Computer Systems

Outline

- Computer hardware
  - Inside the box parts
- Basic components of a computer system
  - CPU
  - Memory -- primary storage
  - I/O systems
- Storage
- History of computer technology

An Example of a Computer System

- Intel® Core™2 Duo Processor E6300 1.86GHz, 1066 FSB
- Memory 2GB Dual Channel DDR2 SDRAM at 533MHz-200MHs
- Video Card 256MB nVidia GeForce 7300LE TurboCache
- Hard Drive 160GB Serial ATA Hard Drive 7200RPM w DataBurst Cache™
- Network Interface Integrated 10/100 Ethernet
- Modem 56K PCI Data Fax
- CD or DVD Drive 16x DVD ±RW Drive
- Sound Card Integrated 7.1 Channel Audio
- Operating System Genuine Windows® XP Media Center 2005 Edition

System Case or Box

- Front Off Frame
- Back Off Frame
- Power Card Plug
- I/O Connector Ports
- Power Supply
- Fan Vent
- I/O Template Extension SM Interfaces
- Vent Holes
- Fast (Black Fiar)
Power Supply Connector

Connectors or Ports

Connectors or Ports

Inside the Box

- Motherboard
- Power supply
- Cooling fan
- Internal speaker
- Drive bays
What’s on the Motherboard

- Microprocessor
- RAMs
- IC (Integrated Circuits) chips
- System clock
- Video card
- Sound card

Processors

Cooling Fans

Memory – Primary Storage
Introduction to Computer Technology

Network Card

Basic Computer Architecture

- central processing unit (CPU)
- memory unit
- input devices
- output devices

The von Neumann Model (1946)

- Today’s stored-program computers have the following characteristics:
  - Four hardware systems:
    - A central processing unit (CPU)
    - A main memory system
    - An I/O system
    - The capacity to carry out sequential instruction processing.
  - A single data path between the CPU and main memory.

Hardware Organization

- CPU
- Memory
- I/O devices
- Data bus
Central Processing Unit - CPU

- **Microprocessor**
  - Arithmetic logic unit (ALU): performs arithmetic and logic calculations.
  - Control unit (CU): coordinates the actions of the other components so that instructions (the program) are executed in sequence.

Arithmetic Logic Unit

- Arithmetic operations: addition, subtraction, multiplication, and division
- Logical operations: AND, OR, and NOT
- Comparison operations: equal to, greater than, less than, greater or equal to, less than or equal to, and not equal to

Control Unit

- Fetch an instruction: retrieve an instruction or data from memory
- Decoding the instruction: translate the instruction into the commands the computer understand
- Executing the instruction: carry out the commands (by ALU)
- Store the result: write the result to memory

Registers

- Temporary storage
- Different types of registers, each with a specific function:
  - Storing the memory location where the instruction is fetched
  - Storing an instruction while it is being decoded
  - Storing data while the ALU processes it
  - Storing the result of a calculation
The von Neumann Model

The control unit fetches the next instruction from memory using the program counter to determine where the instruction is located.

The instruction is decoded into a language that the ALU can understand.

Any data operands required to execute the instruction are fetched from memory and placed into registers within the CPU.

The ALU executes the instruction and places results in registers or memory.
System Clock

- The CU controls the timing of all computer operations according to the system clock.
- The system clock generates regular electronic pulses or ticks (clock cycles).
- A CPU requires a fixed number of clock cycles to execute an instruction.
- Processor speed is determined by clock speed in MHz (megahertz).

What does “1.86 GHz” clock speed mean?

- 1.86 GHz refers to the processor that can process instructions at the speed of 1.86 billion cycles per second.

What is computer memory or memory?

- The American Heritage® Dictionary: Memory is a unit of a computer that preserves data for retrieval.
- Capacity for storing information: two gigabytes of memory.

- The Encyclopedia Britannica: Computer Memory is a device that is used to store data or programs (sequences of instructions) on a temporary or permanent basis for use in an electronic digital computer.

