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Computer Architecture Exercise 5

Given - 20% of the commands in the program are branch commands. It is known that 10% of the loop commands are LOOP commands when $CPI_{LOOP} = 14$,
Therefore the rest of the Branch orders constitute an additional 10%, when $CPI_{Branch} = 12$.
We will separate the conditional branch commands for the connection of commands that are a conditional branch of LOOP and the rest of the commands that are JCC:
$CPI_{Branch} = 12$ (given)

$$12 = CPI_{LOOP} * \frac{10}{20} + CPI_{JCC} * \frac{10}{20} = 14 * \frac{1}{2} + CPI_{JCC} * \frac{1}{2}$$

$$\frac{CPI_{JCC}}{2} = 5$$

$CPI_{JCC} = 10$

We will update the table according to the deposit of the conditional branch orders:

Type i	IC_i/IC	CPI_i
ALU	50%	5
LOOP	10%	14
JCC	10%	10
LOAD	20%	10
STORE	10%	10

Calculate the updated CPI:
CPI = 5*0.5 + 14*0.1 + 10*0.1 + 10*0.2 + 10*0.1 = 7.9
If it is possible to change the combinations in 50% of the cases of using the JCC command, there is a change in IC_i.
For the following commands:
ALU (because we download 2 ALU commands in exchange for replacing one LOOP command),
LOOP (because we add 50% more LOOP commands in the program),
JCC (because we replace 50% of these orders in the program).
Therefore the table is recalculated. Let's start by calculating the changed commands:
IC_i (i=ALU) = 0.50*IC.
IC_i' (i=ALU) = 0.50*IC – 2*0.50*0.10*IC = 0.40*IC.

2 ALU commands were replaced by a LOOP command which is 10% of the total program, so we reduced them.
IC_i (i=LOOP) = 0.1*IC.
IC_i' (i=LOOP) = 0.10*IC + 0.50*0.10*IC = 0.15*IC.

The extra IC*0.10*0.50 is due to adding 50% LOOP commands to our program.
IC_i (i=JCC) = 0.10*IC.
IC_i' (i=JCC) = 0.50*0.10*IC = 0.05*IC.
Because we reduced the use of JCC commands in our program by 50%.

The rest of the commands have not changed:
IC_i (i=LOAD) = 0.20*IC, ICi (i=STORE) = 0.10*IC
IC' = 0.40*IC + 0.15*IC + 0.05*IC + 0.20*IC + 0.10*IC = 0.90*IC

The new table we received:

Type i	**IC_i'/IC'**	**CPI_i'**
ALU	0.40/0.90	5
LOOP	0.15/0.90	10
JCC	0.05/0.90	10
LOAD	0.20/0.90	10
STORE	0.10/0.90	10

We received from the new table for each new CPI_i - type i. That's why we calculate the CPI' of the entire program:

$$CPI' = \sum_i CPI_i' \times \frac{IC_i'}{IC'} = 5 \times \frac{0.4}{0.9} + 10 \times \frac{0.15}{0.9} + 10 \times \frac{0.05}{0.9} + 10 \times \frac{0.2}{0.9} + 10 \times \frac{0.1}{0.9} = \frac{70}{9} \approx 7.78.$$

And in total, according to the definition, the general improvement to the processor that will be obtained is:

$$s = \frac{T}{T'} = \frac{CPI \times IC \times \tau}{CPI' \times IC' \times \tau'} = \frac{7.9 \times IC \times \tau}{7.78 \times 0.9 \times IC \times \tau} = \frac{7.9}{7.78 \times 0.9} \approx 1.2824 = \mathbf{1.3}$$