only 3 stages: fetch, decode and execute (as assumed in the lecture on superscalar execution). Show the pipeline diagram assuming (1) simple pipelining (2) superscalar execution and (3) out-of-order execution.

5. (2 marks) Consider the code below and answer the following two questions:

```
for ( int i=0; i<N; i++) { /* B1 */
```

```
val = array [ i ] ;
```

```
if ( val % 20 == 0 ) { /* B2 */
```

```
sum += val ;} }
```

For branch B1 to be a biased branch, what should be the condition on the value of N and what should be the condition on values of array[]. If no condition is required, just say so.

For branch B2 to be an un-biased branch, what should be a condition on the value of N and and what should be the condition on values of array[]. If no condition is required, just say so.

6. (2 marks) Represent 6.6979 in single-precision and double-precision floating point notation (you may use online tool for this). Also, find the difference between the number (i.e., 5.6677) and what is stored for both single and double precision-numbers. In which case, is the error (difference) smaller?

7. (2 marks) Think of a recursive function to compute fibonnaci series in SimpleRISC. In your answer, you have to only write the changes in the code for fibonnaci series compared to that shown for factorial in L09. Write original code (for factorial) and new code (for fibonnaci)

8. (3 mark) Show the 32-bit SimpleRISC encoding of each of the following instructions:

\* ret

\* call .factorial       //address of factorial in binary is 110101

\* st ra, 4[sp]

\* b .continue       //address of this instruction (PC) is 001011 and address of .continue is 110100

\* sub r1 r9 8

\* lsl r5 r8 r9

9. [2 mark] Show pipeline diagram for the following instructions assuming interlocking technique is used. You need not explain the diagram.

add r1, r2, r3

mul r7, r9, r10

sub r4, r1, r5

10. [1 mark] Write clearly why isLd is an input to the adder in ALU even though load instruction loads data from memory. [refer L10]

11. [6 marks] Consider a branch which shows "TAKEN" outcome for five times consecutively and "NOT-TAKEN" twice consecutively. This pattern is repeated indefinitely, i.e., **1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 0, 0**, and so on.

We use a two-level local history predictor where we remember the history of past **three** outcomes of this branch. Find out the accuracy of this branch predictor as  $p/q$  (where  $q=7$ ). Ignore the accuracy for first five rounds (i.e., first 35 accesses) because that is the warmup period. (Hint: you may write a C/C++ code to find this but you don't have to upload the code. You can also answer without writing code, just by reasoning.)

12.

Use the code uploaded on google-classroom. Write the value of [bias, weight1, weight2] after 1000 predictions for following cases and accuracy. (Do not use any seed for random number generation. Due to random number generation, the answer of different students may not match, which is OK.)

(a) [1 mark]

```
n =rand();
```

```
if (n is divisible by 2?) //B1
```

```
if (n is divisible by 9?) //B2 (correlated branch)
```

```
if(n is divisible by 18?) → we use neural branch predictor for this branch
```

(b) [1 mark]

```
n =rand();
```

```
if (n is divisible by 2?) //B1
```

```
if (n is divisible by 7?) //B2 (uncorrelated branch)
```

```
if(n is divisible by 18?) → we use neural branch predictor for this branch
```

(c) [1 mark]

```
n =rand();
```

```
if (n is divisible by 2?) //B1
```

```
if (n >0) //B2 (highly biased branch)
```

```
if(n is divisible by 18?) → we use neural branch predictor for this branch
```

(d) [1mark] We now remove the biased branch and find correlation with only one branch. You need to write only bias and weight1 for this case

n=rand();

if (n is divisible by 2?) //B1

if(n is divisible by 18?) → we use neural branch predictor for this branch