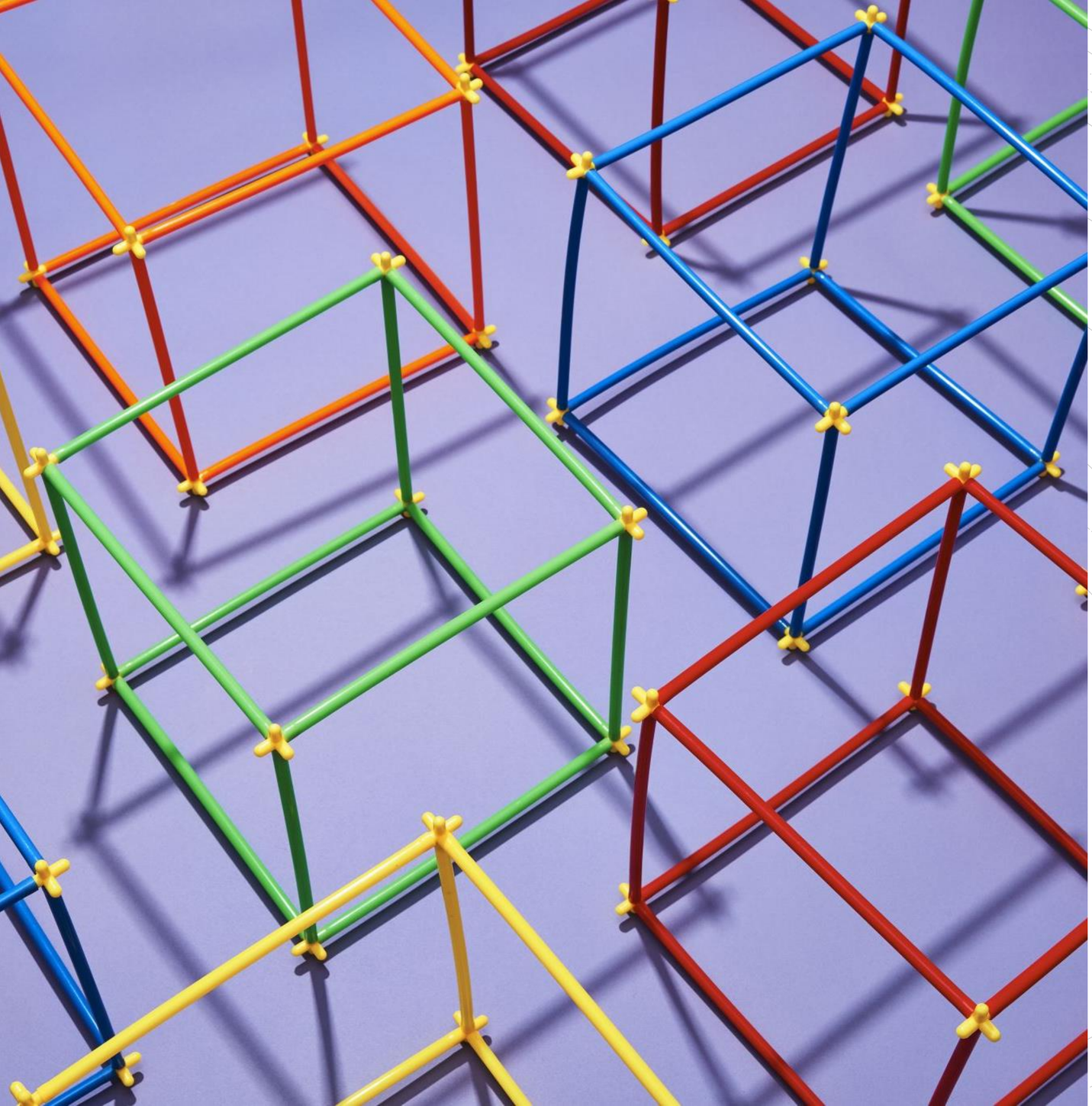


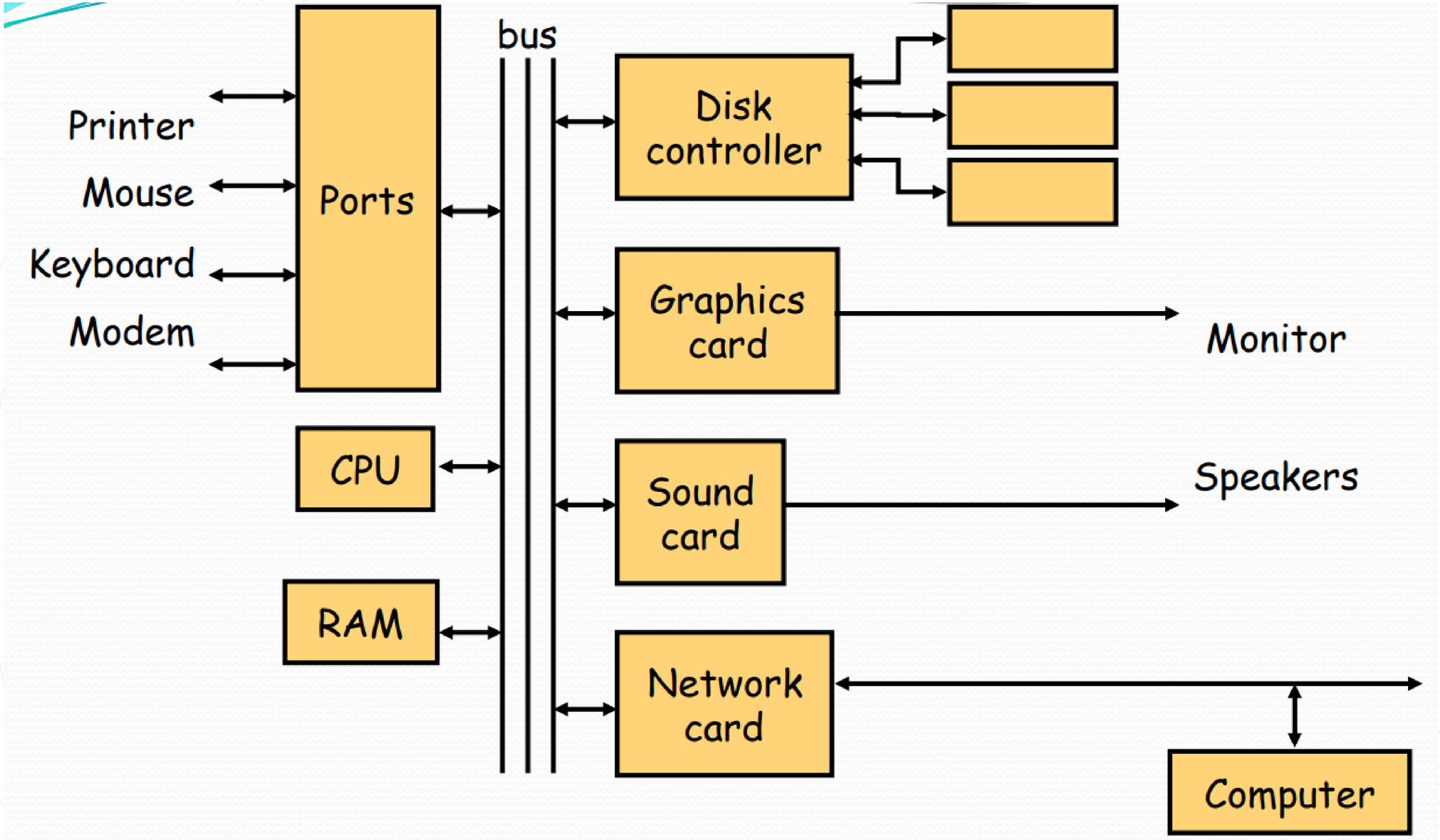
Essentials of Computer Organization and Architecture IN 2300

Chamalka Rajapaksha


Desktop Computer (System Unit)
Flat-panel Display (Output Device)
Speaker (Output Device)
Keyboard (Input Device)
Mouse (Input Device)

