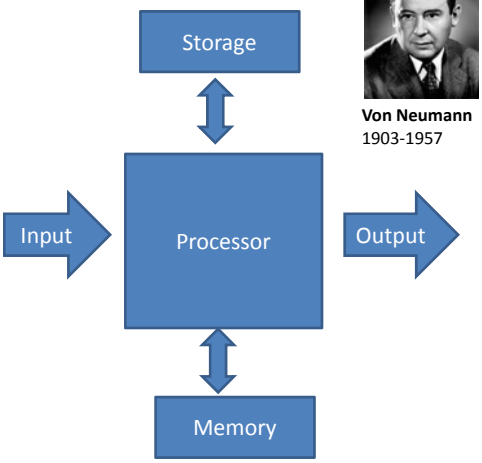
ET0023 Operating Systems

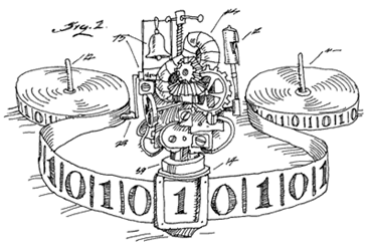
2: Computer Systems Overview

Computer System Architecture

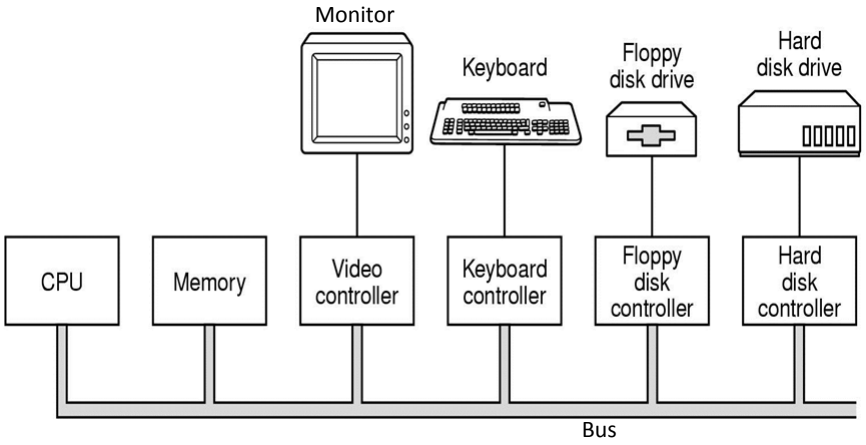


Von Neumann
1903-1957

Alan Turing
1912-1954



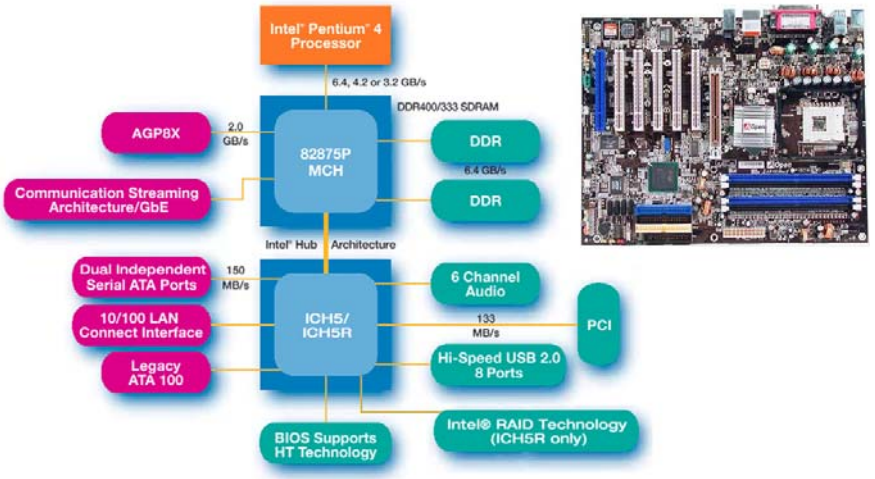
Components of a PC



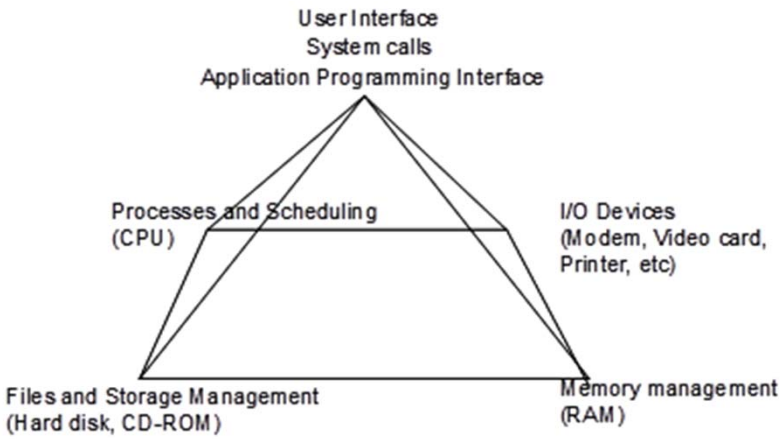
Generic x86 CPU System

- CPU
- Fast Memory Buses (Memory, Video)
  - Northbridge handles High Speed Ops
  - Southbridge handles Slower I/O
- Medium speed interfaces for Networking, USB, Hard-disk, DVD/CD Storage
- Slow speed mouse, keyboard and legacy I/O

Intel P4 Hub chipset

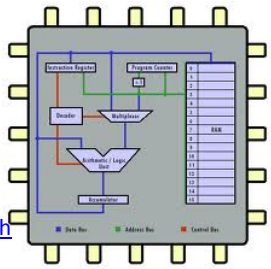


OS Pyramid



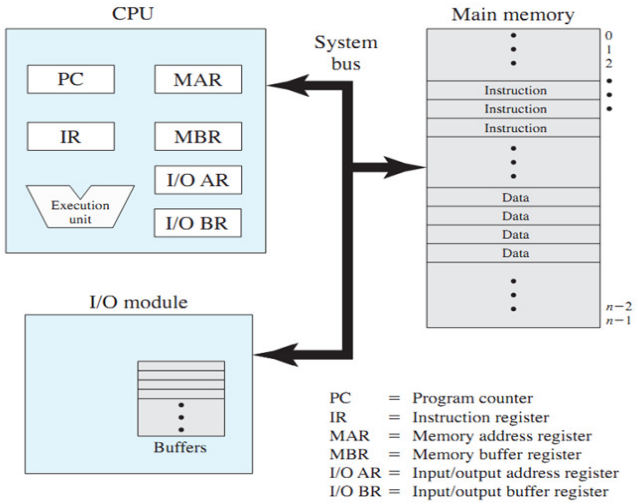
The CPU

- Central Processing Unit built using VLSI
- Contains ALU, Registers, Program Counter, Control.
