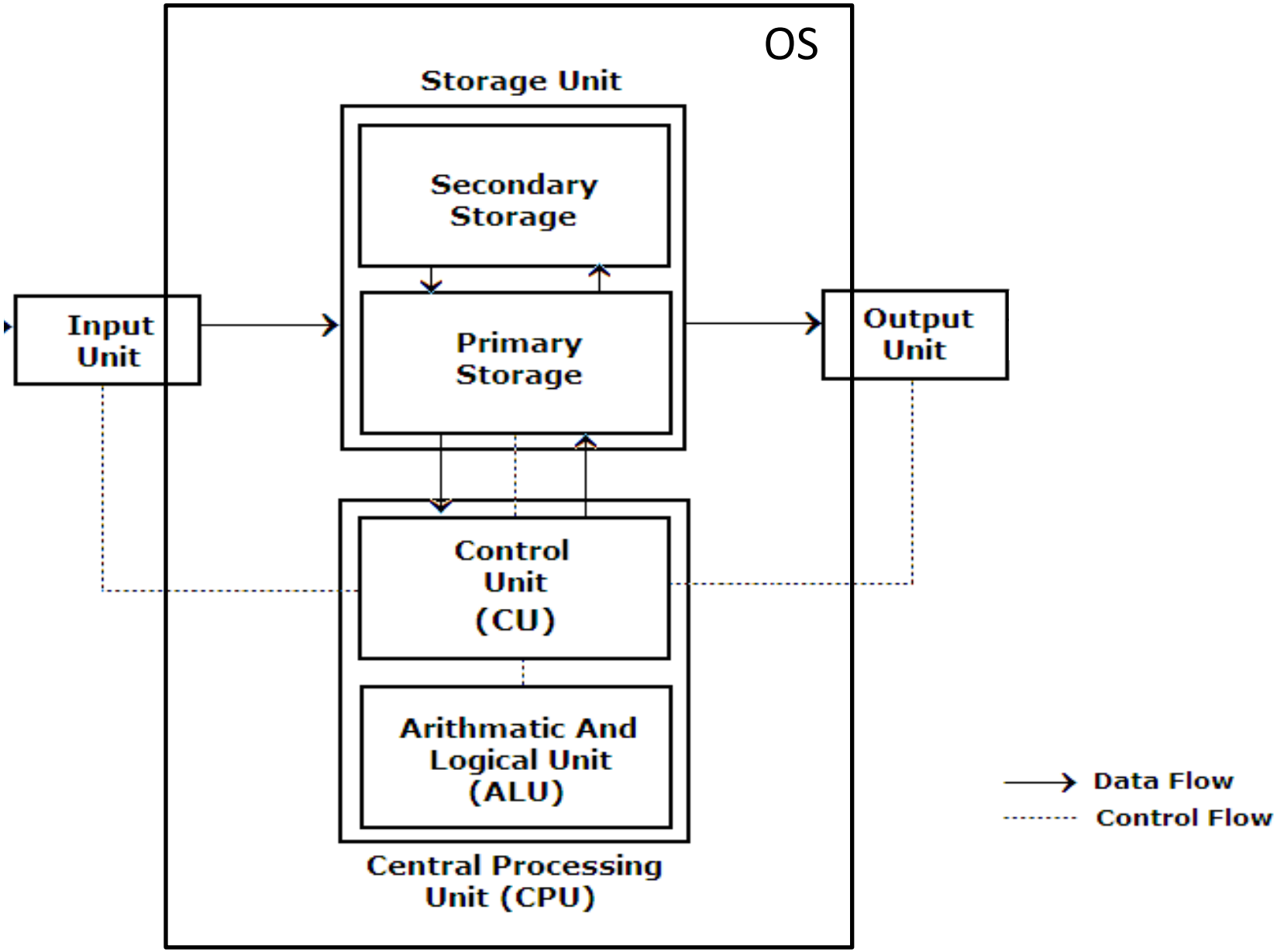
Chapter 4

Computer Organization and Architecture : The CPU, and the OS

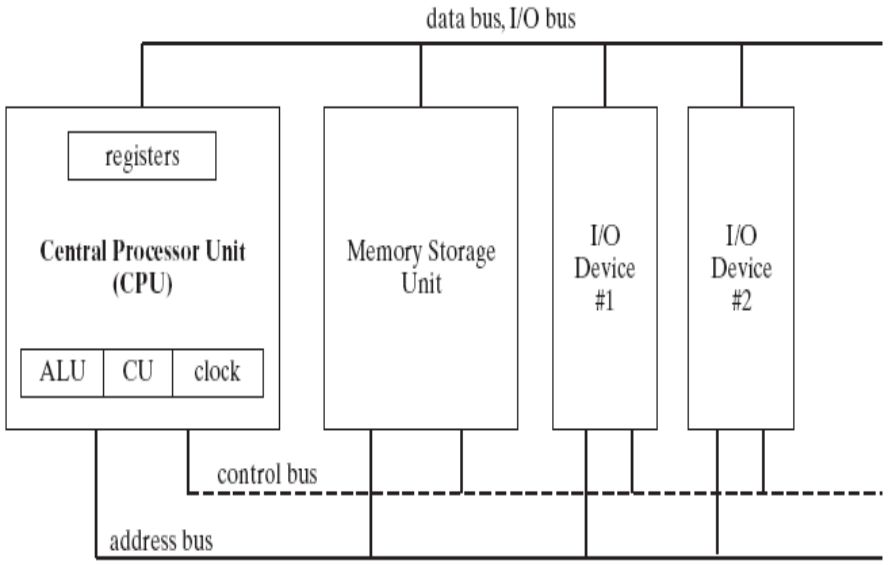
Outline

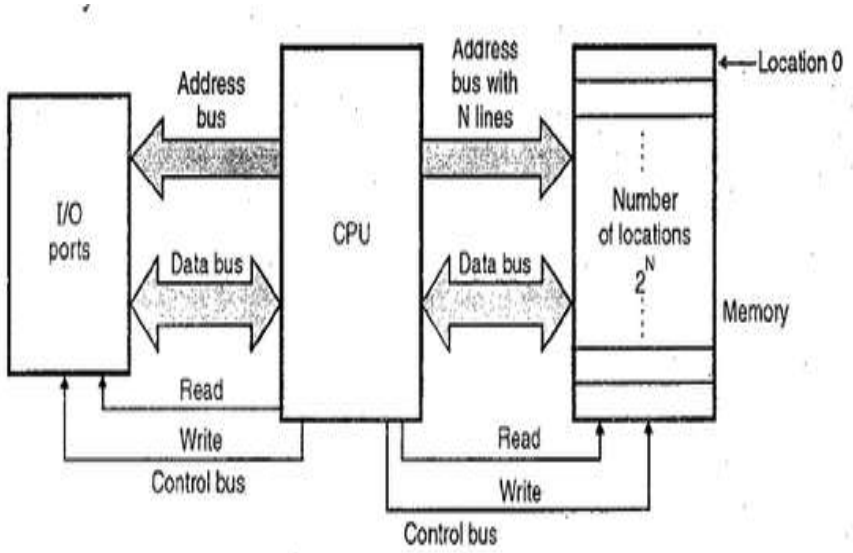
- Computer Program execution process and the CPU organization
- Hierarchical Organization of the Computer System (Architecture)
- The Operating System Functions and components
- Programming Concepts*
- About Programming languages *



Basic computer Organization Block Diagram

Block Diagram of a Microcomputer





- Address bus width limits the amount of memory that can be installed in the computer

Program Execution

- The operating system reads the program into memory
  - adds it to a list of programs that want to execute
- It gives it a time slice of the CPU
  - adds it to a list of programs that are executing
- It saves the current state of the CPU when it gives another program a time slice of the CPU
  - Context switching
- It restores the state of the CPU when a stopped program resumes execution.

When you double click on an icon to run a program, here is what happens:

1. The program, which is stored inside the hard disk drive, is transferred to the RAM memory.
2. The CPU, using a circuit called memory controller, loads the program data from the RAM memory as directed by the OS.
3. The data, now inside the CPU, is processed. A program is a sequence of instructions to the CPU.
4. What happens next will depend on the program. The CPU could continue to load and execute the program or could do something with the processed data, like displaying something on the screen.

The sequence of CPU steps can be expressed in pseudocode:

loop

fetch the instruction pointed by (the value in) IP

advance the instruction pointer (IP++)

