

The worked out example in the textbook (Example 5.5 on page 168 in Chapter 5) has an error. Here is the correct solution.

Example 5.5 in the textbook

Instruction	CPI
Add	2
Shift	3
Others	2
Add/Shift	4

If the sequence ADD followed by SHIFT appears in 20% of the dynamic frequency of a program, what is the speedup of the program with all {ADD, SHIFT} replaced by the new instruction?  
 [Hint: a) For every 10 instructions in the original program, 2 instructions are the ADD/SIFT combo. b) The number of instructions in the new program shrinks to 90% of the original program.]

Solution:

Let  $N$  be the number of instructions in the original program. Then, the execution time of the original program

$$\begin{aligned}
 &= N * \text{frequency of ADD} * 2 + N * \text{frequency of SHIFT} * 3 + N * \text{frequency of others} * 2 \\
 &= N * 0.1 * 2 + N * 0.1 * 3 + N * 0.8 * 2 = 2.1 N
 \end{aligned}$$

With the combo instruction replacing {ADD, SHIFT} the number of instructions in the new program shrinks to 0.9  $N$  in the new program. The frequency of the combo instruction is 1/9 and the other instructions are 8/9.

The execution time of the new program is

$$\begin{aligned}
 &= (0.9 N) * \text{frequency of combo} * 4 + (0.9 N) * \text{frequency of others} * 2 \\
 &= (0.9 N) * (1/9) * 4 + (0.9 N) * (8/9) * 2 \\
 &= 2N
 \end{aligned}$$

Speedup of the program = old execution time/new execution time

$$\begin{aligned}
 &= 2.1 N / 2N \\
 &= 1.05
 \end{aligned}$$