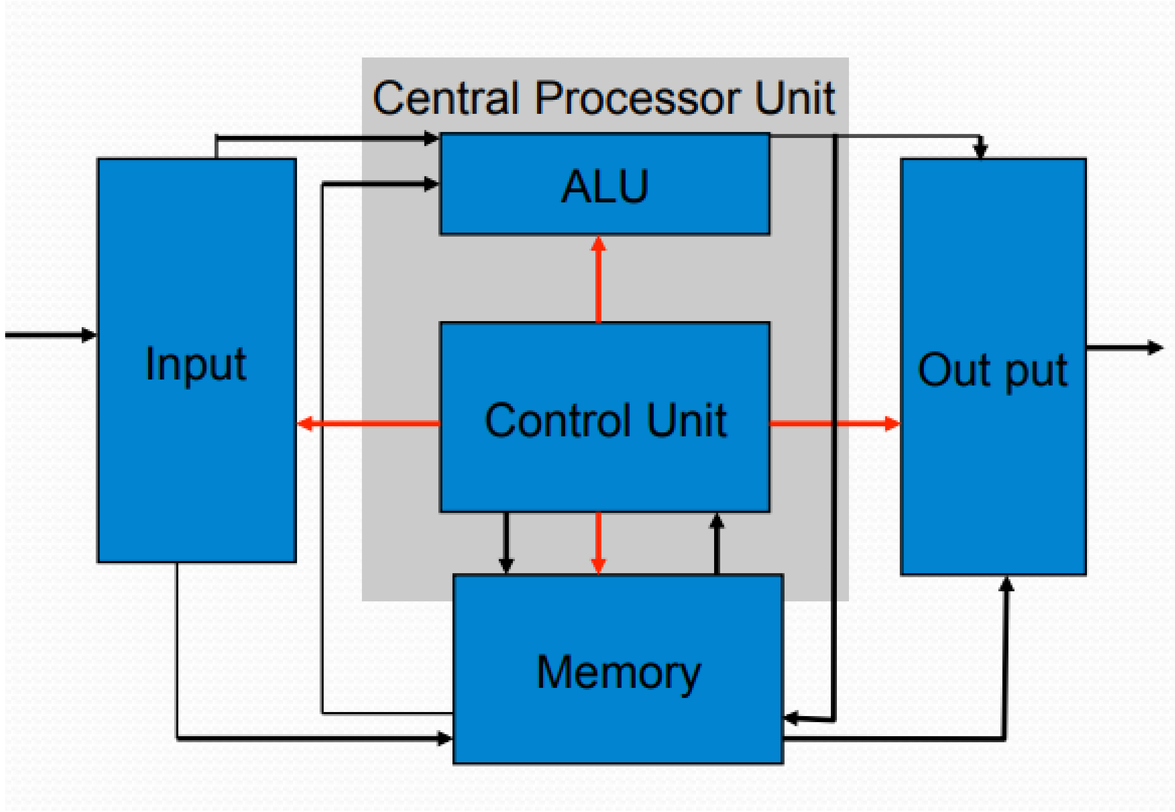
Computer Operations

- Computer is an electronic device capable of doing arithmetic calculations faster
- It serves different purposes to different people
- Computer is a machine capable of solving problems and manipulating data
  - Accepts data, processes the data by doing some mathematical and logical operations and gives us the desired output.
- Some time it is a monitoring and controlling device
- Can see a computer as a device that transforms data
  - Accept data
  - Store data
  - Process data as desired
  - Retrieve the stored data
  - Print the result in desired format


bus
Printer
Mouse
Keyboard
Modem
Ports
CPU
RAM
Disk controller
Graphics card
Monitor
Sound card
Speakers
Network card
Computer

Basic Computer Organization

- Every computer contains five essential elements or units:
  - Arithmetic and Logic Unit (ALU)
  - Memory
  - Control Unit
  - Input Unit
  - Output Unit



- Memory
  - Main memory (Including cache)
  - Auxiliary storage
- Control Unit
  - Directs the operations of all units

Outline Components

- Input

This is the process of entering data and programs in to the computer system. Computer takes as inputs raw data and performs some processing giving out processed data. Therefore, the input unit takes data from us to the computer in an organized manner for processing

Outline Components (Cont.)

- Storage (Memory):

The process of saving data and instructions permanently is known as storage (Memory). Data has to be fed into the system before the actual processing starts. It provides space for storing data and instructions.

  - All data and instructions are stored here before and after processing.
  - Intermediate results of processing are also stored here.

Outline Components (Cont.)

- Processing:

The task of performing operations like arithmetic and logical operations is called processing. The Central Processing Unit (CPU) takes data and instructions from the storage unit and makes all sorts of calculations based on the instructions given and the type of data provided. It is then sent back to the storage unit.

Outline Components (Cont.)

- Output:

This is the process of producing results from the data for getting useful information. Similarly the output produced by the computer after processing must also be kept somewhere inside the computer before being given to you in human readable form. Again the output is also stored inside the computer for further processing.

Outline Components (Cont.)

- Control:

The manner how instructions are executed and the above operations are performed. Controlling of all operations like input, processing and output are performed by control unit. It takes care of step by step processing of all operations in side the computer.

