

## **Computer Organization**

Purpose: In-depth understanding of the inner workings of modern computers

Study of the hierarchy of layers that comprise computer systems -

- Hardware
- Systems Software
- Applications Software

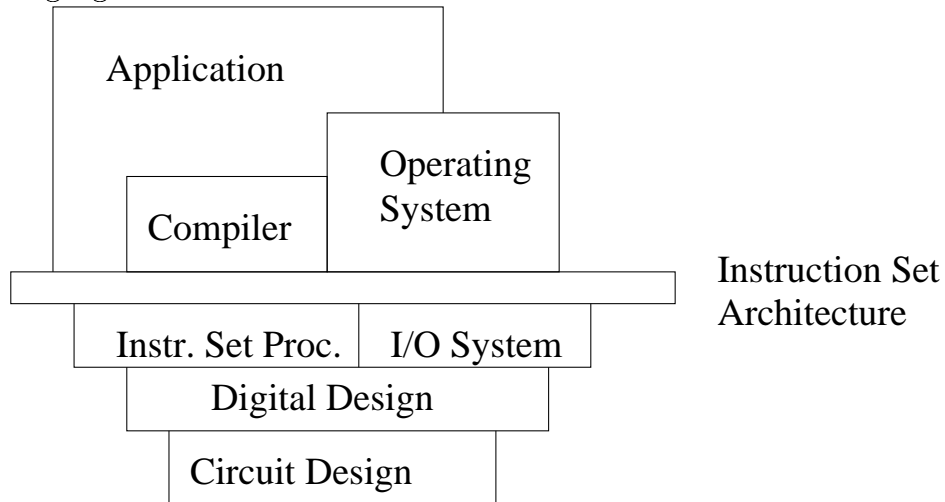
## **Principle of Abstraction**

Applies equally to Hardware and Software

Work at level appropriate to task - higher level  $\Rightarrow$  less detail,  
lower level  $\Rightarrow$  more detail

## What is Computer Architecture?

Coordination of *levels of abstraction* under a set of rapidly changing forces



## Instruction Set Architecture

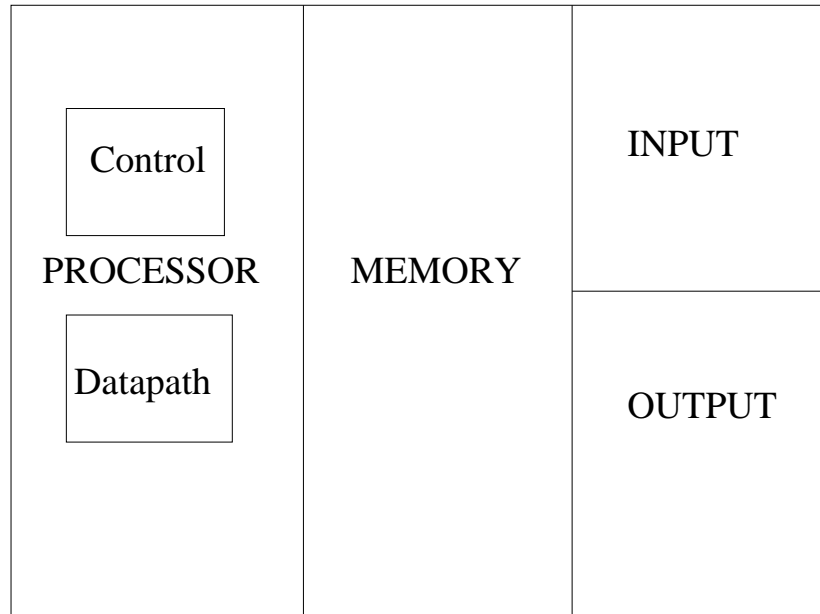
Key interface between levels of abstraction

Interface between hardware and lowest level software

Interface/functionality separated from implementation

Implementation influences design

## Hardware - Simple View



## Processor

Datapath - performs arithmetic operations

Control - controls datapath, memory, I/O

## **Memory**

Main or Primary memory - DRAM

Cache - small, fast buffer for DRAM memory

## **Network**

Communication/Resource sharing/Non-local access

Local area networks - Ethernet, Token ring, FDDI (Fiber Distributed Data Interconnect), ATM (Asynchronous Transfer Mode)

Wide area networks - ISDN (Integrated Services Digital Network), ATM

## I/O

Mouse

Keyboard

Graphics display → Raster CRT display

- Refresh rate - 30 to 60 frames/sec (no flicker)
- Resolution - 512x340 to 1560x1280 pixels
- Hardware support - raster refresh buffer for bitmap of image
  - black & white - 1 bit per pixel
  - gray scale - 8 bits per pixel
  - color - 8 bits for each primary color (red, blue, green)

## I/O - Permanent Storage

Secondary memory - non-volatile, magnetic

Magnetic hard disk -

- collection of metal platters
- 3600 to 5400 rpm
- covered with magnetic recording material on both sides
- diameter 10.25-13"
- movable arm contains electro-magnetic coil or read-write head
- mechanical - 5-20 msec vs 50-150 nsec for DRAM

## **Secondary storage (continued)**

Floppy disk - made of mylar vs. metal - flexible, removable

Magnetic tape - cheaper, slower, sequential - access time in seconds

CD-ROMs - Optical

## **Technology Trends**

...and their influence on design and organization

Capacity doubling about every 1.5 years

Challenge: make use of increased capacity

## **Important Characteristics**

Performance

Price

Physical/functional characteristics

## **New ideas**

Hardware -

- pipelining
- superscalar design
- access locality exploitation (cache)

Software - solve larger, harder problems, e.g. human genome project.

## Hardware Cost

$$DieCost = \frac{Wafer\ Cost}{Dies\ per\ Wafer \times Die\ Yield}$$

$$Die\ Yield = Wafer\ Yield \times \left\{ 1 + \frac{Defects\ per\ unit \times Die\ area}{a} \right\}^{-a}$$

Typical values: Wafer Yield = 90%, Defects per unit area =  $1\ cm^2$ ,  $a = 2$  or  $3$

The bigger the chip, the less likely it is to come out working correctly

## Summary

All computers consist of five components -

- Processor : datapath and control
- Memory - main memory, cache
- Input and Output devices - disks, networks

Principle of abstraction helps to deal with complexity and handle each aspect independently

The instruction set architecture is the abstract interface between hardware and low-level software that enables implementations of varying cost and performance to run identical software



**Assignment: Read**

- **Chapter 2 of Tanenbaum**
- **Chapter 1 of Hennessy & Patterson**