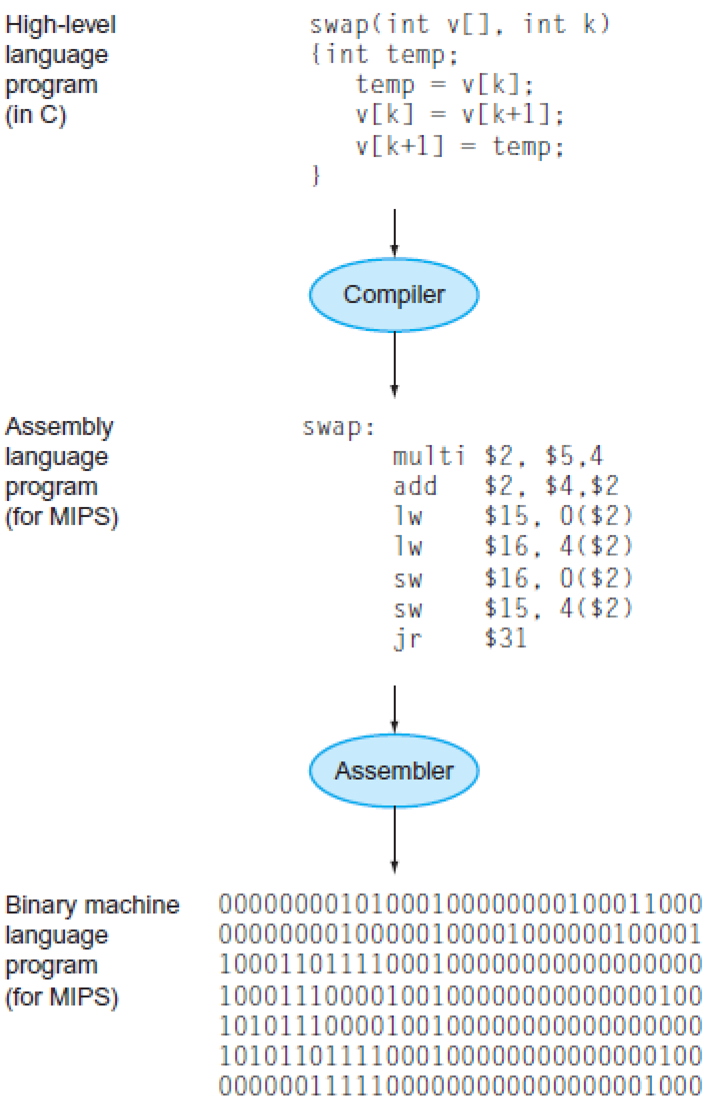
1.3 [2] <§1.3> Describe the steps that transform a program written in a high-level language such as C into a representation that is directly executed by a computer processor.

Answer :



You can find this figure and detail description from P.14-P.15.

1.5 [4] <§1.6> Consider three different processors P1, P2, and P3 executing the same instruction set. P1 has a 3 GHz clock rate and a CPI of 1.5. P2 has a 2.5 GHz clock rate and a CPI of 1.0. P3 has a 4.0 GHz clock rate and has a CPI of 2.2.

Answer :

Processor	Clock Rate	CPI
P1	3×10^9	1.5
P2	2.5×10^9	1.0
P3	4×10^9	2.2

a. Which processor has the highest performance expressed in instructions per second?

$$CPU\ time = \frac{Instruction\ Count \times CPI}{Clock\ Rate}$$

If we want to compare the performance with several processors directly, we can use CPU time equation as below :

Processor 1 time $= 5 \times \mathrm{IC} \times 10^{-10}$

Processor 2 time $= 4 \times \mathrm{IC} \times 10^{-10}$

Processor 3 time $= 5.5 \times \mathrm{IC} \times 10^{-10}$

Because the instruction set is same, we do not consider IC.