Computing Systems

- Computers have two kinds of sub systems:
  1. Hardware, consisting of its physical devices (CPU, memory, bus, storage devices, …)
  2. Software, consisting of the programs it has (Operating system, applications, utilities, …)
- Central Processing Unit (CPU):
  - the "brain" of the machine
  - location of circuitry that performs arithmetic and logical ML statements
  - measurement: speed (roughly) in megahertz (millions of clock-ticks per second) or Gigahertz
  - examples: Intel Pentium, AMD K6, Motorola PowerPC, Sun SPARC,

Hardware - RAM

- Memory technology – DRAM
  - Bits stored as charge in capacitors
  - Charges leak
  - Need refreshing even when powered
  - cycle time traditionally longer than the access time
  - Simpler construction
  - Smaller per bit
  - Less expensive
  - Need refresh circuits
  - Slower
- “main” memory, which is fast, but volatile…
- analogous to a person’s short-term memory.

Hardware – RAM (Cont.)

- many tiny "on-off" switches: for convenience
  - "on" is represented by 1, "off" by 0.
- each switch is called a binary digit, or bit.
  - 8 bits is called a byte.
  - 2^{10} bytes =1024 bytes is called a kilobyte (1K)
  - 2^{20} bytes is called a megabyte (1M).

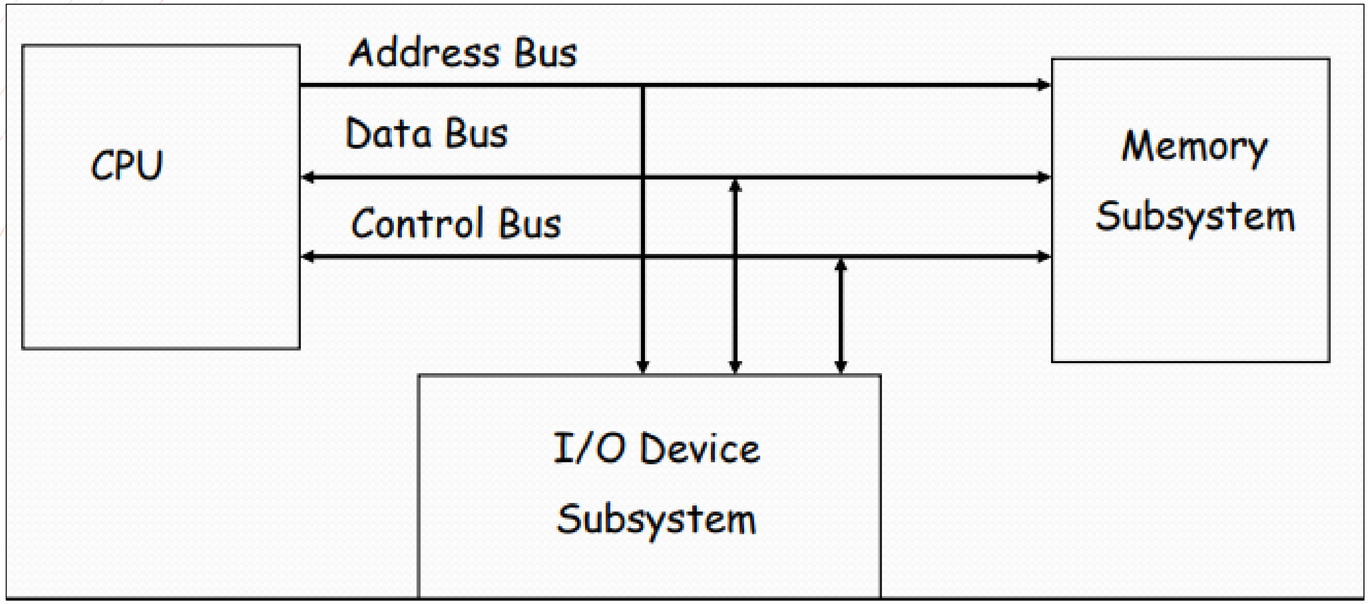
Hardware - Disk

- Secondary Memory (Disk):
- Stable storage using magnetic or optical media.
- Analogous to a person's long-term memory.
- Larger capacities
- Slower to access than RAM.
- Examples:
  - Floppy disk (measured in kilobytes)
  - Hard disk (measured in GB, TB)
  - CD-ROM (measured in megabytes)

Hardware – The Bus

- The Bus:
  - Connects CPU to other hardware devices.
  - Analogous to a person's spinal cord.
  - Speed measured in megahertz (like the CPU), but typically much slower than the CPU…

Interconnected Components of Computer



- The CPU (ALU, Control Unit, Registers)
- The Memory Subsystem (Stored Data)
- The I/O subsystem (I/O devices)

Each of these Components are connected through Buses.

