SNS COLLEGE OF ENGINEERING

Kurumbapalayam (PO), Coimbatore – 641 107
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DEPARTMENT OF INFORMATION TECHNOLOGY

COURSE NAME: 19IT301 COMPUTER ORGANIZATION AND ARCHITECTURE

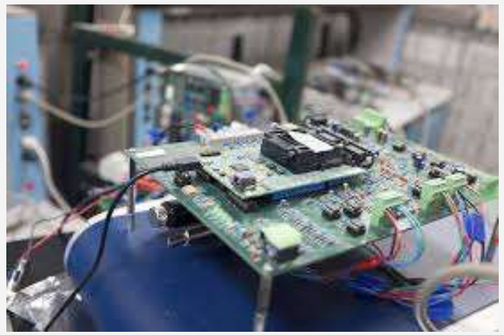
II YEAR/ III SEM

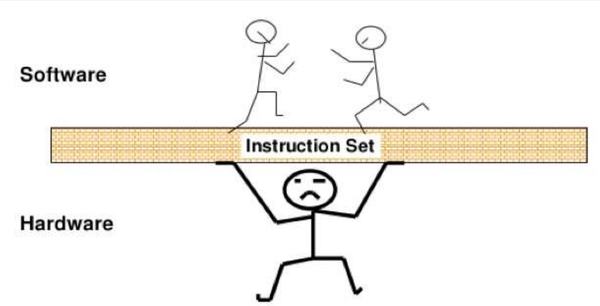
Unit 1 : BASIC STRUCTURE OF COMPUTERS Topic 3:

Performance

Performance

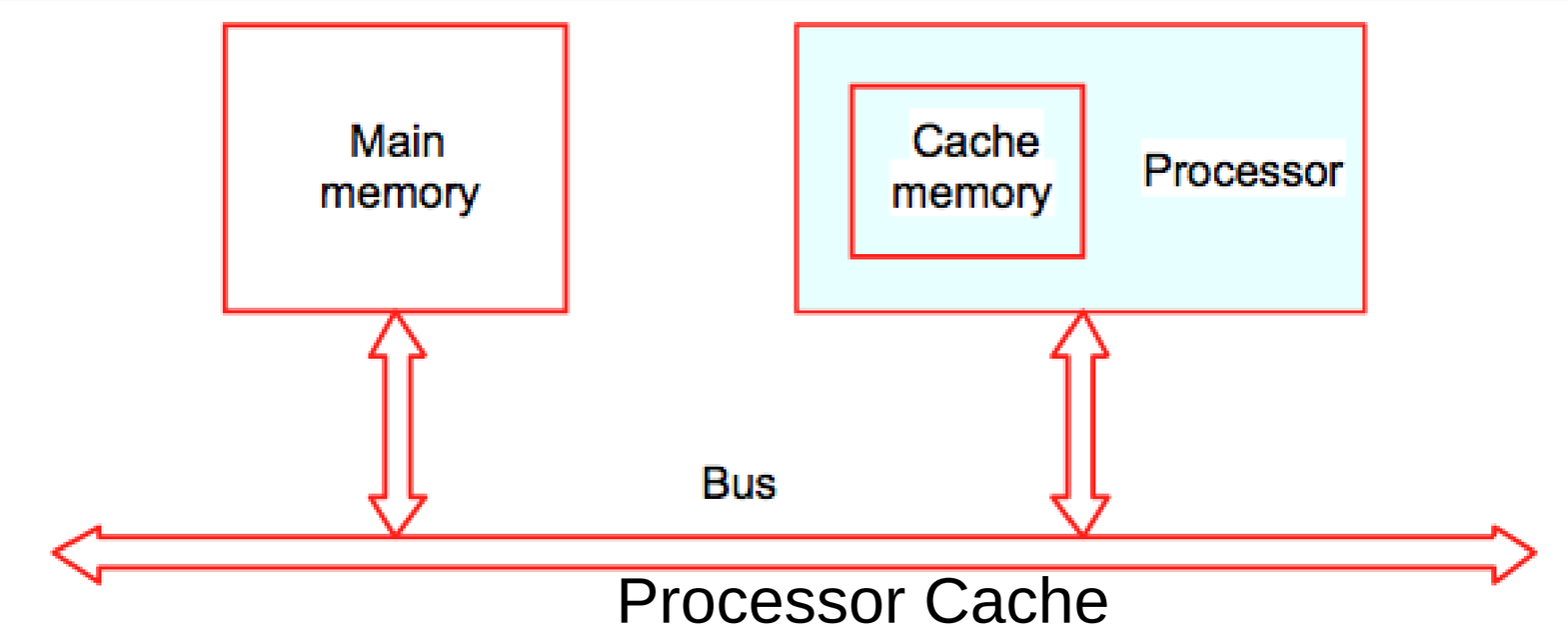
- The most important measure of a computer is how quickly it can execute programs.
- Three factors affect performance:
  - ✓ Hardware design
  - ✓ Instruction set
  - ✓ Compiler





