CSCI 4717/5717
Computer Architecture

Topic: Functional View & History

Reading: Sections 1.2, 2.1, & 2.3

Function

All computer functions are comprised of four basic operations:

- Data processing
- Data storage
- Data movement
- Control

Data Processing

- The basic function of any computer is to process data
- Describes arithmetic and logical operations performed on data
- Although end result may be complex, there are few distinct types of data processing

Data Storage

- Long term
  - Logging
  - Data records
- Short term
  - temp variables – e.g., buffer containing the last key pressed
  - program control data – e.g., loop variables

Data Movement

- Computer must be able to communicate with outside world
- Data must be “accessible” to devices outside computer
- Two types:
  - Peripheral
  - Data communications

Data movement to a peripheral

- Data must be passed between computer and I/O devices connected to computer
- Typically to simple devices
- Examples
  - monitors and keyboards
  - data acquisition
  - peripheral control

Data Movement to remote devices (data communications)

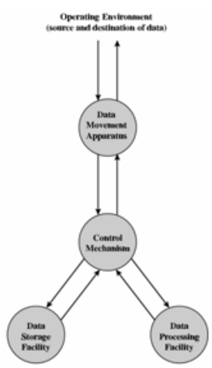
- Data communications is data movement over a longer range
- Typically to smart devices or other computers

Control

- Something needs to monitor operation and maintain control of data processing, data storage, and data movement.
- Automated control of computer's resources

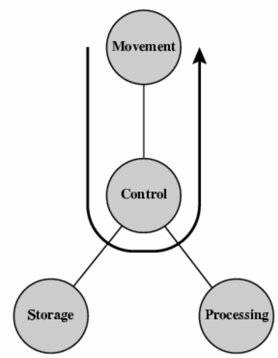
Functional view

Figure 1.1, p. 9



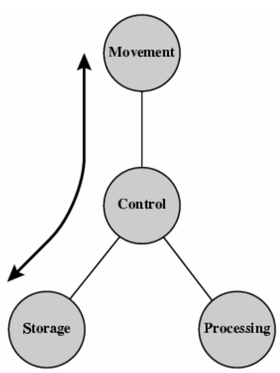
Operations: Data movement

Figure 1.2a, p. 11



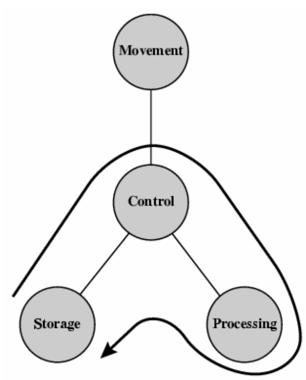
Operations: Storage

Figure 1.2b, p. 11



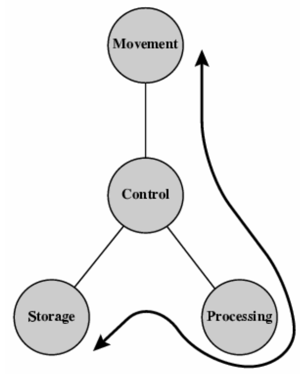
Operations: Processing from/to storage

Figure 1.2c, p. 11



Operations: Processing from storage to I/O

Figure 1.2d, p. 11



In-Class Exercise

- Determine which of the previous operations applies each of the following uses:
  - Router system
  - Hard drive controller
  - SETI@Home
  - Video capture or CD player
- Come up with additional examples for each of the previous operations

Structure - Top Level

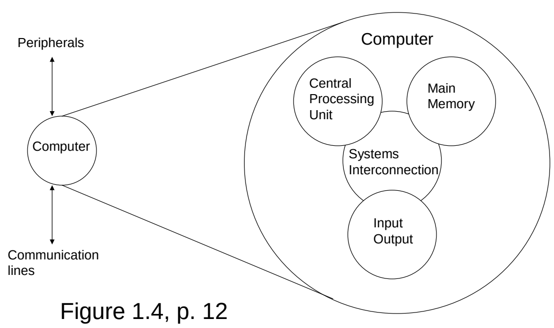


Figure 1.4, p. 12

Structure - The CPU

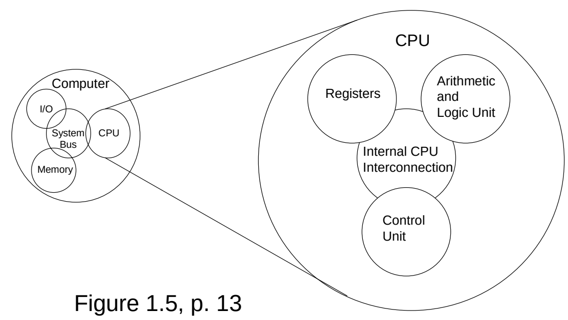


Figure 1.5, p. 13

Structure - The Control Unit

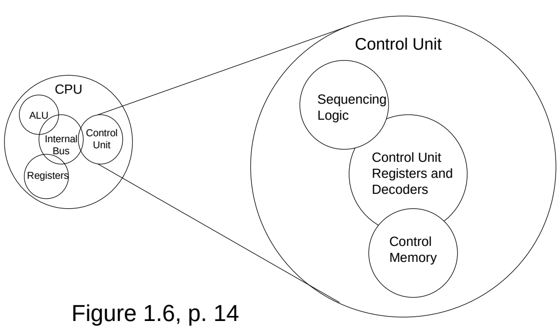


Figure 1.6, p. 14

In-Class Exercise

- Think back to your first computer
- Try to recall the characteristics
  - Processor type
  - Processor speed (Hz)
  - Memory size
  - Characteristics such as:
    - Types of storage devices
    - Cache
    - Bus
    - Network