- BUS - Physically a set of wires. The components of the Computer are connected to these buses.
- Address Bus
- Data Bus
- Control Bus

Address Bus

- Used to specify the address of the memory location to access.
- Each I/O devices has a unique address. (monitor, mouse, cd-rom)
- CPU reads data or instructions from other locations by specifying the address of its location.
- CPU always outputs to the address bus and never reads from it.

Data Bus and Control Bus

- Data
  - Actual data is transferred via the data bus.
  - When the cpu sends an address to memory, the memory will send data via the data bus in return to the cpu.
- Control
  - Collection of individual control signals.
  - Whether the cpu will read or write data.
  - CPU is accessing memory or an I/O device
  - Memory or I/O is ready to transfer data

I/O Bus or Local Bus

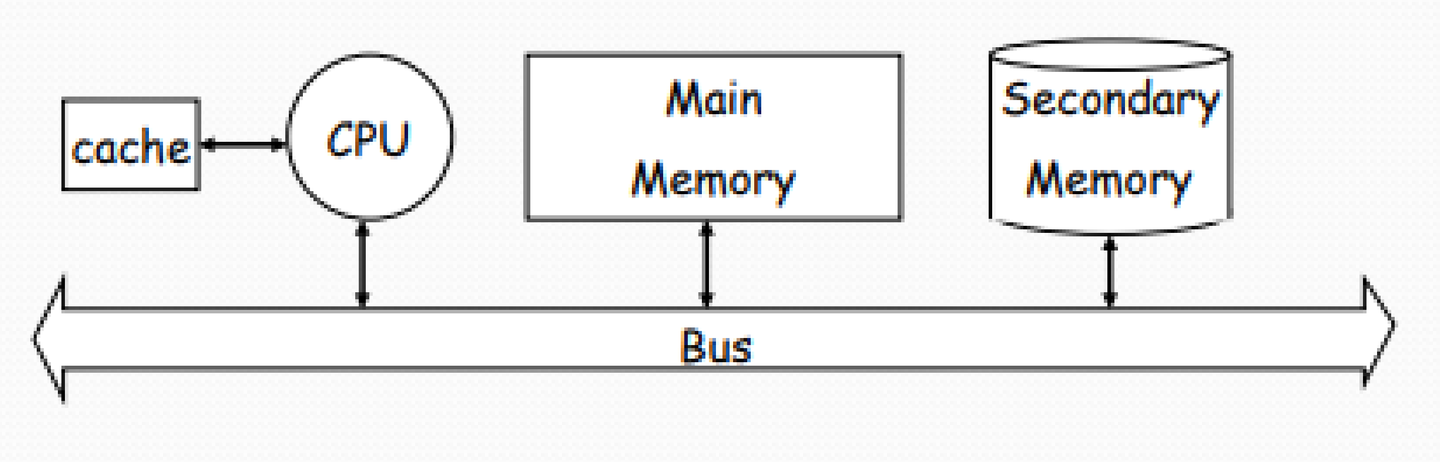
- In today's computers the the I/O controller will have an extra bus called the I/O bus.
- The I/O bus will be used to access all other I/O devices connected to the system.
- Example: PCI bus

Hardware: Cache

- While accessing RAM is faster than accessing secondary memory, it is still quite slow, relative to the rate at which the CPU runs.
- To circumvent this problem, most systems add a fast cache memory to the CPU, to store recently used instructions and data.