- From the Webopedia Computer Dictionary, “Every computer comes with a certain amount of physical memory, usually referred to as main memory or RAM. You can think of main memory as an array of boxes, each of which can hold a single byte of information. A computer that has 1 megabyte of memory, therefore, can hold about 1 million bytes (or characters) of information.”

Intel Processors

<table>
<thead>
<tr>
<th>Year</th>
<th>CPU</th>
<th>Clock Speed</th>
<th>Cache</th>
<th>Bus Width</th>
<th># of Transistors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>8080</td>
<td>2 MHz</td>
<td>None</td>
<td>8 bits</td>
<td>6,000 (6 microns)</td>
</tr>
<tr>
<td>1978</td>
<td>8086</td>
<td>4.77, 8, 10 MHz</td>
<td>None</td>
<td>16 bits</td>
<td>29,000 (3 microns)</td>
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<tr>
<td>1979</td>
<td>8088</td>
<td>4.77, 8 MHz</td>
<td>None</td>
<td>8 bits</td>
<td>29,000 (3 microns)</td>
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<tr>
<td>1982</td>
<td>80286</td>
<td>6, 10, 12 MHz</td>
<td>None</td>
<td>16 bits</td>
<td>134,000 (1.5 microns)</td>
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<tr>
<td>1985</td>
<td>80386 EX</td>
<td>16, 20, 25, 33 MHz</td>
<td>None</td>
<td>16/32 bits</td>
<td>275,000 (1.5 micron)</td>
</tr>
<tr>
<td>1988</td>
<td>80386 SX</td>
<td>8 KB L1</td>
<td>None</td>
<td>16/32 bits</td>
<td>275,000 (1 micron)</td>
</tr>
<tr>
<td>1989</td>
<td>80486 DX</td>
<td>8 KB L1</td>
<td>None</td>
<td>32 bits</td>
<td>1.2 million (.8, 1 micron)</td>
</tr>
<tr>
<td>1991</td>
<td>80486 SX</td>
<td>8 KB L1</td>
<td>None</td>
<td>32 bits</td>
<td>1.2 million (.8, 1 micron)</td>
</tr>
<tr>
<td>1997</td>
<td>Pentium II</td>
<td>233-300 MHz</td>
<td>512 KB L2</td>
<td>32 bits</td>
<td>7.5 million (0.35 micron)</td>
</tr>
<tr>
<td>1998</td>
<td>Celeron</td>
<td>200-300 MHz</td>
<td>16 KB L1</td>
<td>32 bits</td>
<td>7.5 million (0.25 micron)</td>
</tr>
<tr>
<td>1999</td>
<td>Pentium III</td>
<td>400 MHz - 1 GHz</td>
<td>256 KB L2</td>
<td>32 bits</td>
<td>28.1 million (0.18 micron)</td>
</tr>
<tr>
<td>2000</td>
<td>Pentium 4</td>
<td>1.3 - 2 GHz</td>
<td>512 KB L2</td>
<td>32/64 bits</td>
<td>42 million (0.18 micron)</td>
</tr>
<tr>
<td>2006</td>
<td>Pentium Core Duo</td>
<td>1.06 - 1.20 GHz</td>
<td>2 MB L2</td>
<td>32 bits</td>
<td>152 million (65 nm)</td>
</tr>
</tbody>
</table>
Memory
- consists of memory locations (or words)
- each memory location contains a string of zeros or ones.
  - ROM - Read Only Memory
  - RAM - Random Access Memory
  - Addressing Data

RAM
- There are 3 basic types of memory used in PCs
  - dynamic RAM
  - static RAM
  - video RAM
  - CMOS (Complementary Metal-Oxide Semiconductor) RAM -- store system setup information

