Problem1:

$$\text{Cpu time(P1)}$$

$$= \frac{10\% \times 1 + 20\% \times 2 + 50\% \times 3 + 20\% \times 3}{2.5 \times 10^9} \times 1 \times 10^6$$

$$= 1.04 \text{ ms}$$

$$\text{Cpu time(P2)}$$

$$= \frac{10\% \times 2 + 20\% \times 2 + 50\% \times 2 + 20\% \times 2}{3 \times 10^9} \times 1 \times 10^6$$

$$= 0.67 \text{ ms}$$

As Cpu time(P1)>Cpu time(P2), so the implement of P2 is faster than P1.

1. What is the global CPI for each implementation?

A:

$$\text{global CPI (P1)} = 10\% \times 1 + 20\% \times 2 + 50\% \times 3 + 20\% \times 3 = 2.6$$

$$\text{global CPI (P2)} = 10\% \times 2 + 20\% \times 2 + 50\% \times 2 + 20\% \times 2 = 2$$

2. Find the clock cycles required in both cases.

A:

$$\text{clock cycles (P1)}$$

$$= (10\% \times 1 + 20\% \times 2 + 50\% \times 3 + 20\% \times 3) \times 1 \times 10^6$$

$$= 2.6 \times 10^6$$

$$\text{clock cycles (P2)}$$

$$= (10\% \times 2 + 20\% \times 2 + 50\% \times 2 + 20\% \times 2) \times 1 \times 10^6$$

$$= 2 \times 10^6$$

Problem2:

1. Find the CPI if the clock cycle time is 0.333ns.

A:

$$\mathrm{CPI} = \frac{\text{Execution time}}{\text{Instruction count} \times \text{clock cycle time}}$$

$$= \frac{750}{2.389 \times 10^{12} \times 0.333 \times 10^{-9}} = 0.943$$

2. Find the SPECratio.

A:

$$\text{SPECratio} = \frac{\text{reference time}}{\text{execution time}} = \frac{9650}{750} = 12.87$$

3. Find the new CPU time if the number of instructions of the benchmark is increased by 10% without affecting the CPI.

A:

$$\text{new CPU time} = \frac{\text{CPI} \times \text{new Instruction count}}{\text{clock rate}}$$

$$= \frac{\text{CPI} \times (1 + 10\%)\text{old Instruction count}}{\text{clock rate}}$$

$$= (1 + 10\%) \times \text{old CPU time} = 110\% \times 750 = 825 \;\; \mathrm{s}$$

4. Find the new CPU time if the number of instructions of the benchmark is increased by 10% and the CPI is increased by 5%.

A:

$$\text{new CPU time} = \frac{\text{new CPI} \times \text{new Instruction count}}{\text{clock rate}}$$

$$= \frac{(1+5\%)\text{old CPI} \times (1+10\%)\text{old Instruction count}}{\text{clock rate}}$$

$$= (1+5\%) \times (1+10\%) \times \text{old CPU time}$$

$$= 105\% \times 110\% \times 750 = 866.25 \ \text{ s}$$

5. Find the new SPECratio for this change.

A:

$$\text{new SPECration} = \frac{\text{reference time}}{\text{new execution time}} = \frac{9650}{866.25} = 11.14$$

6. Suppose that we are developing a new version of the AMD Barcelona processor with a 4 GHz clock rate. We have added some additional instructions to the instruction set in such a way that the number of instructions has been reduced by 15%. The execution time is reduced to 700 s and the new SPECratio is 13.7. Find the new CPI.

A:

$$\text{new CPI} = \frac{\text{new CPU} \times \text{new clock rate}}{\text{new Instruction count}} = \frac{700 \times 4 \times 10^{9}}{2.389 \times 10^{12} \times (1-15\%)}$$

$$= 1.379$$

Problem3

1. Assume 23 and 112 are signed 8-bit decimal integers stored in two’s complement format. Calculate 23 + 112 using saturating arithmetic. The result should be written in decimal. Show the steps for calculation.

A: rewrite 23 and 112 in binary format:23: 00010111 , 112: 01110000, as they are stored in two’s complement format , so convert them back to what actually they are. 00010111 ->00010111 and 01110000 ->01110000, the range of signed 8-bit decimal integer is [-128,127] , so (23)+(112)=135 > 127, thus the result of saturating arithmetic is 127.

2. Assume 23 and 112 are signed 8-bit decimal integers stored in two’s complement format. Calculate 23 - 112 using saturating arithmetic. The result should be written in decimal. Show the steps for calculation.

A: rewrite 23 and 112 in binary format:23: 00010111 , 112: 01110000, as they are stored in two’s complement format , so convert them back to what actually they are. 00010111 ->00010111 (23 in decimal) and 01110000 ->01110000 (112 in decimal) , the range of signed 8-bit decimal integer is [-128,127] , so 23-112= -89 in the range, thus the result of saturating arithmetic is -89.

3. Assume 23 and 112 are unsigned 8-bit integers. Calculate 23 + 112 using saturating arithmetic. The result should be written in decimal. Show the steps for calculation.

A:rewrite 23 and 112 in binary format:23: 00010111 , 112: 01110000, so

00010111+01110000=10000111 (135 in decimal) , the range of unsigned 8-bit decimal integer is [0,255] , so 23+112=135 in the range, thus the result of saturating arithmetic is 135.

Problem4:

Calculate the product of the hexadecimal unsigned 8-bit integers 62 and 13 using the hardware described below. You should show the contents of each register on each step. Use a table to show the detailed process.

product	multiplicand
00000000|00010011	01100010
00110001|00001001	01100010
01001001|10000100	01100010
00100100|11000010	01100010
00010010|01100001	01100010
00111010|00110000	01100010
00011101|00011000	01100010
00001110|10001100	01100010
00000111|01000110	01100010

The equation is 01100010 × 00010011 = 0000011101000110

Problem5

Calculate 52 divided by 21 using the hardware described below. You should show the contents of each register on each step. Assume both inputs are unsigned 6-bit integers. Use a table to show the detailed process.

Quot	Divisor	Remainder
000000	010101000000	000000110100
000000	001010100000	000000110100
000000	000101010000	000000110100
000000	000010101000	000000110100
000000	000001010100	000000110100
000000	000000101010	000000110100
000001	000000010101	000000001010
000010	000000001010	000000001010

The equation is 110100 / 10101 = 10