Processor 2 has the highest performance expressed

b. If the processors each execute a program in 10 seconds, find the number of cycles and the number of instructions.

$$Total\ cycles\ of\ CPU\ = Execution\ Time \times Clock\ Rate$$

Processor 1 cycles $= 10 \times 3 \times 10^9 = 3 \times 10^{10}$ cycles

Processor 2 cycles $= 10 \times 2.5 \times 10^9 = 2.5 \times 10^{10}$ cycles

Processor 3 cycles $= 10 \times 4 \times 10^9 = 4 \times 10^{10}$ cycles

$$Instruction\ Count = \frac{Execution\ Time \times Clock\ Rate}{CPI}$$

Processor 1 Instructions $= \dfrac{10 \times 3 \times 10^9}{1.5} = 2 \times 10^{10}$ instructions

Processor 2 Instructions $= \dfrac{10 \times 2.5 \times 10^9}{1.0} = 2.5 \times 10^{10}$ instructions

Processor 3 Instructions $= \dfrac{10 \times 4 \times 10^9}{2.2} \cong 1.818 \times 10^{10}$ instructions

c. We are trying to reduce the execution time by 30% but this leads to an increase of 20% in the CPI. What clock rate should we have to get this time reduction?

$$Execution\ time\ \times\ 0.7\ =\ \frac{(Instruction\ count\ \times (CPI\ \times\ 1.2))}{(New\ Clock\ rate)}$$

$$New\ Clock\ Rate = \frac{12}{7} \times Old\ Clock\ Rate$$

$$\text{Processor 1 Clock Rate} = \frac{12}{7} \times 3 \times 10^9 \text{ GHz}$$

$$\text{Processor 2 Clock Rate} = \frac{12}{7} \times 2.5 \times 10^9 \text{ GHz}$$

$$\text{Processor 3 Clock Rate} = \frac{12}{7} \times 4 \times 10^9 \text{ GHz}$$

1.6 [20] <§1.6> Consider two different implementations of the same instruction set architecture. The instructions can be divided into four classes according to their CPI (class A, B, C, and D). P1 with a clock rate of 2.5 GHz and CPIs of 1, 2, 3, and 3, and P2 with a clock rate of 3 GHz and CPIs of 2, 2, 2, and 2.

Given a program with a dynamic instruction count of 1.0E6 instructions divided into classes as follows: 10% class A, 20% class B, 50% class C, and 20% class D, which implementation is faster?

Answer :

	Clock Rate	CPI of A	CPI of B	CPI of C	CPI of D
P1	2.5×10^9	1	2	3	3
P2	3×10^9	2	2	2	2

	A	B	C	D
Instruction Count	1×10^5	2×10^5	5×10^5	2×10^5

$$P1\ CPU\ Time$$
$$= \frac{(1 \times 1 \times 10^5) + (2 \times 2 \times 10^5) + (3 \times 5 \times 10^5) + (3 \times 2 \times 10^5)}{2.5 \times 10^9}$$
$$= 1.04 \times 10^{-3}$$
$$P2\ CPU\ Time$$
$$= \frac{(2 \times 1 \times 10^5) + (2 \times 2 \times 10^5) + (2 \times 5 \times 10^5) + (2 \times 2 \times 10^5)}{3.0 \times 10^9}$$
$$= \frac{20}{3} \times 10^{-4}$$

a. What is the global CPI for each implementation?

$$Global\ CPI = \frac{CPU\ Time \times Clock\ Rate}{Instruction\ Count}$$

$$\text{P1 Global CPI} = \frac{1.04 \times 10^{-3} \times 2.5 \times 10^{9}}{10^{6}} = 2.6$$

$$\text{P2 Global CPI} = \frac{\frac{20}{3} \times 10^{-3} \times 3 \times 10^{9}}{10^{6}} = 2$$

b. Find the clock cycles required in both cases.

$$Clock\ Cycle = Instruction\ count \times CPI$$

$\text{P1 Clock Cycle} = 2.6 \times 10^{6}$

$\text{P2 Clock Cycle} = 2 \times 10^{6}$