Dynamic RAM
- Main memory or RAM is where programs and data are kept when a program is running
  - hold data for a short period of time and must be refreshed periodically or it loses its contents
  - DRAM chips require two CPU wait states for each execution
  - can only execute either a read or write operation at one time.
  - FPM RAM (Fast Page Mode RAM) -- 30 MHz
    - faster access to data located within the same row
  - EDO RAM (enhanced data-out RAM) -- 66 MHz
    - requires only one CPU wait state. You can gain a 10 to 15% improvement in performance with EDO memory.
  - BEDO RAM (burst enhanced data-out RAM)
    - requires zero wait states and provides at least another 13 percent increase in performance.
  - SDRAM (synchronous dynamic RAM) -- 100 MHz
    - introduced in late 1996
    - retains memory and does not require refreshing
    - it synchronizes itself with the timing of the CPU
    - it also takes advantage of interleaving and burst mode functions SDRAM is faster and more expensive than DRAM. It comes in speeds of 66, 100, 133, 200, and 266 MHz.
  - DDR RAM (Double Data Rate SDRAM) -- 200 MHz

Types of Memory
- SIMM (Single In-line Memory Modules)
  - one SIMM can contain several chips.
  - when CPU's began to read 32-bit chunks, a wider SIMM was developed and contained 72 pins.
  - 72 pin SIMMS are 3/4" longer than 30 pin SIMMs and have a notch in the lower middle of the PCB.
  - 72 pin SIMMs install at a slight angle.
- DIMM (Dual In-line Memory Modules)
  - allows two rows of DRAM, EDO or BEDO chips.
  - contains 168 pins and transfers data in 64 bit chunks.
  - DIMMs install straight up and down and have two notches on the bottom of the PCB.
- SODIMM (Small Outline DIMM)
  - are commonly used in notebooks and are smaller than normal DIMMs.
  - there are two types of SODIMM,
    - 72 pins with a transfer rate of 32 bits
    - 144 pins with a transfer rate of 64 bits.
Static RAM

RAM chip primary for special high-speed memory called level-2 cache memory

- SRAM (static RAM) --
  - faster and more expensive than DRAM
  - speeds between 8 and 12 ns
  - synchronous or asynchronous
  - does not require a refresh operation
- PBSRAM (pipeline burst SRAM) --
  - collect and send multiple request for memory as a single pipelined request

Video RAM

Stores data that appears on a video display, there are 3 types

- VRAM (video RAM) --
  - store color pixels
  - dual-ported -- one port to refresh the display while the other port writes data to the display
- WRAM (windows RAM) --
  - optimized for video graphics
- SGRAM (synchronous graphics RAM) --
  - two video memory pages can be opened at the same time - 3D graphics

ROM

- Read-Only Memory
- The data stored in ROM is permanent, cannot modified.
- PROM (Programmable Read-Only Memory)
- Flash memory -- used is cellular phones, digital cameras, notebook computers

Cache

- Cache Memory is fast memory that serves as a buffer between the processor and main memory.
- The cache holds data that was recently used by the processor and saves a trip all the way back to slower main memory.
- High speed memory
- Two types:
  - Level 1 -- internal cache
  - Level 2 -- external cache
  - Level 3?????
Memory Structure of PCs

- The memory structure of PCs is often thought of as just main memory, but it's really a five or six level structure:
  - The first two levels of memory are contained in the processor itself, consisting of:
    - the processor's small internal memory, or registers.
    - L1 cache, which is the first level of cache, usually contained in the processor.
  - The third level of memory is the L2 cache, usually contained on the motherboard. However, the Celeron chip from Intel actually contains 128K of L2 cache within the form factor of the chip. More and more chip makers are planning to put this cache on board the processor itself. The benefit is that it will then run at the same speed as the processor, and cost less to put on the chip than to set up a bus and logic externally from the processor.
  - The fourth level, is being referred to as L3 cache. This cache used to be the L2 cache on the motherboard, but now that some processors include L1 and L2 cache on the chip, it becomes L3 cache. Usually, it runs slower than the processor, but faster than main memory.
  - The fifth level (or fourth if you have no "L3 cache") of memory is the main memory itself.
  - The sixth level is a piece of the hard disk used by the Operating System, usually called virtual memory. Most operating systems use this when they run out of main memory, but some use it in other ways as well.

