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CS4515
HW2

[15/15] <C.2> Suppose the branch frequencies (as percentages of all instructions) are as follows:

Conditional branches: 15%
Jumps and calls: 1%
Taken conditional branches: 60% are taken

a. [15] <C.2> We are examining a four-stage pipeline where the branch is resolved at the end of the second cycle for unconditional branches and at the end of the third cycle for conditional branches. Assuming that only the first pipe stage can always be completed independent of whether the branch is taken and ignoring other pipeline stalls, how much faster would the machine be without any branch hazards?

First we must, determine the branch stall for unconditional branch stall:

(N-1 stalled cycles – parallelisable cycles) * frequency = unconditional branch stall
such that unconditional branch stall >= 0

(1 - 1) * 0.05 = 0

Next we can determine the amount of Conditional branch stalls for those taken and those not.

(N-1 stalled cycles – parallelisable cycles) * frequency = Taken Conditional Branch Stall
such that unconditional branch stall >= 0

(2-1) * 0.6 * 0.15 = 0.09

Note: the parallelisable cycles is 1 due to first pipe stage can always be completed independent of whether the branch is taken and ignoring other pipeline stalls.

Next we can determine the amount of Conditional branch stalls for those taken and those not.

(N-1 stalled cycles – parallelisable cycles) * frequency = Taken Conditional Branch Stall
such that unconditional branch stall >= 0

(2-1) * 0.4 * 0.15 = 0.06

We can then calculate the new Cycles per instruction as:

1 + Conditional + Unconditional = new CPI
1 + 0 + 0.09 + 0.06 = 1.15

We can then calculate the speed up (assuming that the clock cycle time stays constant) by

Pipeline Speedip = Pipeline Depth / (1 + Branch frequency * Branch penalty)

Pipeline Speed up = 4 / 1.15 ~= 3.4783

b. [15] <C.2> Now assume a high-performance processor in which we have a 15-deep pipeline where the branch is resolved at the end of the fifth cycle for unconditional branches and at the end of the tenth cycle for conditional branches. Assuming that only the first pipe stage can always be completed independent of whether the branch is taken and ignoring other pipeline stalls, how much faster would the machine be without any branch hazards?

As before, we need to find the stall frequencies for each of the branch stalling factors using:

(N-1 stalled cycles – parallelisable cycles) * frequency = branch stall
such that unconditional branch stall >= 0

Unconditional:

$$(4-1) * 0.01 = 0.03$$

Conditional-Taken:

$$(9-1) * 0.06 * 0.15 = 0.072$$

Conditional-Not-Taken:

$$(9-1) * 0.04 * 0.15 = 0.048$$

New CPI = 1 + 0.03 + 0.072 + 0.048 = 1.15
Pipeline Speed up = 15/1.15 ~= 13.043