HW assignment 1

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Exercise 1 [4pts]
Using the information given in the following table for processors P1, P2 and P3, that execute the same set of instructions, answer the next three questions;

Processor	Clock rate	CPI
P1	2GHZ	1.2
P2	3GHZ	0.8
P3	4GHZ	1.9

1) Which processor has the highest performance in terms of instructions executed per second?
2) If each of these processors, execute a program in 10 seconds, then what will be the number of cycles and instructions.
3) We are trying to reduce the time by 30%, but it leads to an increase of 20% in CPI. What will be the clock rate?

1) $t_{CPU} = CPI \cdot IC / f$ (1)

by algebraic manipulation

$$\frac{IC}{t_{cpu}} = \frac{f}{CPI} \quad \text{so} \quad \frac{IC}{t} = \frac{f}{CPI}$$

So:

P1 $IC/t = \frac{2\ GHz}{1,2} = 1,7 \cdot 10^9$ instr./s

P2 $IC/t = \frac{3\ GHz}{0,8} = 3,8 \cdot 10^9$ instr./s

P3: $IC/t = \frac{4\ GHz}{1,9} = 2,1 \cdot 10^9$ instr./s

So P2 has the highest performance in terms of instructions per second.

2) Clock frequency gives the number of cycles per second. The execution time gives the amount of seconds. Hence

$$\#cycles = f \cdot t_{cpu}$$

The values calculated by the previous question give the instructions per second. Hence

$$IC = (IC/t) \cdot t_{cpu}$$

this gives for

P1: cycles = 2 GHz · 10 s = $2 \cdot 10^{10}$ cycles

IC = $1,7 \cdot 10^9 \cdot 10 = 1,7 \cdot 10^{10}$ instr.

P2: cycles = 3 GHz · 10 s = $3 \cdot 10^{10}$ cycles

IC = $3,8 \cdot 10^9 \cdot 10 = 3,8 \cdot 10^{10}$ instr.

P3: cycles = 4 GHz · 10s = $4 \cdot 10^{10}$ cycles

IC = $2,1 \cdot 10^9 \cdot 10 = 2,1 \cdot 10^{10}$ instr.

3) $t = \frac{CPI \cdot IC}{f}$ from (1)

$f = \frac{CPI \cdot IC}{t}$

Increase by a percentage so it is a ratio.

$\frac{f_{new}}{f_{old}}$ needs to be found. Ic does not change so its ratio is 1. So 30% decrease in time means $t_{new}/t_{old} = 0,7$. Increase 20% of CPI means $CPI_{new}/CPI_{old} = 1,2$

$$\frac{f_{new}}{f_{old}} = \frac{CPI_{new}/CPI_{old}}{t_{new}/t_{old}} = \frac{1,2}{0,7} = 1,71$$

So $f_{new} = 1,71 \cdot f_{old}$

SO P1: $f_{new} = 1,71 \cdot 2$ GHz $= 3,42$ GHz

P2: $f_{new} = 1,71 \cdot 3$ GHz $= 5,13$ GHz

P3: $f_{new} = 1,71 \cdot 4$ GHz $= 6,84$ GHz

Exercise 2 [4pts]
Using the information given in the next table, answer the following three questions.

Processor	Clock rate	Number of Instructions	execution time
P1	2GHZ	20.00E+09	5s
P2	3GHZ	30.00E+09	8s
P3	4GHZ	25.00E+09	7s

4) Find IPC (instruction per cycle) for each processor.
5) Find the clock rate for P2 that reduces its execution time to that of P3.
6) Find the number of instructions for P2 that reduces its execution time to that of P3.

4) $t_{ex} = \frac{IC \cdot CPI}{f}$ (1) $\rightarrow t_{ex} = \frac{IC}{f \cdot ICP}$

by logic $CPI = \frac{1}{ICP}$

$ICP = \frac{IC}{f \cdot t_{ex}}$

P1: $ICP = \frac{20 \cdot 10^9}{2 \cdot 10^9 \cdot 5} = 2$ instr/cycle

P2: $ICP = \frac{30 \cdot 10^9}{3 \cdot 10^9 \cdot 8} = 1{,}25$ instr./cycle

P3: $ICP = \frac{25 \cdot 10^9}{4 \cdot 10^9 \cdot 7} = 0{,}89$ instr./cycle

5) $f = \frac{IC}{t \cdot ICP}$ (1). $\frac{f_{new}}{f_{old}}$ needs to be found.

Since IC, ICP do not change

$\frac{f_{new}}{f_{old}} \propto \frac{1}{t_{new}/t_{old}} = \frac{t_{old}}{t_{new}} = \frac{t_{P2}}{t_{P3}} = \frac{8}{7}$

So $f_{new} = \frac{8}{7} \cdot f_{old,P2} = \frac{8}{7} \cdot 3\ GHz = 3{,}43\ GHz$

6) $IC = f \cdot t \cdot IPC$ from (1)

again, find $\frac{IC_{new}}{IC_{old}}$, and f, IPC do not change

So

$\frac{IC_{new}}{IC_{old}} \propto \frac{t_{new}}{t_{old}} = \frac{t_{P3}}{t_{P2}} = \frac{7}{8}$

$IC_{new} = \frac{7}{8} \cdot IC_{P2} = \frac{7}{8} \cdot 30 \cdot 10^9 = 26{,}3 \cdot 10^9$ instructions

Exercise 3 [2pts]
Assume three processors execute the same set of instructions. There are three classes of instructions with the given CPI in the following table. The distribution percentage of the instructions is 60% of class A, 30% of Class B, and 10% of class C. What is the average weighted CPI for each processor?

Processor	Clock rate	CPI(A)	CPI(B)	CPI(C)
P1	4GHZ	1	1.5	4.1
P2	3GHZ	2.5	1	1
P3	3GHZ	1.5	1.5	1

$$CPI_{w,avg} = \sum_i P_i \cdot CPI_i = P_A \cdot CPI(A) + P_B \cdot CPI(B) + P_C \cdot CPI(C)$$

P1: $CPI_{w,avg} = 0,6 \cdot 1 + 0,3 \cdot 1,5 + 0,1 \cdot 4,1$ (values of CPI from P1)

$= 1,46$ cycles/instr.

P2: $CPI_{w,avg} = 0,6 \cdot 2,5 + 0,3 \cdot 1 + 0,1 \cdot 1$

$= 1,9$ cycles/instr.

P3: $CPI_{w,avg} = 0,6 \cdot 1,5 + 0,3 \cdot 1,5 + 0,1 \cdot 1$

$= 1,9$ cycles/instr.