CSE - 340
Computer Architecture

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Answer to the question no 1

Given that,

A program has a total of 1.0×10^6 instruction count, and the instructions are divided into classes as follows:

30% Class A, 50% Class B, 10% class C, 10% class D

$\therefore$ Instruction count for class A = 0.3×10^6

$\therefore$ Instruction count for class B = 0.5×10^6

$\therefore$ Instruction count for class C = 0.1×10^6

$\therefore$ Instruction count for class D = 0.1×10^6

(1)

For Playstation 5,

Total instruction count = 1×10^6

We know,

$$\text{Clock Cycles} = \sum_{i=1}^{n} (CPI_i \times \text{instruction count}_i)$$

$\therefore$ Clock cycles for play station 5

$$= (0.3 \times 10^6 \times 7) + (0.5 \times 10^6 \times 2) + (0.1 \times 10^6 \times 3) + (0.1 \times 10^6 \times 6)$$

$$= 4 \times 10^6$$

We know, average CPI = $\dfrac{\text{Clock Cycles}}{\text{instruction count}}$

$\therefore$ Avg CPI for playstation 5 = $\dfrac{4 \times 10^6}{1 \times 10^6} = 4$

For Xbox:

Total instruction count = 1×10^6

We know,

$$\text{Clock cycles} = \sum_{i=1}^{n} (CPI_i \times \text{instruction count}_i)$$

and,

$$\text{average } CPI = \frac{\text{Clock Cycles}}{\text{instruction count}}$$

∴ Clock cycles for xbox,

$$= (0.3 \times 10^6 \times 5) + (0.5 \times 10^6 \times 4) + (0.1 \times 10^6 \times 2) + (0.1 \times 10^6 \times 1)$$

$$= 3.8 \times 10^6$$

$$\therefore \text{Avg } CPI = \frac{3.8 \times 10^6}{1 \times 10^6} = 3.8$$

∴ Playstation 5 will take $(4 - 3.8) = 0.2$ clock cycles per instruction more than Xbox.

From (1) we got,

Clock cycles for Playstation 5 = 4.0×10^6

Clock cycles for Xbox = 3.8×10^6

Given that,

Clock rate of Playstation 5 = 2.7 GHz

Clock rate of Xbox = 3 GHz

We know,

$$\text{execution time} = \frac{\text{CPU clock Cycles}}{\text{clock rate}}.$$

$\therefore$ execution time of Playstation 5 $= \dfrac{4.0 \times 10^6}{2.7 \times 10^9}$

$= 1.481 \times 10^{-3}$ s

$= 1.481$ ms

$\therefore$ execution time of Xbox $= \dfrac{3.8 \times 10^6}{3 \times 10^9}$

$= 1.267 \times 10^{-3}$ s

$= 1.267$ ms.

$\therefore$ Differences between the execution time of these two control is $(1.481 - 1.267)$ms $= 0.214$ ms

From (2), we got,

execution time of Playstation 5 = 1.481 ms

Given,

reference time = 120 ms.

We know,

$$\text{Spec ratio of a program} = \frac{\text{reference time}}{\text{execution time}}$$

$$= \frac{120}{1.481}$$

$$= 81.0263$$

(4)

The performance of a programe can be affected by algorithm, compiler and ISA in the following ways,

• Algorithms:

The algorithm used to implement a program can have a significant impact on its performance. For example, if a program is built for sorting an array and the program uses merge sort instead of bubble sort. Then the program will perform better than a program which uses bubble sort algorithm. As, algorithms determines the number of operations executed.

- **Compilers:**

Compilers can optimize code for the targeted computer architecture. A well-optimized compiler can reduce CPI by generating more efficient code. Therefore, compiler organizations plays a crucial role in improving overall performance.

- **ISA:**

ISA can also improve the overall performance of a computer. As, ISA can directly affect the instruction count and CPI. and clock rate.

Answer to the question no 2

(1)

Assuming,

The CPI is x.

We know that,

execution time = instruction count × CPI × Clock cycle time.

Given that,

execution time = 540 s

instruction count = 1.35×10^{12}

clock cycle time = 0.22 ns = 0.22×10^{-9} s.

So,

$$540 = 1.35 \times 10^{12} \times \cancel{x} \times 0.22 \times 10^{-9}$$

$$\Rightarrow x = \frac{540}{1.35 \times 10^{12} \times 0.22 \times 10^{-9}}$$

$$\Rightarrow x = \frac{20}{11}$$

$$\Rightarrow x = 1.8181$$

∴ The CPI is 1.8181

(2)

From (1) we got,

$CPI = 1.8181$

Given that,

- The number of instructions is increased by 12%
- The CPI is increased by 6%
- Clock Cycle time = $0.22 ns = 0.22 \times 10^{-9} s$
- Reference time = 1394 s.

$\therefore$ Updated $CPI = 1.8181 + (1.8181 \times 6\%)$

$= 1.927186$

$\therefore$ Updated number of instructions $= (1.35 \times 10^{12}) + (1.35 \times 10^{12} \times 12\%)$

$= 1.512 \times 10^{12}$

We know,

execution time = number of instruction × CPI × Clock Cycle Time

$= 1.512 \times 10^{12} \times 1.927186 \times 0.22 \times 10^{-9}$

$= 641.059151$ s

$\therefore$ Updated spee ratio $= \dfrac{\text{reference time}}{\text{execution time}}$

$= \dfrac{1394}{641.059151}$

$= 2.17452$

Answer to the question no 3

(1)

Given that,

- Initial execution time = 2100 s
- The password generation was taking 90% of the total time.

According to Amdhal's law,

$$T_{improved} = \frac{T_{affected}}{\text{improvement factor, } n} + T_{unaffected}$$

$$\Rightarrow \frac{100}{5} = \frac{90}{n} + 10$$

$$\Rightarrow 20 = \frac{90}{n} + 10$$

$$\Rightarrow n = \frac{90}{10}$$

$$\Rightarrow n = 9$$

∴ The password generation operation has to improved by a factor of 9 to meet the requirements.

From (1) we got,

Given, improvement factor, $n = 9$

initial execution time = 2100 s

initial affected time = $(2100 \times 90\%)$ s

= 1890 s.

initial unaffected time = $(2100 - 1890)$ s

= 210 s

Now, we have to find the new execution time of the program.

According to Amdhal's law, we know,

$$T_{improved} = \frac{T_{affected}}{\text{improvement factor, } n} + T_{unaffected}$$

$$\therefore T_{improved} = \frac{1890}{9} + 210$$

$$\Rightarrow T_{improved} = 210 + 210$$

$$\Rightarrow T_{improved} = 420 \text{ s}$$

∴ New execution time of the program = 420 s.

As, it's mentioned that, generation operation takes 90% of the execution time.

∴ New time of the program taken by generation operation

$= (420 \times 90\%) = 378$ s