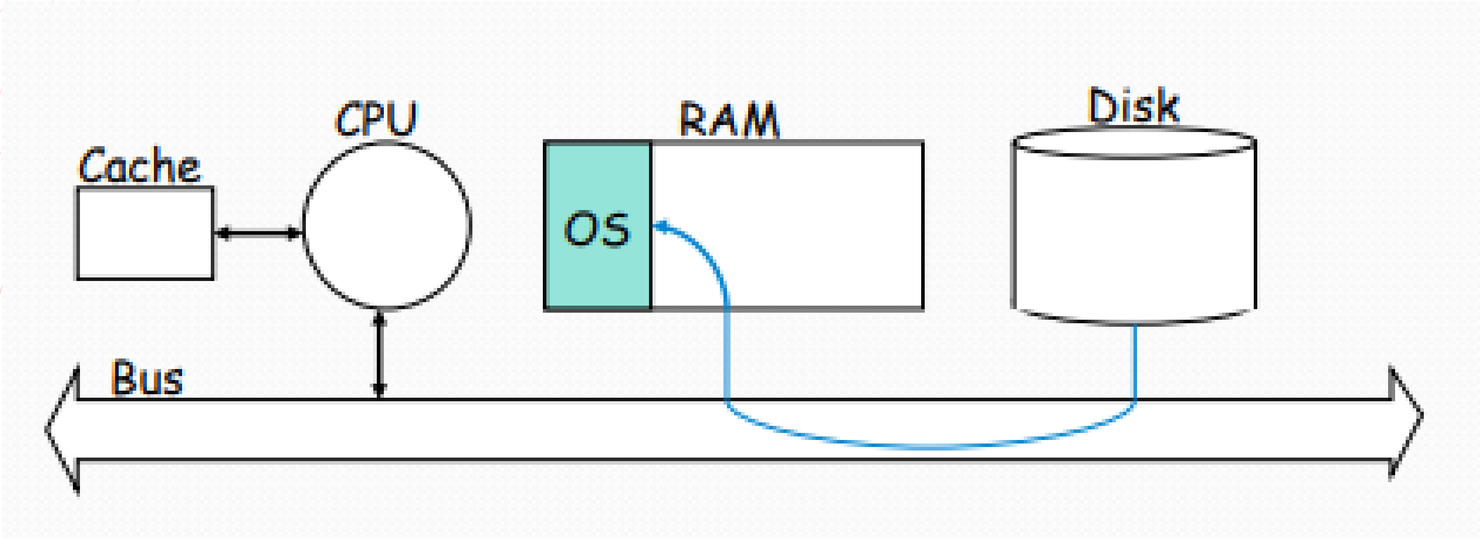
(Assumption: Since such instructions/data were needed recently, they will be needed again in the future)

Hardware



- Programs are stored (long-term) in secondary memory, and loaded into main memory to run, from which the CPU retrieves and executes their statements.

Software - OS



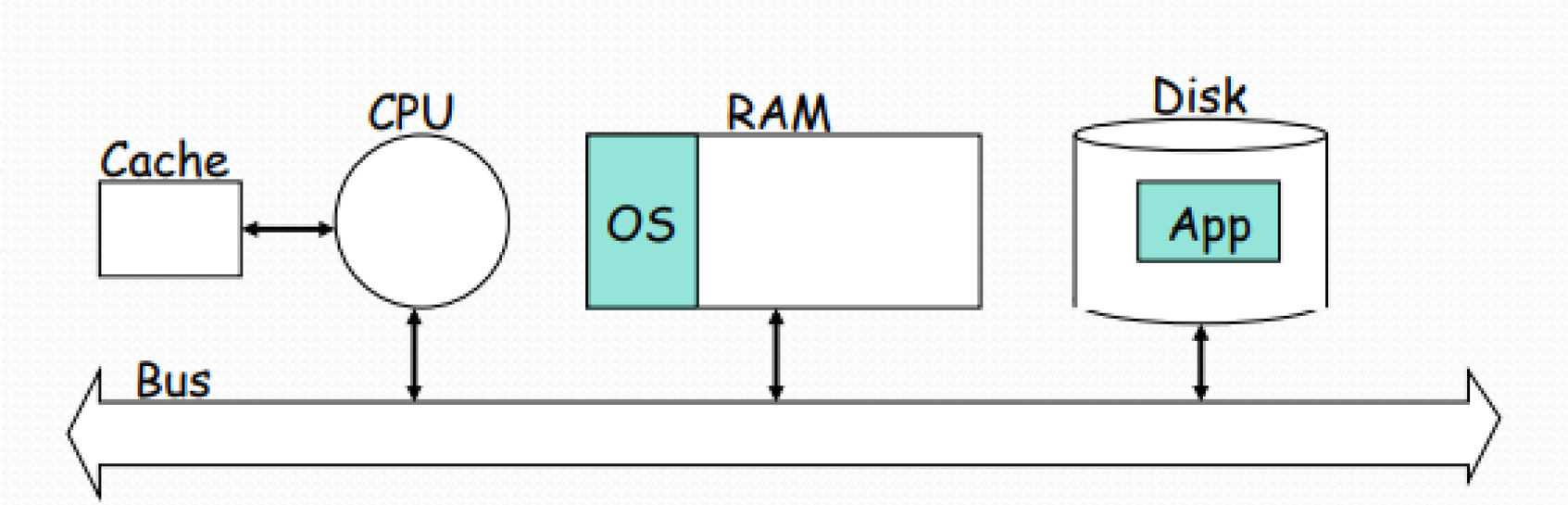
- The operating system (OS) is loaded from secondary memory into main memory when the computer is turned on, and remains in memory until the computer is turned off.