- Executes machine instructions, maintains the "heartbeat" of the system, controls operations
- Driven by a clock/pulse generator
- Each instruction completes in "X" clock cycles



http://courses.cs.vt.edu/csonline/MachineArchitecture/Lessons/CPU/Lesson.html

CPU Internal Structures



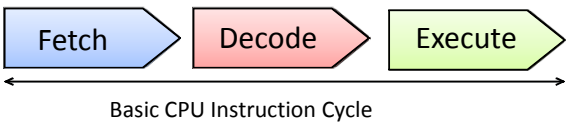
http://www.c-jump.com/CIS77/CPU/VonNeumann/lecture.html

CPU Internal structures

- Address
  - Program Instruction Counter
  - Address pointers
- Memory
  - Registers
  - Stack Pointer
- ALU (Arithmetic Logic Unit)
  - Program Status Word
- Pipelined architectures

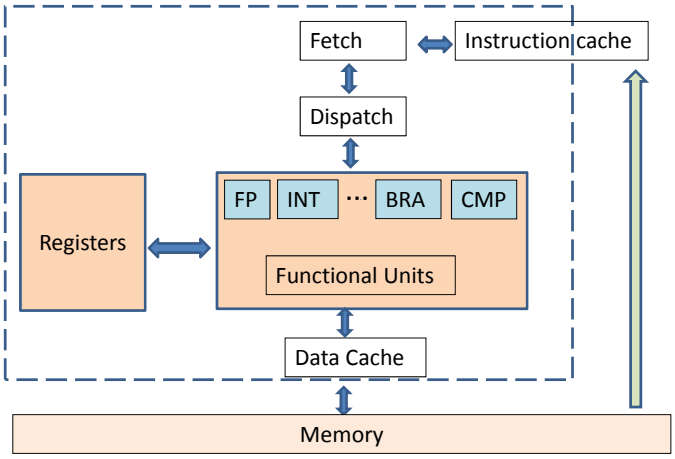
Fetch Execute Cycle

- CPU fetches instructions from memory, decodes and executes them
- Each CPU has specific set of instructions that it can execute
- CPU speed is measured based on the speed of executing instructions

