How Computers Work

The Boot Process

PC Hardware Components

Buying a Computer
Input, Process, Output, and Storage

- Most operating systems provide functions to read and write data on files.
- It then translates requests for operations on files into operations that the disk controller can carry out.
- The operating system performs four basic operations,
  1. Input
  2. Processing
  3. Output
  4. Storage
Initializing and Testing the System Hardware

- For an operating system to run, it must be loaded into the Random Access Memory (RAM).
- When a computer is first turned on, it launches the bootstrap loader.
- The primary functions of bootstrap are to test the computer hardware and to locate and load the operating system into RAM.
- During the BIOS firmware routines, three major sets of operations happen:
  - Power-On Self-Tests or POST
  - Initialization
  - BIOS moves the starting address and mode information into the DMA controller then Master Boot Record (MBR)
Initializing and Testing the System Hardware (cont.)

- To test the computer hardware, the bootstrap program runs the power-on self-test or POST.

- In this test, the central processing unit (CPU) checks itself first and then checks the computer system timer.

- The POST checks the RAM by writing data to each RAM chip and then reading that data.

- Any difference indicates a problem.

- If the POST finds errors, it sends a message to the computer monitor.
Initializing and Testing the System Hardware (cont.)

- If the POST finds errors that cannot be displayed on the monitor, it sends errors in the form of beeps.
- The POST sends one beep and the screen begins to display OS loading messages once the bootstrap has determined that the computer has passed the POST.
- The meaning of any beep code depends on the manufacturer of the BIOS. There are 3 major manufacturers of BIOS chips.
Loading the Operating System and Hardware Configuration

- The next step for the bootstrap program is to locate the OS and copy it to the computer RAM.
- The bootstrap loader first looks to see if the OS boot file is located on a floppy drive.
- If not, it looks for it on the hard disk.
- If the operating system is not found on either the floppy drive or the hard disk, the bootstrap loader will look for the OS on the built-in CD ROM.
The Boot Sequence

- The number of events that happen in the boot process depends on the version of Windows and whether it is a cold boot or a warm boot.

- **Warm boot** – Performed whenever the PC is restarted or reset with the power still on.

- **Cold boot** – Starts whenever the PC power switch is turned on.
Computer Cases

- Computer cases are either desktop or tower models.
- The desktop model sits on a desk horizontally. The monitor can be set on top.
- The tower model stands upright in a vertical position that allows easy placement on the floor.
- Mini-tower, mid-tower, and full tower cases are available.
- A power supply provides the needed voltage to power the various electronic circuits that make up the PC.
Power Supplies

• A power supply provides the needed voltage to power the various electronic circuits that make up the PC.

• It receives external power and AC electricity.

• It is contained in a metal box. Within this box, a transformer converts the current that is generated from standard outlets into voltages and current flows that the computer parts need to operate.

• A fan installed in the power supply prevents the computer and its components from overheating by maintaining an air flow.
Cooling Systems

- The power supply fan helps prevent the computer components from overheating by maintaining airflow in the case.
- A heat sink is made of a material that absorbs generated heat. It is designed to disperse the heat away from the CPU.
- Computer cases made of aluminum create a much cooler environment for the installed components.
- Liquid cooling systems use a small radiator much like a car, and fluid moves through the radiator and copper pipes to move heat away from the processor.
The Motherboard

- Everything else in the system plugs into it, is controlled by it, and depends on it to communicate with other devices on the system.
- The system board is the largest of the printed circuit boards and every system has one.
- It houses the CPU, the controller circuitry, the bus, RAM, expansion slots for additional boards, and ports for external devices.
The Motherboard (cont.)

- The motherboard chipset determines the motherboard’s compatibility with several other vital system components.
- It consists of a group of microcircuits contained on several integrated chips or combined into one or two very large scale integration (VLSI) integrated chips.
- These are chips that have over 20,000 circuits.
- The motherboard chipset determines motherboard performance and limitations.
# The Motherboard Form Factors

Most new systems come with the ATX motherboard form factor.