Software - OS

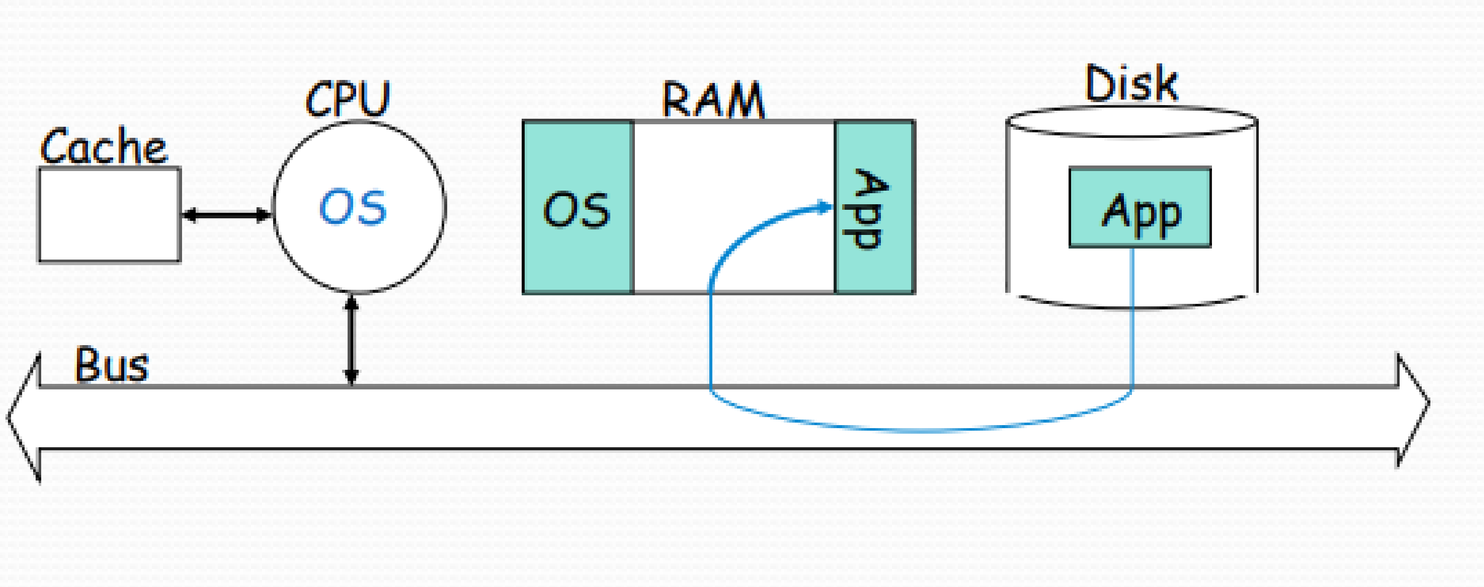
- The OS acts as the “manager” of the system, making sure that each hardware device interacts smoothly with the others.
- It also provides the interface by which the user interacts with the computer, and awaits user input if no application is running.
- Examples: MacOS, Windows UNIX, Linux, Solaris, …