Buses

- Buses transfer bits from:
  - input devices to memory
  - memory to CPU
  - CPU to memory
  - memory to output devices

- There are 2 types of buses:
  - data bus -- transfer the actual data
  - address bus -- transfer information where the data should go in memory

Bus Size

- Bus width is determined by the number of bits that information can be transfer at one time.
  - Power of 2 -- 8, 16, 32, 64
  - Use to compare CPUs
Input/Output Devices

- Input devices
- Output devices

What Is Input?

*Input* is any data or information entered in a computer. In general, there are four types of input:
- Data
- Commands
- User responses
- Programs

Input Devices

An *input device* is any hardware component that allows you to enter data, programs, commands, or user responses into a computer. For examples:
- Keyboards
- Pointing devices
- Scanners and reading devices
- Digital cameras, digital video cameras

Keyboards

- One of the primary input devices is the *keyboard*.
- Number of keys on a keyboard depends on the type of the computer, 101 to 105 keys.
- Includes alphabets, numbers, space, punctuation marks, function keys, special keys, command keys,...
Pointing Devices

A pointing device is an input device that allows you to control a pointer on the screen. Pointing devices include:

- Mouse
  - Mechanical mouse -- with rubber ball or metal ball
  - Optical mouse -- has no moving mechanical parts
  - Wireless or cordless mouse
- Track ball -- a stationary pointing device with a mechanical ball on top.

Touch pad -- is a small, flat, rectangular pointing device that sensitive to pressure and motion, with or without buttons.
- Pointing stick -- is a pressure-sensitive pointing device shaped like a pencil eraser that used in notebook computers.
- Joystick -- is a vertical lever mounted on a base with additional buttons.

Touch screen -- is a monitor that has a touch-sensitive panel on the screen.
- Pen-based systems
  - Light pen -- is a handheld input device that contain a light source or can detect light.
  - Graphic tablet -- is a digitizing tablet consists of a flat, rectangular, electronic plastic board used to input drawings, sketches, or graphical data.

Scanners and Reading Devices

Devices that capture data directly from source documents include:

- Optical scanners
- Bar code scanners
- Finger print scanner
- Optical character recognition
- Magnetic-ink character recognition
Digital Cameras and Digital Video Cameras
- Still pictures can be captured digitally by digital cameras
- Moving pictures can also be captured digitally by digital video cameras
- These pictures can be transferred to be processed and saved on the computer

Microphones
Audio input can be done though a microphone.

What Is Output?
- Output is data that has been processed into a useful form of information such as text, graphics, audio, and video.

Output Devices
An output device is any computer component capable of conveying information to a user.
- Display devices
- Printers
- Plotters
- Projectors
- Speakers
Display Devices

- CRT monitor (Cathode Ray Tube) or monitor
- LCD (Liquid Crystal Display)

Printers

There are two types of printers:

- Impact printers
  - Dot-matrix printers
  - Line printers
- Non-impact printers
  - Ink-jet printers
  - Laser printers

Secondary/Auxiliary Storage

- magnetic tape drives
- disk drives
- CD ROM drives
- DVD ROM Drives
- flash drives

Storage

- Storage devices
- Storage hierarchy
- Disk drives
- Hard disks
- Magnetic tape
- CD-ROM Drives
- DVD-ROM Drives
- Other storage devices
Why is storage necessary?

Two types of storage
- Volatile: RAM -- for working storage
- Nonvolatile: secondary storages -- for long-term storage
- Much cheaper than memory
- Does not transfer data as fast as memory
- Store setup information for BIOS at the startup
- Store application software
- Store result data

Comparisons

<table>
<thead>
<tr>
<th>Device</th>
<th>Access Speed</th>
<th>Cost/MB</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEMORY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cache Memory</td>
<td>Fastest</td>
<td>Highest</td>
</tr>
<tr>
<td>RAM</td>
<td>Fast</td>
<td>High</td>
</tr>
<tr>
<td>STORAGE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard Disk</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>CD-ROM disc</td>
<td>Slow</td>
<td>Low</td>
</tr>
<tr>
<td>Backup tape</td>
<td>Very slow</td>
<td>Lowest</td>
</tr>
</tbody>
</table>