ENIAC (Electronic Numerical Integrator And Computer)

Need:

- Army's Ballistic Research Lab developed range and trajectory tables for new weapons
- Used >200 people with desktop calculators to create trajectory tables for weapons

ENIAC (continued)

- Mauchly (EE professor) and Eckert (grad student) at University of Pennsylvania's Moore School of Electrical Engineering
- Proposed general purpose computer
- Started 1943
- Finished 1946
  - 1 year to design
  - 18 months to build
  - Cost $500,000
  - Too late for war effort

ENIAC (continued)

General purpose nature proven by using ENIAC to perform calculations for:

- hydrogen bomb feasibility
- weather prediction
- cosmic-ray studies
- thermal ignition
- random-number studies
- wind-tunnel design

ENIAC (continued)

- Programmed manually by 6,000 switches (programming took weeks)
- Used 17,468 vacuum tubes (relays had been used up to this point)
- Other components included 70,000 resistors, 10,000 capacitors, 1,500 relays, and 5 million soldered joints
- 30 tons, 1800 square feet of floor space
- Consumed 160 kilowatts of electrical power

ENIAC (continued)

- Twenty 10 digit accumulators
- Decimal (base-10) machine, each digit represented by one of ten tubes "ON"
- 5,000 additions per second (1,000 times faster then any other device at that time)
- 357 multiplications per second
- 38 divisions per second

ENIAC I/O

- Constants were loaded using switches
- Numbers changed during the course of computation were entered using punch cards or punch tape
- The basic memory device was a flip-flip (latch) that had a neon lamp to represent its state

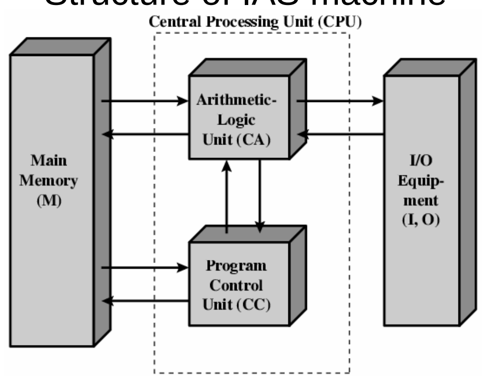
von Neumann/Turing Stored Program Computer

- ALU operates on binary data
- Main memory stores both instructions and data – must be considerable in order to carry out long, complicated sequences of operations
- Control unit interprets instructions from memory and causes them to be executed
- Input and output equipment operated by control unit

Princeton Institute for Advanced Studies (IAS)

- First implementation of von Neumann stored program computer
- Completed 1952

Structure of IAS machine



IAS Memory

1000 x 40 bit words of either number or instruction

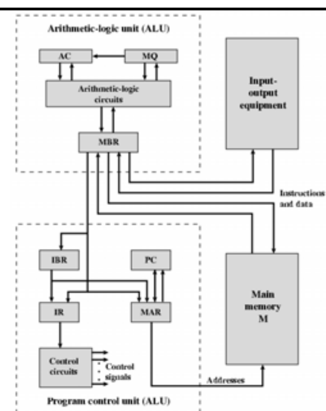
- Signed magnitude binary number
  - 1 sign bit
  - 39 bits for magnitude
- 2 x 20 bit instructions
  - Left and right instructions (left executed first)
  - 8-bit opcode
  - 12 bit address

IAS Registers

- Set of registers (storage in CPU)
  - Memory Buffer Register (MBR)
  - Memory Address Register (MAR)
  - Instruction Register (IR)
  - Instruction Buffer Register (IBR)
  - Program Counter (PC)
  - Accumulator (AC)
  - Multiplier Quotient (MQ)

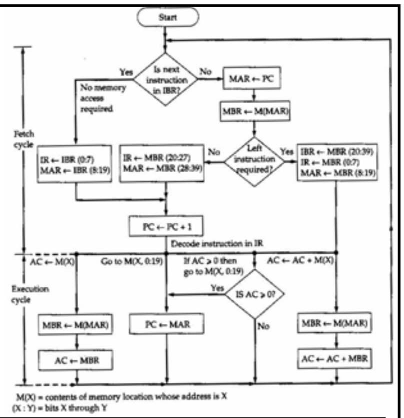
Structure of IAS

Figure 2.3, p. 22



IAS execution of instruction

Figure 2.4, p. 23



Transistors

- Replaced vacuum tubes
- Smaller
- Cheaper
- Less heat dissipation
- Solid State device
- Made from Silicon (Sand)
- Invented 1947 at Bell Labs by William Shockley et al.

Moore's Law

- Gordon Moore - cofounder of Intel
- He observed (based on experience) that number of transistors on a chip doubled every year
- Since 1970's growth has slowed a little
- Number of transistors doubles every 18 months
- Cost of a chip has remained almost unchanged
- Higher packing density means shorter electrical paths, giving higher performance
- Smaller size gives increased flexibility/portability
- Reduced power and cooling requirements
- Fewer system interconnections increases reliability

Growth in CPU Transistor Count