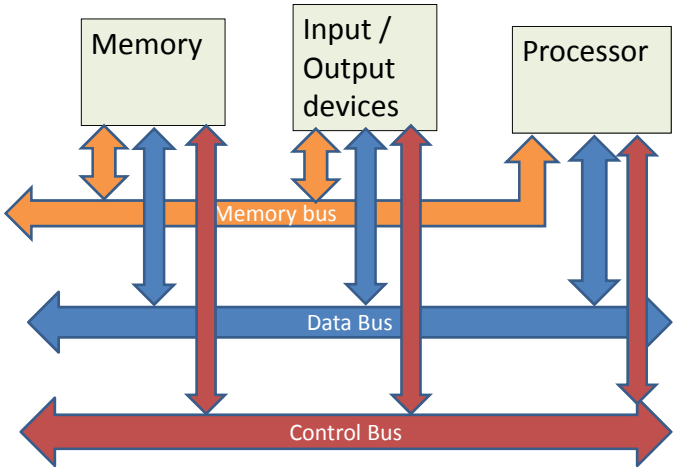


Basic CPU Instruction Cycle

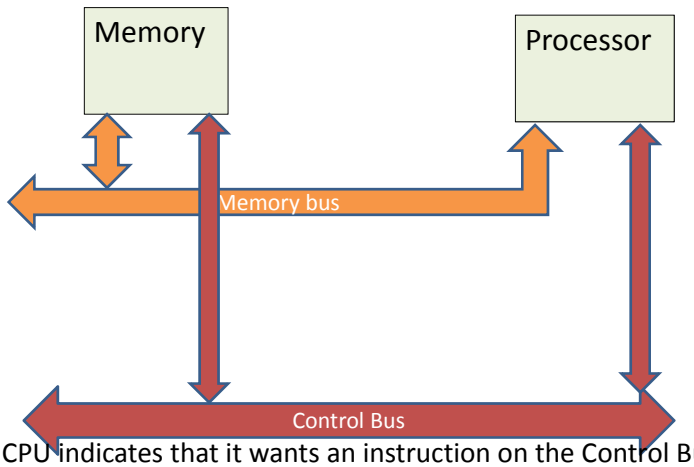
General Processor Block Diagram



Three-bus Architecture

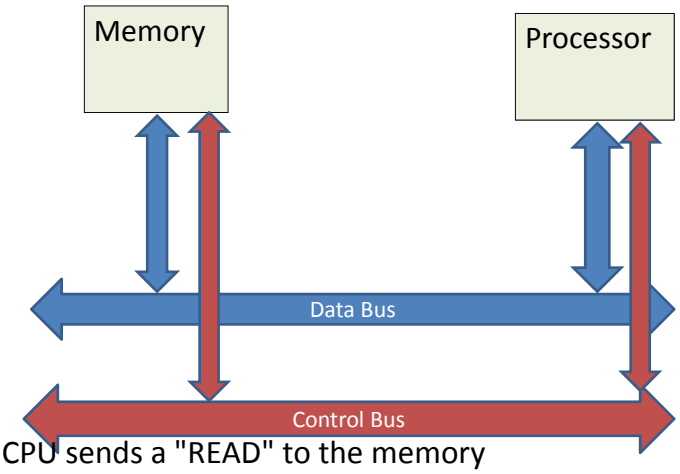


1. Instruction Fetch



- CPU indicates that it wants an instruction on the Control Bus
- CPU outputs address for next instruction to select Memory