Performance

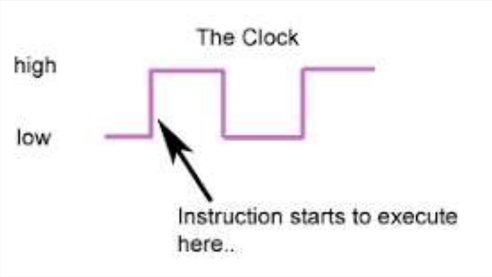
- **Processor time** to execute a program depends on the hardware involved in the execution of individual machine instructions.



- The processor and a relatively small cache memory can be fabricated on a single integrated circuit chip.

Processor Clock

- Processor circuits are controlled by a timing signal called a Clock
- Clock defines a regular time intervals called clock cycle (P), and clock rate(cycles per second), R=1/P
- The execution of each instruction is divided into several steps (Basic Steps), each of which completes in one clock cycle.
- Hertz(Hz) – cycles per second
- 500 million cycles/second = 500MHz (clock period(P) = $1/500*10^6 = 2*10^{-9}$ = 2ns)
- 1250 million cycles/second = 1.25GHz (clock period =0.8ns)



Basic Performance Equation

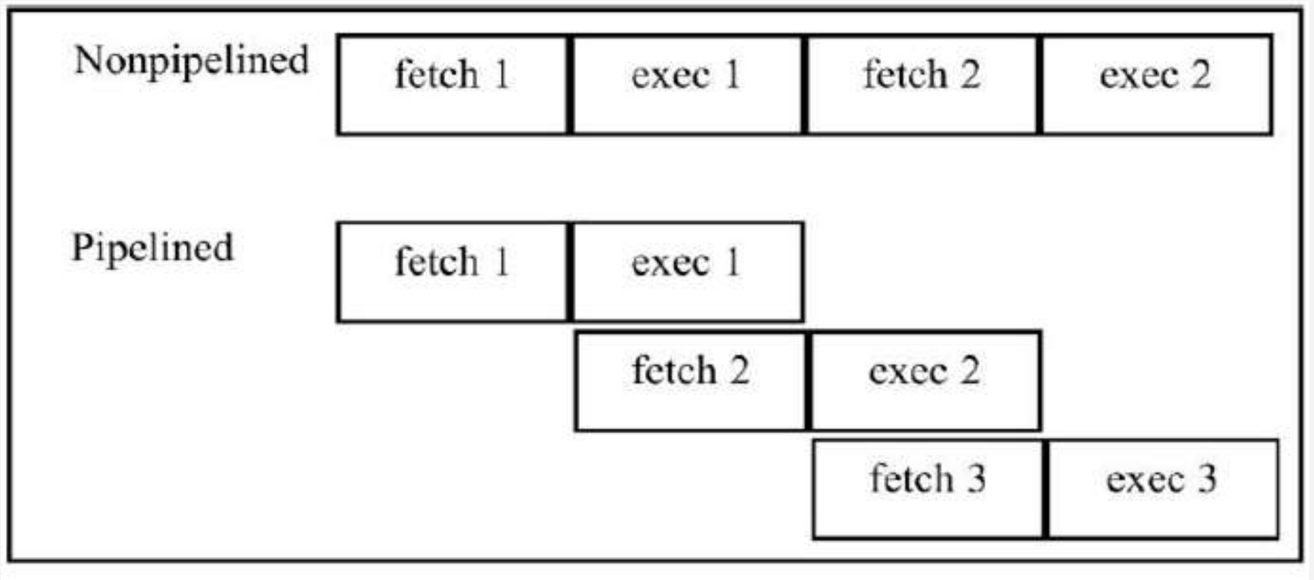
- T – processor time required to execute a program that has been prepared in high-level language
- N – number of actual machine language instructions needed to complete the execution (note: loop)
- S – average number of basic steps needed to execute one machine instruction. Each step completes in one clock cycle
- R – clock rate
- *Note:* these are not independent to each other