decode the instruction

execute the instruction

if memory operand needed, read value from memory

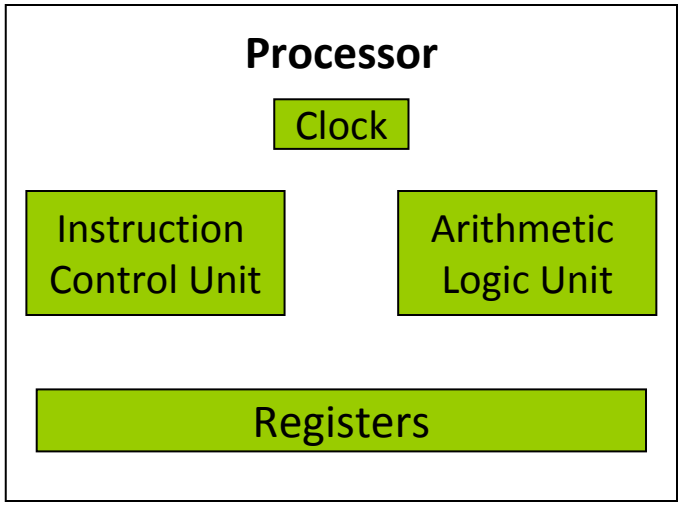
else if result is memory operand, write result to memory

else if …

…

else …

continue loop

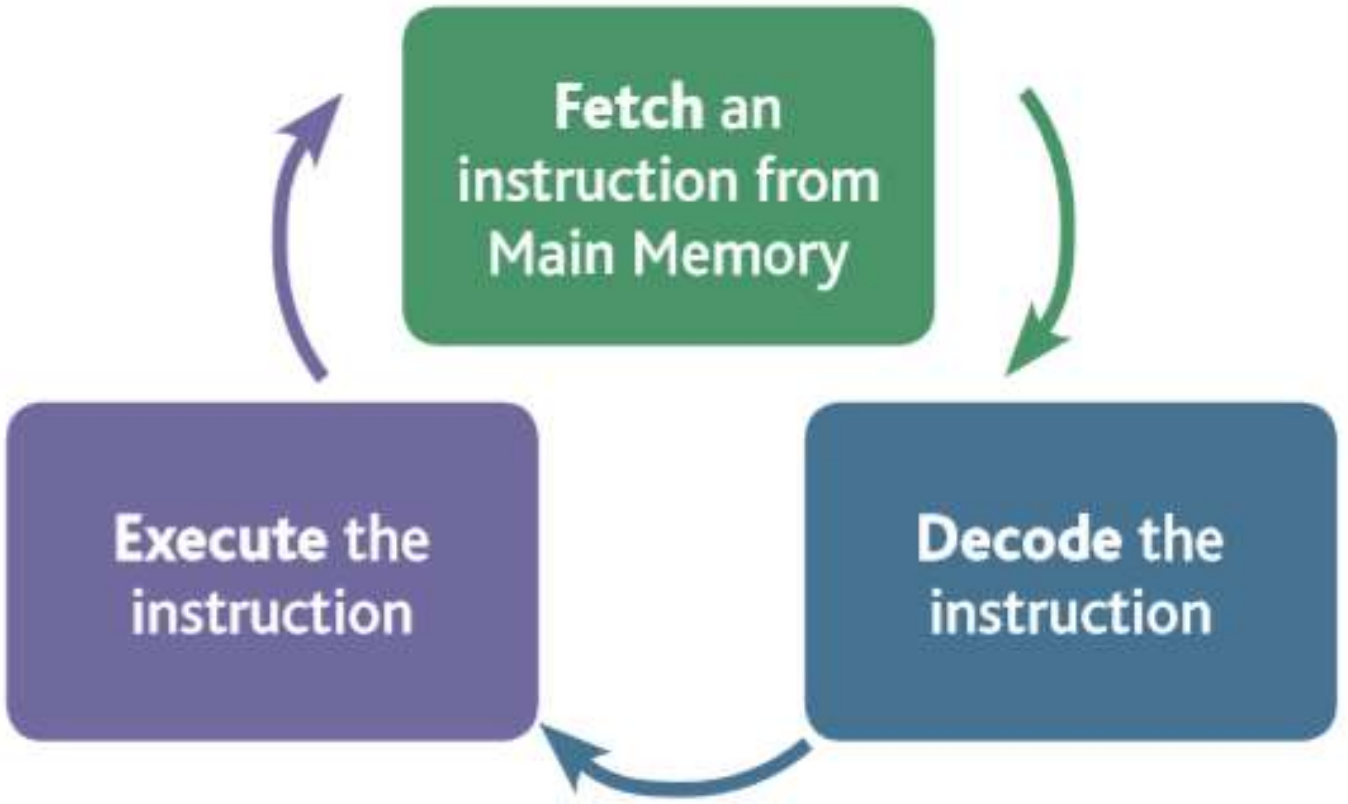


The CPU

- **CPU = Central Processing Unit**
- **Internal clock ticks very fast (e.g., 2.6 GHz = 2.6 billion ticks per second)**
  - **activities are synchronized to start on a clock tick**
  - **some activities take more than one clock tick**
- **Instruction execution is automatic**
  - **(tick) find memory address of next instruction**
  - **(tick) retrieve instruction from memory**
  - **(tick) decode the instruction**
  - **(tick) fetch argument from memory if necessary**
  - **(tick) execute instruction**
  - **(tick) store result in memory if necessary**