2. Instruction Read

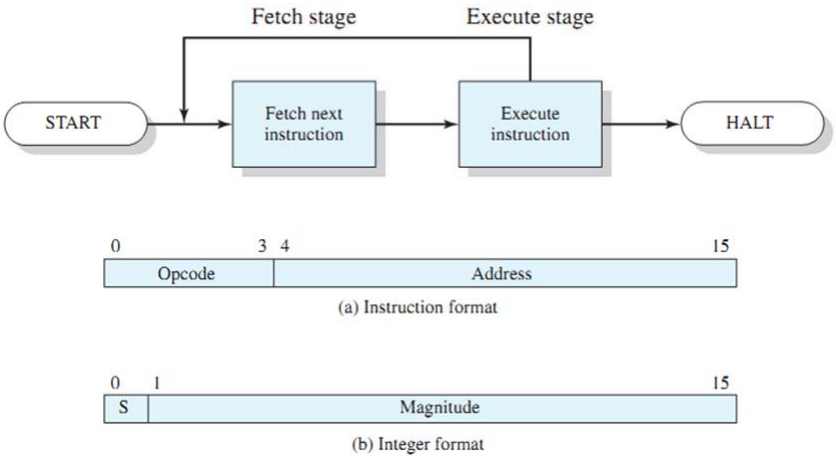


- CPU sends a "READ" to the memory
- CPU reads instruction from the memory

3. Instruction Decode/Execute

- CPU decodes the instruction based on the Functional Unit/Microcode
- CPU "Executes"
  - Perform an internal operation
  - Read another data
  - Write data
- Buses are NOT used during this period

Basic Instruction Cycle



Examples: Instruction

- Intel x86 Instruction set
  - JMP 300
  - MOV AX, 940
  - ADD AX, 941
  - MOV 941, AX
  - IN

http://en.wikibooks.org/wiki/X86_Assembly/X86_Family

Program Execution

Operating Systems:
Internals & Design Principles
William Stallings

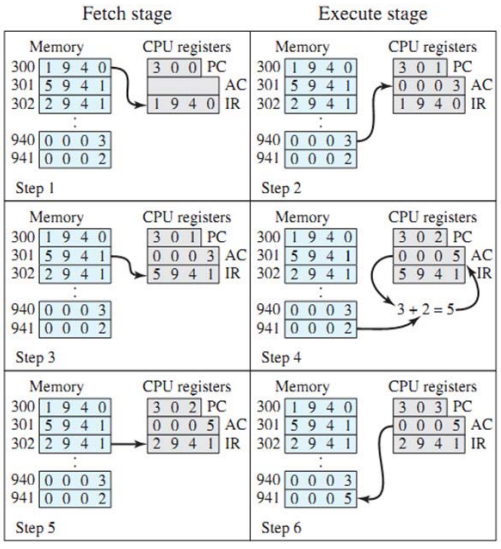


Figure 1.4 **Example of Program Execution** (contents of memory and registers in hexadecimal)

Memory Hierarchy

Typical access time		Typical capacity
1 nsec	Register	<1 KB
2 nsec	Cache	4 MB
10 nsec	Main Memory	512 MB – 16 MB
10 msec	Magnetic Disk	500 GB – 2 TB
100 msec	Magnetic Tape	500 GB – 4 TB

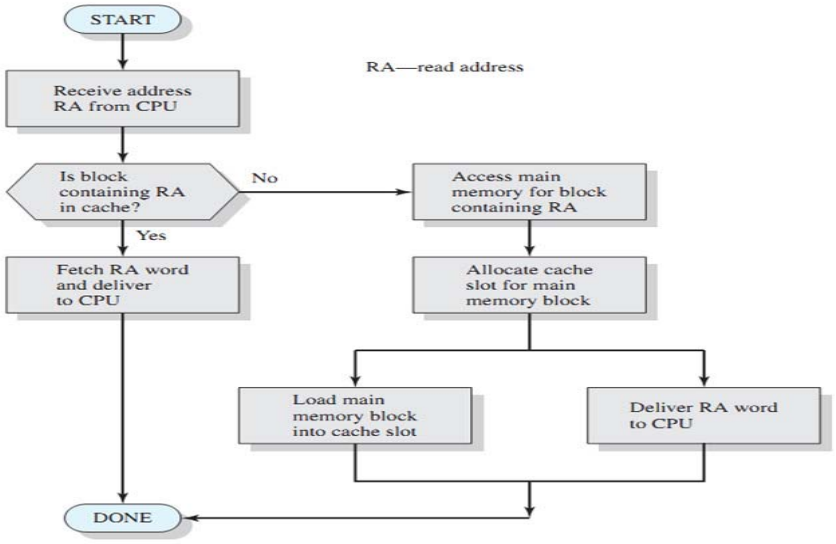
What is the cost per GB for a typical 1TB HDD?