Types of Storage

Types of storage determined by
- Operations -- read or read/write
- Method used to access information -- sequential or random access
- Technology -- magnetic, optical or combination of the two
- Location in the storage hierarchy

Read/Write and Read-Only media

- Read/write media enables a computer to perform reading and writing operations such as diskettes
- A computer can only perform reading from Read-only media such as CD-R discs
Sequential and Random-Access Storage

**Sequential storage device:** information can be accessed through the order that information is arranged

**Random-access storage device:** information can be accessed directly without going through the order that information is arranged

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Storage Technology

**Magnetic storage media:**
- the media is coated by magnetic substance such as tapes or disks
- an electromagnetic **read/write head** records information by transforming electrical impulses into a varying magnetic field that forces the particles to be arranged as a pattern.

**Optical storage media:**
- Use laser beams to read microscopic patterns of data encoded on the surface of plastic discs

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Storage Hierarchy

**On-line storage (primary storage):**
- a storage that is actively accessible by the computer without human interaction
- hard disk

**Near-on-line storage (secondary storage):**
- A storage that can be accessible by the computer with human interaction
- diskettes, CD-ROM disc, USB drive

**Offline storage (archival storage):**
- use as a backup
- Magnetic tape

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Access time

<table>
<thead>
<tr>
<th>Device</th>
<th>Typical Access time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static RAM (SRAM)</td>
<td>5-15 nanoseconds</td>
</tr>
<tr>
<td>Dynamic RAM (DRAM)</td>
<td>50-70 nanoseconds</td>
</tr>
<tr>
<td>Solid state disk (SSD)</td>
<td>0.1 millisecond</td>
</tr>
<tr>
<td>Hard disk drive</td>
<td>6-12 milliseconds</td>
</tr>
<tr>
<td>CD-ROM drive</td>
<td>80-800 milliseconds</td>
</tr>
</tbody>
</table>
Data Storage Devices

Floppy drive/Floppy disk (diskette)
- A floppy disk is a circular plastic coated with magnetic film same material as on a cassette tape.
- 1.44 MB
- Use head actuator to move read/write head over the disk surface

Hard Drive/Hard Disk

- A hard disk is a high capacity, high-speed storage.
- Interfaces: provides communication from processor to hard disk
  - IDE (Integrated Device Electronics) / EIDE (Enhanced Integrated Device Electronics)
  - SATA – Serial Advanced Technology Attachment
  - SCSI (Small Computer System Interface)
Removable Drives

- Zip drive -- 100, 250, 750 MB
- Jaz drive -- 2 GB
- Thumb drive -- 64, 128, 256, 512 MB, 1, 2, 4, 8, 16, 32 GB
- Magnetic tapes

CD-ROM Disc/Drive

- CD-ROM (Compact Disc Read Only Memory) drives are CD-Players inside of a computer that can range of speeds from 1x and beyond and has the capability of playing audio CDs and also computer data CDs
- CD-R, CD-WO (Write once) or WORM (Write Once Read Many) drive or disc. CD-R discs are discs are capable of having information written to the disc once and then read many times after that.
- Store up to 650 Mb

DVD-ROM Disc/Drive

- DVD (Digital Versatile Disc or Digital Video Disc) is a new type of CD-ROM drive that allows for large amounts of data on one disc the size of a standard Compact Disc, being used for DVD movies however are also being used for games and storage mediums.
- Store up to 17 Gb

Flash Memory Cards

- Uses solid state storage system
- Smart media card
- Compact flash card
- Memory stick
USB drives

Computer system
- Hardware -- physical components of computer that you see or touch
- Software -- computer programs that instruct hardware to perform specific tasks

Categories of Computers
- Personal computers (PCs):
  - Desktop computers
  - Network of computers and Web appliances -- WebTV
  - Laptop or notebook computers
  - Handheld computers -- small personal computers, PDAs, cellular phones
- Minicomputers: A minicomputer is designed for a small group of organizations with a more powerful computing capabilities. The computing process of a minicomputer can be accessed by several users via terminal that connected to it.
- Mainframe computers: A mainframe computer is a large, expensive, and powerful computing process that allows hundred and thousand users access its computing capabilities.
- Supercomputers: A supercomputer is the fastest, most powerful, and most expensive. It is designed specifically for applications requiring complex, sophisticated mathematical calculations -- weather forecasting, medical image processing, petroleum exploration,...