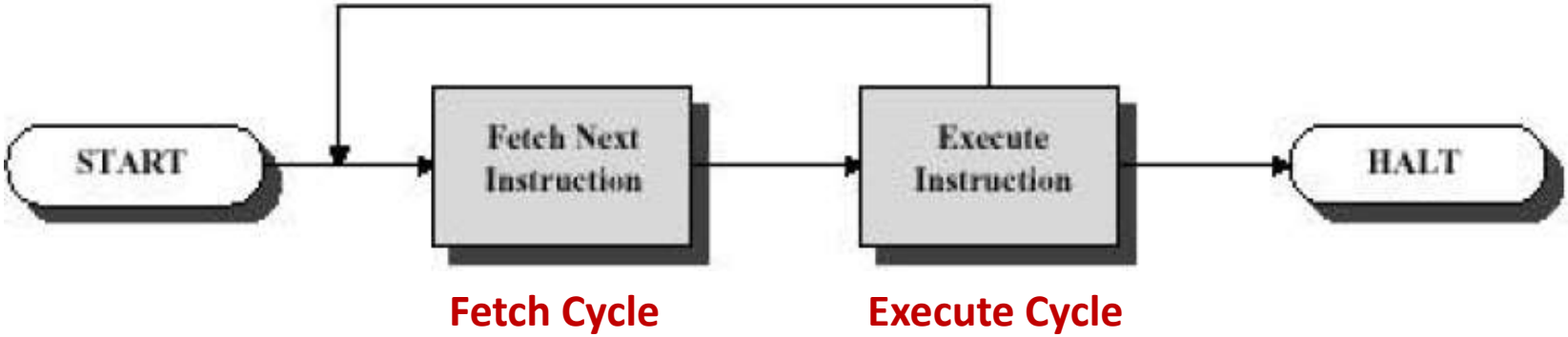
*** Tick stands for start of a clock cycle.**

The CPU Fetch-Execute Cycle



The CPU consists of a control unit, registers, the arithmetic and logic unit, the instruction execution unit, and the interconnections (internal buses) among these components.

- Processing required for a single instruction is called an instruction cycle (Fetch-Execute Cycle), and can be viewed as shown below: **2 Steps**



- Fetch – CPU(CU) reads an instruction from a location in memory and decodes the instruction (determine what it means)
  - Program counter (PC/Instruction Pointer) register keeps track of which instruction executes next
  - Fetched instruction is loaded into the instruction register (IR)
  - Normally, CPU increments PC after each fetch

- Execute - CPU executes the instruction
  - May involve several operations
  - May utilize previously changed state of CPU
  - General categories:
    - CPU-Memory: Data may be transferred from CPU to memory or vice-versa
    - CPU-IO: Data may be transferred between CPU and an I/O module
    - Data Processing: CPU (ALU) may perform some arithmetic or logic operation on the data
    - Control: An instruction may specify that the sequence of execution be altered