Prof. Carver A. Mead:
Moore's Law: The amount of transistors that can be placed on the same amount of silicon doubles every two years.

Memory

- Registers
  - Made of same material as the CPU thus just as fast
  - CISC vs RISC systems
- Cache Memory
  - High speed memory
  - As RAM is accessed in row format, stores row(s) of memory
  - Highly likelihood that next access is in the row
  - Cache Miss / Cache Hit

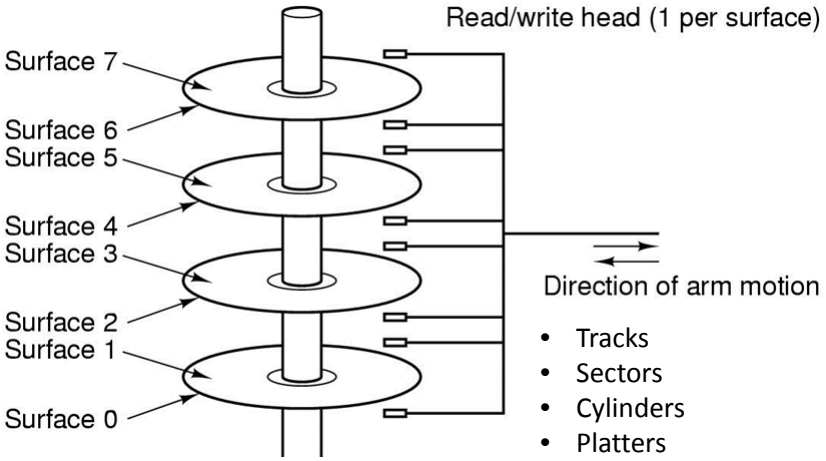
Cache Read Operations



Memory

- RAM (Random Access Memory)
  - Usually dynamic/refreshed memory
  - Fast, large amounts of memory storage
- ROM (Read Only Memory)
  - Stores the startup/bootstrap program of the system
  - Stores BIOS/System Hardware routines
- EEPROM (Electrically Erasable ROM)
  - Able to be electrically erased and re-written
  - Allows flexibility in updating systems

Magnetic Storage



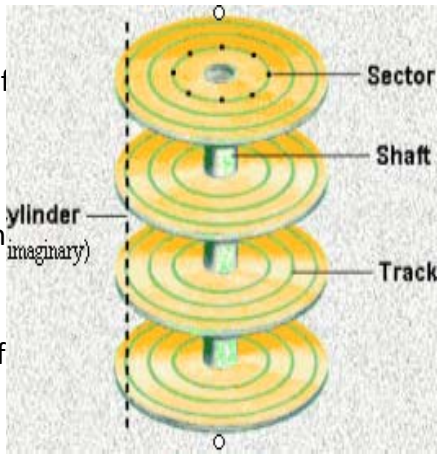
- Tracks
- Sectors
- Cylinders
- Platters
- RPMs
- Access Time

Magnetic Storage Terms

- A disk consists of one or more metal/glass platters which may be accessed on 1 or 2 surfaces.
- Each platter is divided into a number of concentric tracks.
- A cylinder is made up of a track on each of the platters at the same horizontal position.
- Each track is divided into sectors which usually hold 512 bytes of user data.
- Outside tracks (OD)may hold more information than inside tracks (ID) on a platter.
- The platters spin at a high speed measured in RPM.
- Seek time is the time taken for the Read/Write head to move from one track to another for information.
- The amount of data that the drive can read/write per second is known as the data access rate.

Sectors and tracks

- Data is stored on the surface of a platter in **sectors** along the **tracks**.
- Tracks are ***concentric*** circles on the disk.
- And sectors are part portion of a track.