Servers
A server is a computer, commonly a desktop or a more powerful desktop-like computer, connected to a computer network. It provides resources such as programs and information to be accessed by the desktop computers called clients in the network.
History of Computer Technology

- First mechanical computer
- First electronic computer
- Evolution of computer technology

The First Computing Device

- The first computing device is *Abacus* which can be traced back to 5,000 years ago in Asia and still is being used today.
- *Abacus* is considered to be a mechanical computing device.
- Computing devices or computers can be categorized into two types:
  - *mechanical* and
  - *electronic* computing devices or computers.

Mechanical Computing Device

- In 1822 Charles Babbage an English mathematician invented a mechanical computational device using steam engine called *Difference Machine* to compute tables of numbers, such as logarithm tables.
- In 1837 Charles Babbage invented a *mechanical general-purpose computer* called *Analytical Engine*.
- Augusta Ada Lovelace created a programming language for *Analytical Engine*.
- In 1936 Alan Turing invented a theoretical computing machine called *Turing machine* to serve as an idealized model for mathematical calculation.
The First Computer

- The first machine ABC (Atanasoff Berry Computer) to employ electronics (vacuum tubes) was developed in 1937 by a physicist John V. Atanasoff and Clifford Berry at Iowa State University.
- This was used to solve simultaneous linear equations.

ENIAC

- In 1943, J. Presper Eckert and John Mauchly at Moore School of Engineering, University of Pennsylvania developed the first large-scale computer called ENIAC (Electronic Numerical Integrator and Computer).
- It used 17,480 vacuum tubes. This Machine uses the program to control calculations.

Stored-Program Computer

- In 1945, John Von Neumann proposed the concept of stored program computer.
  - encode both program and data as binary number,
  - store the program along with the data electronically in a set of switches (computer memory),
  - provide a central processing unit that not only perform calculations but also fetch, decode and execute the instructions contained in the program.

Evolution of Computer Technology

<table>
<thead>
<tr>
<th>From Year</th>
<th>To Year</th>
<th>Fundamental Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>1956</td>
<td>Vacuum tubes</td>
</tr>
<tr>
<td>1956</td>
<td>1963</td>
<td>Transistors</td>
</tr>
<tr>
<td>1964</td>
<td>1971</td>
<td>Integrated Circuits</td>
</tr>
<tr>
<td>1971</td>
<td>Present</td>
<td>Microprocessors</td>
</tr>
</tbody>
</table>
The First Generation

- In 1951, J. Presper Eckert and John Mauchly built the first general-purpose commercial computer, the UNIVAC.
- This is the first generation of commercial computers.
- The instructions were written in machine language. UNIVAC used less number of vacuum tubes than ENIAC.

The Second Generation

- Vacuum tubes were replaced by transistors.
- Computers are faster and smaller.
- It has punched cards for input, tape storage, and disk storage.
- Development of high-level programming languages: COBOL (Common Business-Oriented Language) and FORTRAN (Formula Translator).
- ASCII (American Standard Code for Information Interchange) was developed in 1963.
- In 1964 IBM announced a new line of computers called System/360.

The Third Generation

- Timesharing
- Batch processing
- Development of integrated circuits (ICs)
- Small-scale integration and medium-scale integration
- Wide area networks
- Internet
The Fourth Generation

- Very-large-scale integration
- Microprocessor
- MS-DOS
- Command line interface
- Graphical interface

The Fourth Generation

- Artificial intelligence (AI)
- World Wide Web
- Local area networks
- Wireless technology
- E-commerce