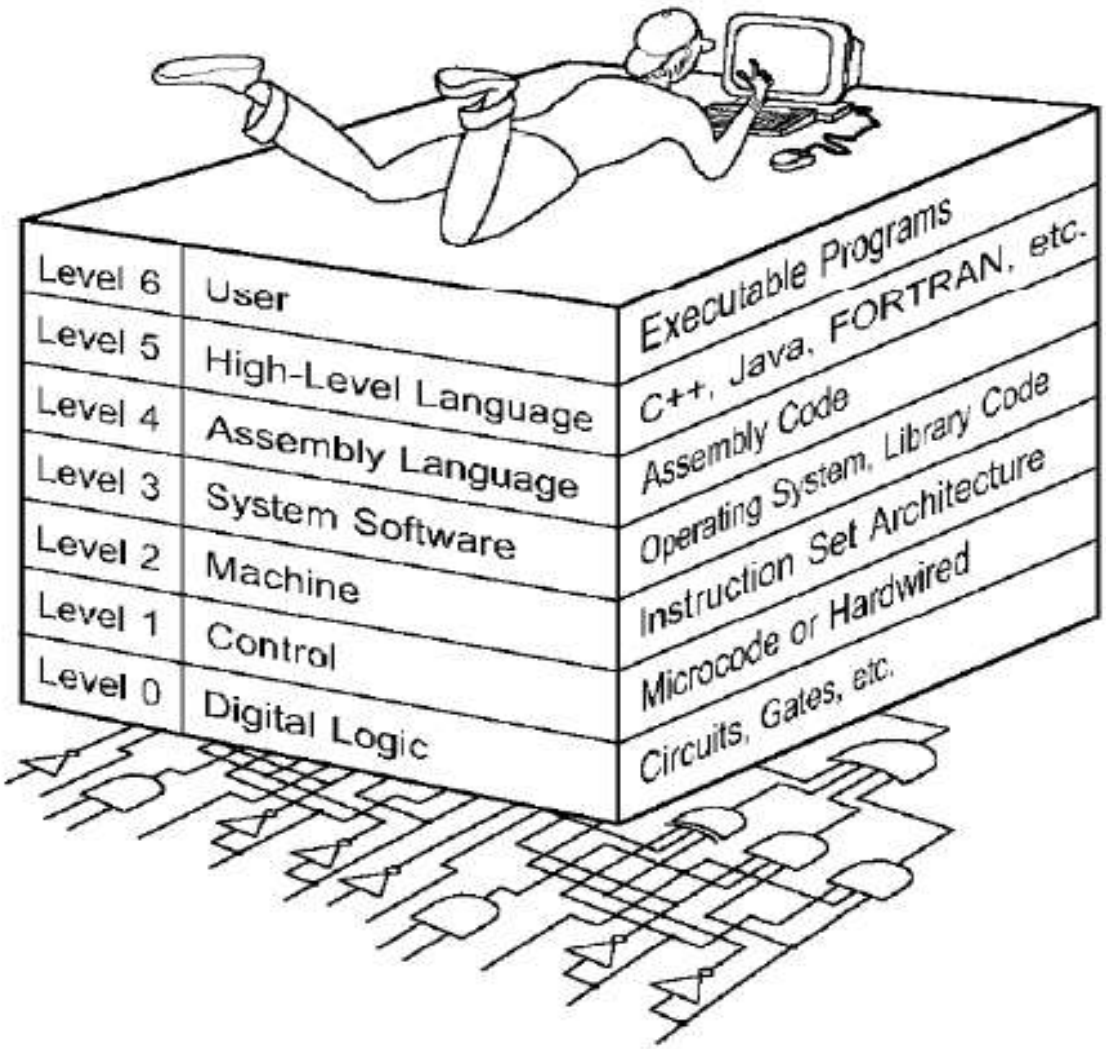
CPU Cont…

Processor speed depends on:

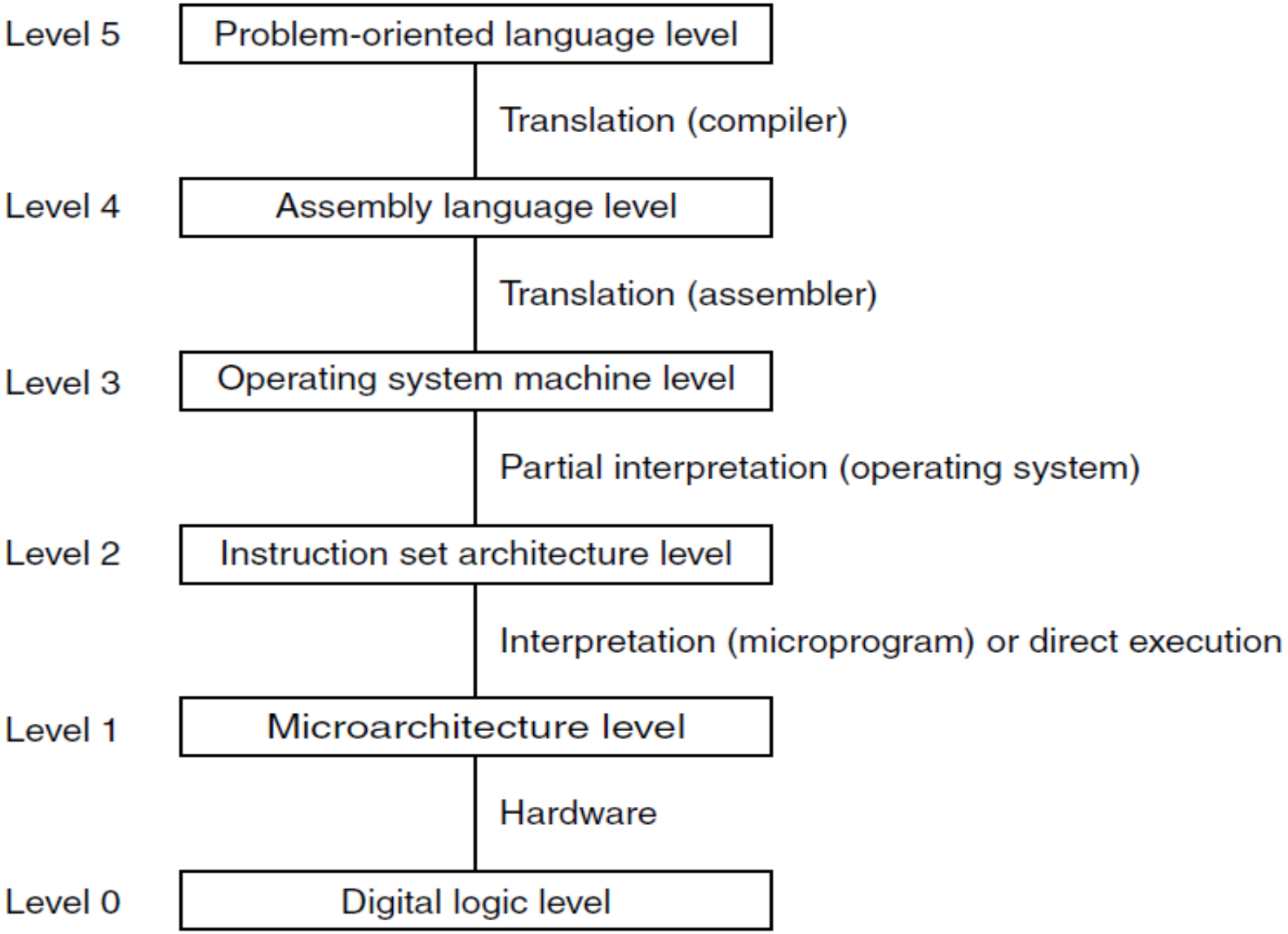
- Internal Clock Speed
- Type of Instruction Set
- Processor Implementation
- Compiler Design (efficient binary executable)
- Cache and Memory Hierarchy
- etc…