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Typical Hard Disk Parameters

Table 1 Drive specifications summary for 1000 and 750

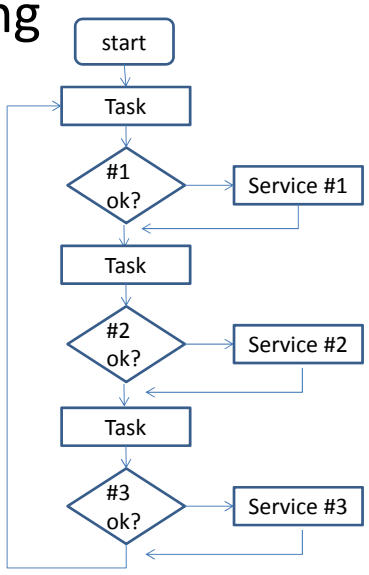
Drive Specification	ST31000524AS
Formatted capacity (512 bytes/sector)*	1000GB
Guaranteed sectors	1,953,525,168
Heads	4
Disks	2
Bytes per sector	512
Default sectors per track	63
Default read/write heads	16
Default cylinders	16,383
Recording density (max)	1413kb/in
Track density (avg)	236 ktracks/in
Areal density (avg)	329Gb/in^2
Spindle speed	7200 RPM
Internal data transfer rate (max)	1695Mb/s
Sustained data transfer rate OD (max)	125MB/s
I/O data-transfer rate (max)	600MB/s
ATA data-transfer modes supported	
Cache buffer	32MB

Tape Drives

- Backup medium for Hard Disk storage
- Holds large data sets
- Full/Incremental backups
- Storage is serial, may need operations to move to the correct locations
- Current Technology: LTO 3/4
- Capacities: 400GB-1.5TB @ 140MB/s

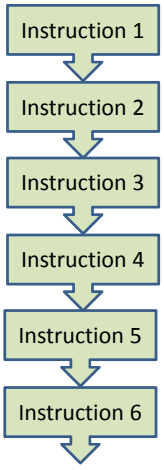
Polling

- Check each device in turn for status
- If service required, check the device
- Keeping doing the operation
- Easy to implement using software
- Hard to manage priorities

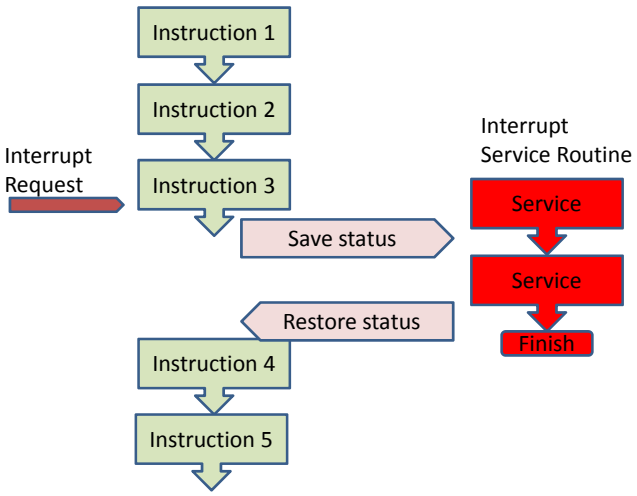


Interrupts

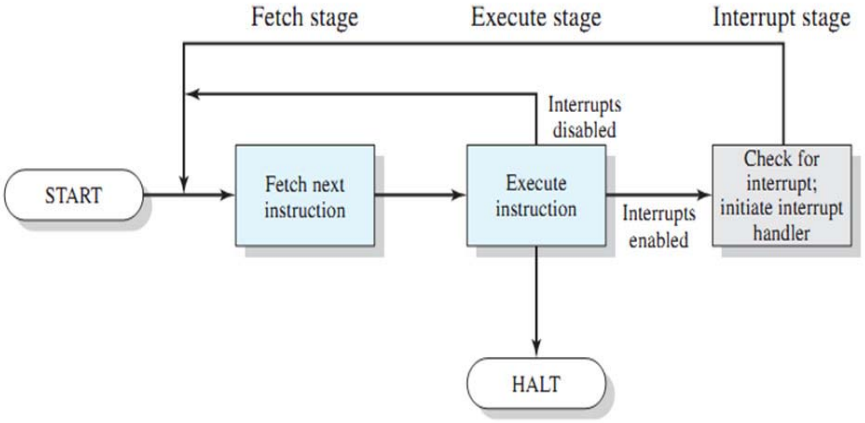
- Normal operations progress
- When device requires service, it sends a hardware request to the CPU
- CPU completes current instruction
- CPU saves the status of operations
- CPU determines who has interrupted and services device
- CPU restores old status