- Motherboards are usually described by their form factors. Form factors describe the physical dimensions of the motherboard. The two most common form factors currently in use are the Baby AT motherboard and the ATX motherboard.

<table>
<thead>
<tr>
<th>Form factor</th>
<th>Dimensions (in.)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baby AT</td>
<td>8.5 X 10-13</td>
<td>Used by older PCs. Becoming outdated.</td>
</tr>
<tr>
<td>ATX</td>
<td>12 X 9.6</td>
<td>The most common form factor in use today.</td>
</tr>
<tr>
<td>Mini ATX</td>
<td>11.2 X 8.2</td>
<td>Used in newer, smaller PCs.</td>
</tr>
<tr>
<td>LPX</td>
<td>9 X 11-13</td>
<td>Found in older PCs. Uses a riser card to save space.</td>
</tr>
<tr>
<td>Mini LPX</td>
<td>8-9 X 10-11</td>
<td>Found in older PCs. Uses a riser card to save space.</td>
</tr>
<tr>
<td>NLX</td>
<td>8-9 X10-13.6</td>
<td>Found in newer PCs. Setup provides easier access to components.</td>
</tr>
</tbody>
</table>
The Motherboard Components

- The components found on a motherboard can vary depending on its age and level of integration.
- Some motherboards will have more or fewer chips or devices on board.
- These are the most common items found on a typical modern motherboard.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expansion Slots</td>
<td>These are receptacles on the motherboard that accept printed circuit boards. All computers have expansion slots that allow additional devices to be added.</td>
</tr>
<tr>
<td>Dip Switches / Jumpers</td>
<td>These devices are used to change various aspects of how the motherboard is configured.</td>
</tr>
<tr>
<td>I/O Support</td>
<td>These are connectors for input and output devices controlled by the main board.</td>
</tr>
<tr>
<td>Internal Busses</td>
<td>Channels for data to move between the devices attached to the system, to the CPU, and its components.</td>
</tr>
<tr>
<td>Chipset</td>
<td>A set of microcircuits that define how much RAM a motherboard can use, the type of RAM chip, cache size and speed, processor types and speeds, and the types of expansion slots the motherboard can accommodate.</td>
</tr>
<tr>
<td>CPU Interface</td>
<td>The socket or slot that the CPU connects to on the motherboard.</td>
</tr>
</tbody>
</table>
The CPU:

- Often referred to as the brains of a computer, the CPU contains two basic components

  **Control unit** – Instructs the rest of the computer system on how to follow a program instructions.

  **Arithmetic/Logic Unit (ALU)** – The ALU performs both arithmetic and logical operations. Arithmetic operations are fundamental math operations.
The CPU (cont.)

- The processor handles most of the operations that are required of the computer by processing instructions and sending signals out, checking for connectivity, and ensuring that operations and hardware are functioning properly.

- It acts as a messenger to major components such as RAM, the monitor, and disk drives.
The CPU (cont.)

- Terminology like socket 7, socket 370, socket 423, or Slot1, will frequently be encountered.

- Socket X (X being any numerical number) is a descriptive term for the way certain processors plug into a computer motherboard so that it makes contact with the motherboard's built-in circuitry or data bus.

- Slot-type processors had a very brief lifespan (just about a year in the market).

- Intel for its Pentium II processor moved from the socket configuration to a processor packaged in a cartridge that fits into a slot in the motherboard.
The CPU (cont.)

- Pentium processors include Pentium IV, Celeron, Centrino, Core 2 Duo, and many others.

- AMD processors include the Athlon, Sempron, Athlon64 x2, and many others.

- A key difference between the AMD and Intel processors, is that you cannot compare speeds straight across. AMD processor number are followed by numbers that represent a rough equivalent to an Intel processor speed, even though the AMD is actually running at a slower speed.
The CPU (cont.)

Every CPU has a rated speed which indicates the maximum operating speed at which the CPU can reliably operate and execute instructions.

The CPU speed is not controlled by the microprocessor itself, but by an external clock located on the motherboard. The speed of the processor is determined by the frequency of the clock signal.