Reading Assignment: CISC & RISC, MIPS & MFLOPS

Computer Level Hierarchy

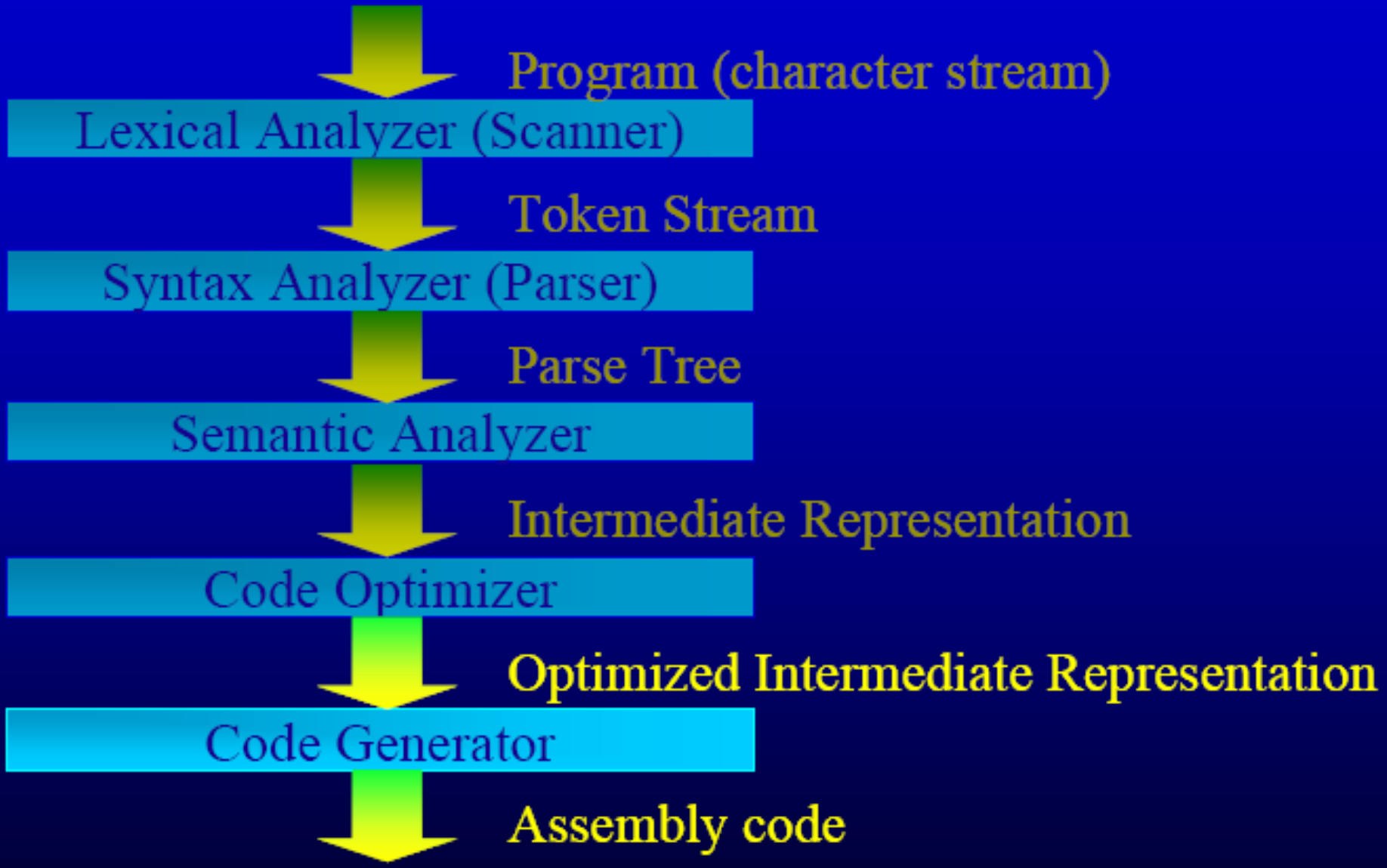


The Computer as a multilevel machine



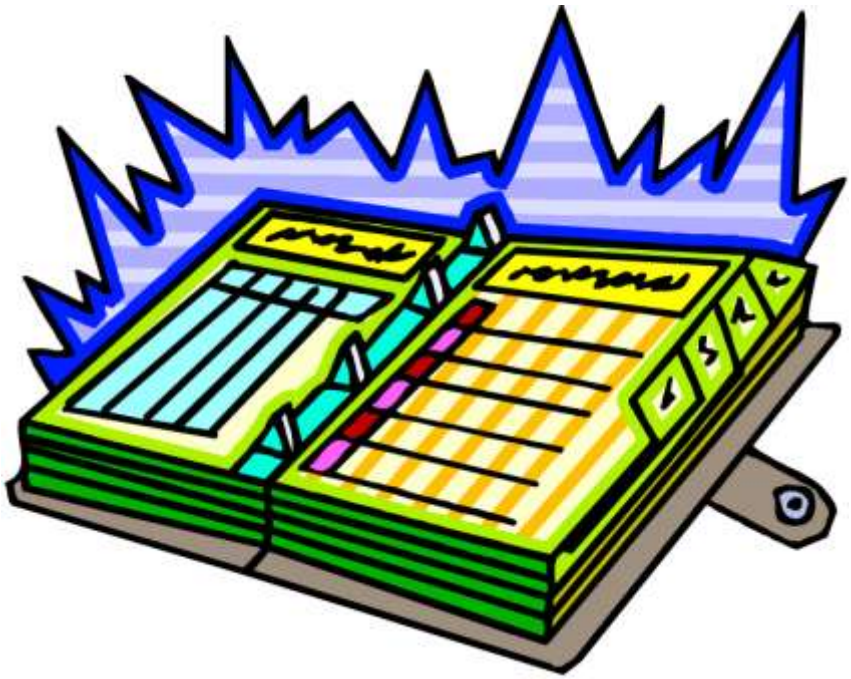
A six-level computer. The support method for each level is indicated below it (along with the name of the supporting program)

Anatomy of a Compiler



Operating System - Organizer

- Keep track of executing programs
  - Give them time with the CPU
  - A program gets a slice of time with the CPU
- Keep track of memory
  - Decide when to move some data to disk (virtual memory)
- Keep track of disk space
  - Decide where to store stuff
- Interface with the user
  - Accept input via keyboard and mouse
- Keep track of devices
  - USB drives, cameras, etc
- Provides networking capabilities



The Operating System and the Kernel

kernel: The operating system kernel is the part of the operating system that responds to system calls, interrupts and exceptions.