Software - Applications

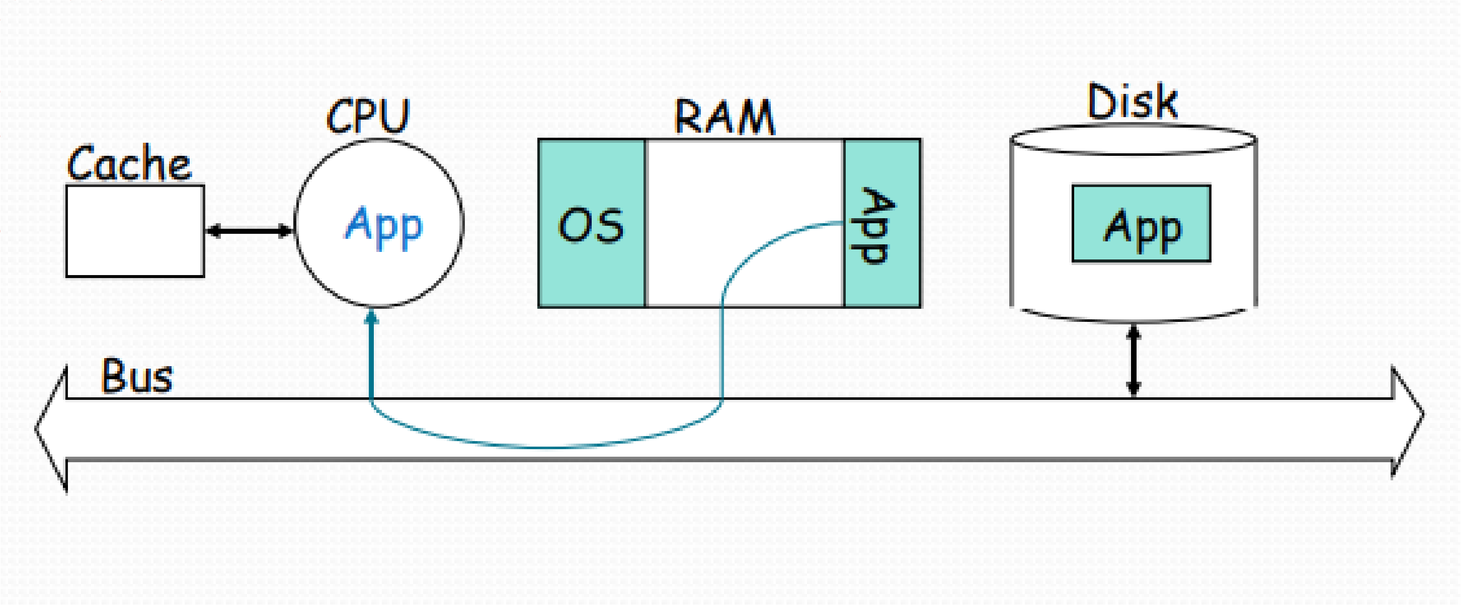
- Applications are non-OS programs that perform some useful task, including word processors, spreadsheets, databases, web browsers, C++ compilers,
- Example C++ compilers/environments:
  - CodeWarrior (MacOS, Windows, Solaris)
  - GNU C++ (UNIX, Linux)
  - Turbo/Borland C++ (Windows)
  - Visual C++ (Windows)



- Programs and applications that are not running are stored on disk.



- When you launch a program, the OS controls the CPU and loads the program from disk to RAM.



- The OS then relinquishes the CPU to the program, which begins to run.

Structure & Function

- The hierarchical nature is necessary for design and description of complex system.
- The designer needs to deal with one level of abstraction at a time. At each level the designer is concerned with structure and function.
- Structure is the way in which components relate to each other
- Function is the operation of individual components as part of the structure

Function

- Computer functions are
  - Data processing
  - Data storage
  - Data movement
  - Control

CPU Organization

- CPU controls the Computer
- The CPU will fetch, decode and execute instructions.
- The CPU has three internal sections: register section, ALU and Control Unit

Register Section

- Includes collection of registers and a bus.
- Processor's instruction set architecture are found in this section.
- Non accessible registers by the programmer. These are to be used for registers to latch the address being accessed and a temp storage register

Arithmetic and Logic Unit (ALU)

- Performs most Arithmetic and logical operations.
- Retrieves and stores its information with the register section of the CPU

Memory Subsystem

- 2 Types of Memory:
- ROM : Read Only Memory
- Program that is loaded into memory and cannot be changed also retains its data even without power.
- The ICs inside the PC that form the ROM. The storage of program and data in the ROM is permanent. The ROM stores some standard processing programs supplied by the manufacturers to operate the personal computer. The ROM can only be read by the CPU but it cannot be changed. The basic input/output program is stored in the ROM that examines and initializes various equipment attached to the PC when the switch is made ON. ROM is non-volatile memory

- Different ROM chips
  - Masked ROM
  - Programable ROM (PROM)
  - Erasable PROM (EPROM)
  - EEPROM

- RAM : Random Access Memory
- Also called read/write memory. This type of memory can have a program loaded and then reloaded. It also loses its data with no power

- Dynamic RAM (DRAM) :
  - Leaky capacitors. Caps are charged and slowly leak until they are refreshed to there original data locations. Ex. Computer RAM
  - Periodical refresh
- Static RAM (SRAM) :
  - Much like a register. The contents stay valid and does not have to be refreshed. SRAM is faster than DRAM but cost more Ex. Cache
  - About 6 MOSFET transistors per bit

- SDRAM
  - Currently on DIMMs § Access is synchronized with an external clock
  - Address is presented to RAM
  - RAM finds data (CPU waits in conventional DRAM)
  - Since SDRAM moves data in time with system clock,
  - CPU knows when data will be ready
  - CPU does not have to wait, it can do something else
  - Burst mode allows SDRAM to set up stream of data and fire it out in block
  - DDR-SDRAM sends data twice per clock cycle (leading & trailing edge)
  - SDRAM includes an on-chip burst counter that can be used to increment column addresses for very fast burst accesses

Questions?