Program Execution time, $T = \frac{N \times S}{R}$ is called basic performance equation

- How to improve T?
- Reduce N and S, increase R

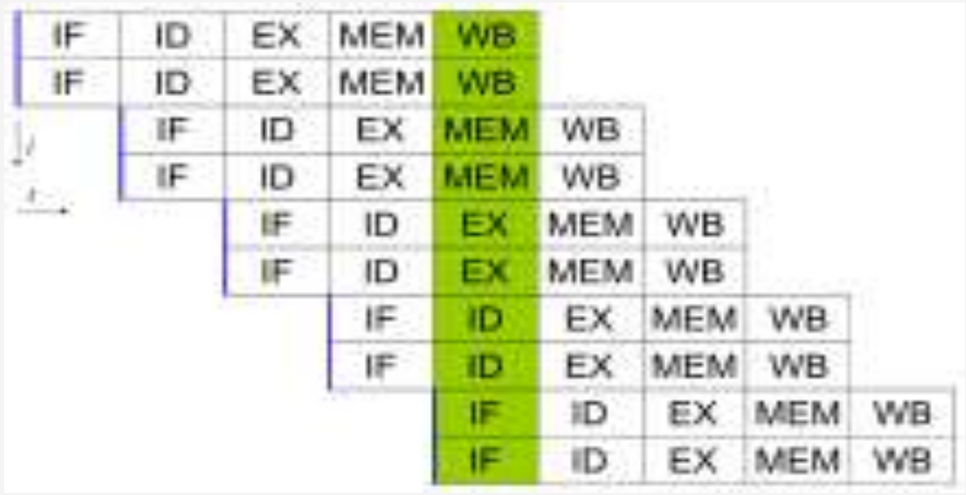
Pipeline and Superscalar Operation

- Instructions are not necessarily executed one after another.
- The value of S doesn't have to be the number of clock cycles to execute one instruction.
- Pipelining – overlapping the execution of successive instructions.
- Add R1, R2, R3 at the same time processor reads next instruction in memory.



Pipeline and Superscalar Operation

- Superscalar operation – multiple instruction pipelines are implemented in the processor.
- Goal – reduce S (could become <1!)



Simple superscalar pipeline. By fetching and dispatching two instructions at a time, a maximum of two instructions per cycle can be completed.

Clock Rate

- Increase clock rate(R)
  - ✓ Improve the integrated-circuit (IC) technology to make the circuits faster by reducing P and increasing R
  - ✓ Reduce the amount of processing done in one basic step (however, this may increase the number of basic steps needed. Ex: P= 2ns, steps – 2. Total: 4ns. Now P=1ns, then steps =4)
- Increase in R that are entirely caused by improvements in IC technology affect all aspects of the processor's operation equally except the time to access the main memory.

Instruction set: CISC and RISC

- Tradeoff between N and S
- A key consideration is the use of pipelining
  - ✓ S is close to 1 even though the number of basic steps per instruction may be considerably larger
  - ✓ It is much easier to implement efficient pipelining in processor with simple instruction sets
- Reduced Instruction Set Computers (RISC) (Large value N , Small Value of S)
- Complex Instruction Set Computers (CISC) (Small value N , Large Value of S)

Compiler

- A compiler translates a high-level language program into a sequence of machine instructions.
- To reduce N, we need a suitable machine instruction set and a compiler that makes good use of it.
- Goal – reduce N×S
- A compiler may not be designed for a specific processor; however, a high-quality compiler is usually designed for, and with, a specific processor.

Performance Measurement

- T is difficult to compute.
- Measure computer performance using benchmark programs.
- System Performance Evaluation Corporation (SPEC) selects and publishes representative application programs for different application domains, together with test results for many commercially available computers.
- Compile and run (no simulation)

$$SPEC\ rating = \frac{\text{Running time on the reference computer}}{\text{Running time on the computer under test}}$$

Overall $$SPEC\ rating = (\prod_{i=1}^{n} SPEC_i)^{\frac{1}{n}}$$

- n is the number of program in the suite

Thank You