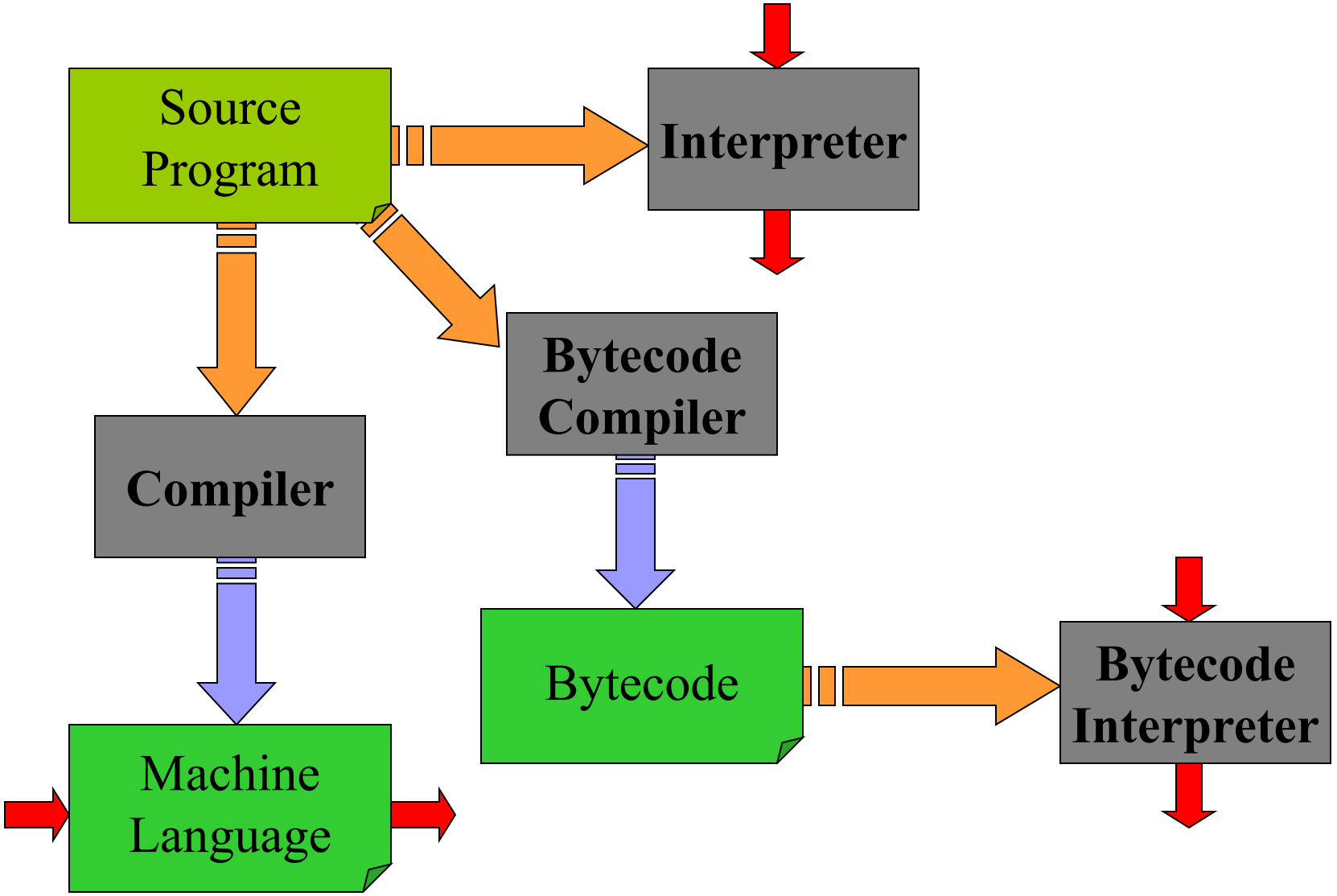
Ex. system("cls"); from C++ source, in <stdlib.h>

operating system: The operating system as a whole includes the kernel, and may include other related programs that provide services for applications.

This may include things like:

- utility programs
- command interpreters
- programming libraries
- device drivers, etc.

Programs can be executed in different ways.



Classification of programming languages

Imperative

- Procedural: C, Ada, **Pascal**, **Algol**, **FORTRAN**, . . .
- Object oriented: **Scala**, C#, Java, **Smalltalk**, **SIMULA**, . . .
- Scripting: Perl, Python, PHP, javascript, . . .

Declarative

- Functional: Haskell, SML, Lisp, Scheme, . . .
- Logic: Prolog
- Dataflow: Id, Val
- Constraint-based: spreadsheets, SQL
- Template-based: XSLT

Why are there so many languages?

- Evolution.
- Special purposes.
- Personal preference.

Assignment:

Make investigations and write an essay about types and functions of operating systems, and CPU scheduling algorithms. Give more emphasis to CPU scheduling algorithms.

Do the assignment in groups of two students.
Submit your work in printed copy.