Performance of Computer Architectures

- Ideally performance of computer system demands perfect match between machine capability and program behaviour.
- Factors affecting program behaviour : algorithm design, data structures, language efficiency, programmer skills, compiler technology.
- Performance factors :

➢ Clock rate and CPI

➢ Total Execution time

➢ MIPS rate

➢ Throughput rate

What is Parallel Processing?

It is an efficient form of information processing which emphasizes on the exploitation of the concurrent events in the computing process.

Efficiency is measured as:-

Efficiency = Time / Speed + Accuracy

System Attributes versus Performance Factors

- The ideal performance of a computer system requires a perfect match between machine capability and program behavior.
- Machine capability can be enhanced with better hardware technology, however program behavior is difficult to predict due to its dependence on application and run-time conditions.
- Below are the five fundamental factors for projecting the performance of a computer.

- **<u>Clock Rate</u> :-** CPU is driven by a clock of constant cycle time (τ).

$$\tau = 1/f \text{ (ns)}$$

2. <u>CPI</u> :- (Cycles per instruction)

As different instructions acquire different cycles to execute, CPI will be taken as an average value for a given instruction set and a given program mix.

3. <u>Execution Time</u> :- Let I_c be Instruction Count or total number of instructions in the program. So

Execution Time = ?

$$\boxed{T = I_c \times CPI \times \tau}$$

Now,

CPI = Instruction Cycle = Processor Cycles + Memory Cycles

$\therefore$ Instruction cycle = $p + m \times k$

where

m = number of memory references

P = number of processor cycles

k = latency factor (how much the memory is slow w.r.t to CPU)

Now let ***C*** be Total number of cycles required to execute a program.

So, C = ?

$$C = I_c \times CPI$$

And the time to execute a program will be

$$T = C \times \tau$$

4. MIPS Rate :-

$$\text{MIPS rate} = \frac{I_c}{T \times 10^6}$$

5. Throughput Rate:- Number of programs executed per unit time.

$$W = ?$$

$$W = 1 / T$$

OR

$$W = \frac{\text{MIPS} \times 10^6}{I_c}$$

Numerical:- A benchmark program is executed on a 40MHz processor. The benchmark program has the following statistics.

Instruction Type	Instruction Count	Clock Cycle Count
Arithmetic	45000	1
Branch	32000	2
Load/Store	15000	2
Floating Point	8000	2

Calculate average CPI,MIPS rate & execution for the above benchmark program.

$$\text{Average CPI} = \frac{C}{I_c}$$

$$\frac{C}{I_c} = \frac{\text{Total \# cycles to execute a whole program}}{\text{Total Instruction}}$$

$$= \frac{45000 \times 1 + 32000 \times 2 + 1500 \times 2 + 8000 \times 2}{45000 + 3200 + 15000 + 8000}$$

$$= \frac{155000}{100000}$$

CPI = 1.55

$$\text{Execution Time} = C / f$$

$$T = 150000 / 40 \times 10^{6}$$

$$T = 0.155 / 40$$

$$\mathbf{T = 3.875\ ms}$$

$$\text{MIPS rate} = I_c / T \times 10^{6}$$

$$\text{MIPS rate} = 25.8$$

Programmatic Levels of Parallel Processing

Parallel Processing can be challenged in 4 programmatic levels:-

3. Job / Program Level

2. Task / Procedure Level

3. Interinstruction Level

4. Intrainstruction Level

1. Job / Program Level :-

It requires the development of parallel processable algorithms.The implementation of parallel algorithms depends on the efficient allocation of limited hardware and software resources to multiple programs being used to solve a large computational problem.

Example: Weather forecasting , medical consulting , oil exploration etc.

2. Task / Procedure Level :-

It is conducted among procedure/tasks within the same program. This involves the decomposition of the program into multiple tasks.
(for simultaneous execution)

3. Interinstruction Level :-

Interinstruction level is to exploit concurrency among multiple instructions so that they can be executed simultaneously. Data dependency analysis is often performed to reveal parallel-