Interrupts



Instruction Cycle with Interrupts



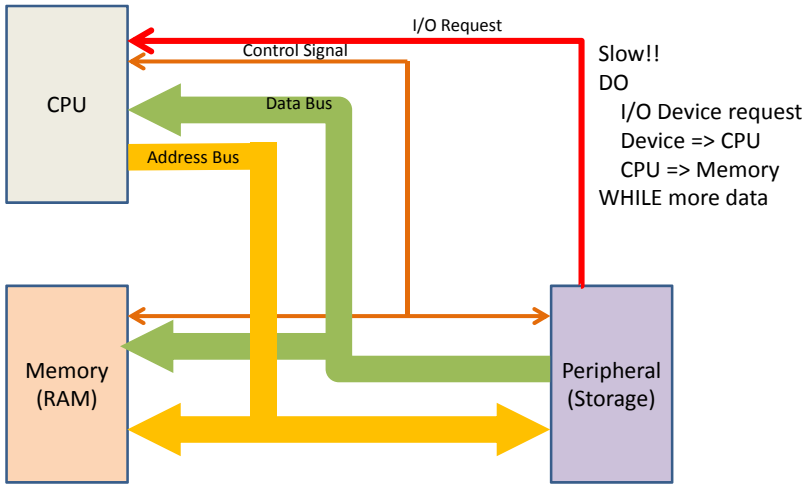
Interrupt Strategies

- Interrupt request: Hardware/Software
- Need to determine who has interrupted
- How do we save the status?
- What do we need to save?
- Which Service routine do we execute?
- How do we return from the service routine?
- How do we restore the status?

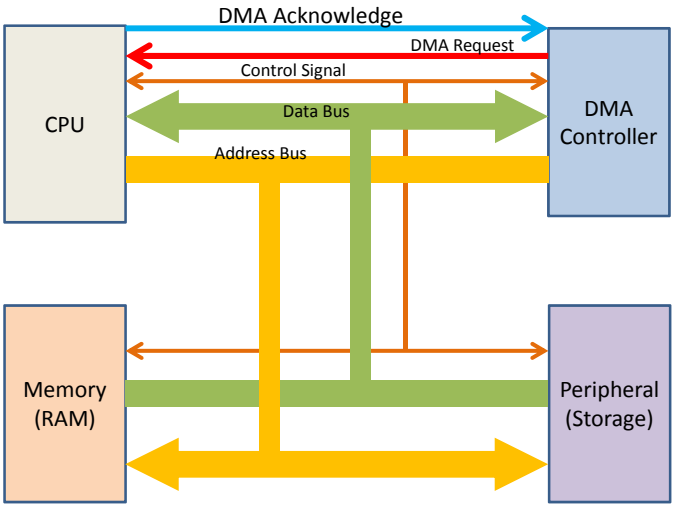
Direct Memory Access

- Allows access to the system memory without CPU intervention.
- Specific hardware is used to transfer data from I/O device to Memory (DMA controller)
- Advantages: Overcomes slow I/O operations from the CPU
- Uses: Storage data transfers, Network transfers
- Main techniques:
  - Cycle Stealing
  - Block DMA requests
  - Transparent mode

Normal I/O Operations

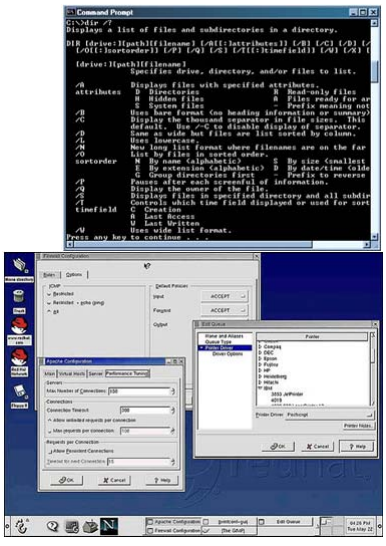


Direct Memory Access



User Interface

- Command Line Interface (CLI)
  - Command interpreter
  - Shells
  - Text input, can be scripted
- Graphical User Interface (GUI)
  - Windows, Gnome, KDI
  - Heavy use of memory and I/O
  - Keyboard, mouse, touch



Application Progg Interfaces (API)

- Functions, library for usage of the interface
- APIs provide libraries for
  - System calls, routines, transfers
  - Graphics
- Makes development of software
  - Consistent with the OS
  - Better controlled
  - Easier for the programmer

- QUESTIONS