Three factors determine how much information can be processed at any given time:

The size of the internal bus
The size of the address bus
The processor's speed ratings
The CPU and the Chip Set

Figure 1-11 This motherboard uses two chips in its chip set (notice the bus lines coming from each chip used for communication)
BIOS

• Read only memory (ROM) chips, located on the motherboard, contain instructions that can be directly accessed by the microprocessor.

• Data transfer from ROM is faster than any disk, but slower than RAM.

• Some examples of ROM chips that can be found on the motherboard include BIOS ROM, electrically erasable programmable read-only memory (EEPROM), and Flash ROM.
BIOS (cont.)

- The instructions and data in the ROM chip that control the boot process and the computer hardware are known as the **basic input/output system (BIOS)**, sometimes called firmware.

- The ROM chip that contains the firmware is called the ROM BIOS chip.

- It is also referred to as ROM BIOS, or simply BIOS, and is usually marked “BIOS” on the motherboard.

- The responsibility of the BIOS is to serve as a liaison between the computer operating software and the various hardware components that support it.
EPROM and EEPROM are ROM chips that can be erased and reprogrammed.

Erasable programmable read-only memory (EPROM) is a special type of programmable read-only memory (PROM) that can be erased by shining ultraviolet light through a clear window on top of the chip.

Flash ROMs are special EEPROM chips that have been developed as a result of advancements in EEPROM technology.

Flash ROM holds the firmware, or BIOS, in most new systems.
Expansion Slots

- Expansion slots (sockets) are receptacles on the computer motherboard that accept printed circuit boards.

- Common expansion slots likely to be encountered include the following:
  - Industry Standard Architecture (ISA)
  - Peripheral Component Interconnect (PCI)
  - Accelerated Graphics Port (AGP)
  - PCI Express
Bus Types

- All the basic components of the computer are connected together by communication paths that are referred to as buses.

- There are three major system bus types that can be identified based on the type of information they carry.
  
  address bus (a uni-directional pathway for data flow)
  
  data bus (a bi-directional pathway for data flow)
  
  control bus (carries the control and timing signals needed to coordinate the activities of the entire computer)
RAM

- Random access memory (RAM) is the place in a computer where the OS, application programs, and data in current use are kept so that they can be quickly reached by the processor.
- RAM is considered temporary, or volatile memory.
- The contents of RAM are lost when the computer power is turned off.
- The more RAM a computer has, the more capacity the computer has to hold and process large programs and files.
There are two classes of RAM that are commonly used today. These are Static RAM (SRAM) and Dynamic RAM (DRAM).

SRAM is relatively more expensive, but it is fast and holds data when the power is turned off for a brief period of time. This is useful in such circumstances as an unexpected loss of power. It is used for cache memory.

DRAM is inexpensive and somewhat slow, and requires an uninterrupted power supply to maintain the data. DRAM stores data in tiny capacitor that must be refreshed to maintain the data. Once the power is turned off, the data is lost.
Identifying SIMMs and DIMMs

- A **SIMM** plugs into the motherboard with a 72-pin or 30-pin connector.
- The pins connect to the system bus, creating an electronic path through which memory data can flow to and from other system components.
Identifying SIMMs and DIMMs (cont.)

- A DIMM has two completely different sets of contacts, one on each side of the module. Hence, Dual In-line Memory Module.

- There are many different types of DIMM, with different voltages, number and spacing of notches, and pins ranging from 72 to 240.
Figure 1-14  Types of RAM modules
Monitors/Display Devices

- Monitors are available in different types, sizes, and characteristics. When purchasing a new computer, the monitor may have to be purchased separately.

- Understanding the characteristics of a good monitor will help determine which is best suited for a specific system.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Resolution</th>
<th># of pixels</th>
<th>Rec. Size</th>
<th>Refresh Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>VGA</td>
<td>640 x 480</td>
<td>307,200</td>
<td>14&quot;</td>
<td>60 - 72 HZ</td>
</tr>
<tr>
<td>SVGA</td>
<td>800 x 600</td>
<td>480,000</td>
<td>15&quot;, 17&quot;</td>
<td>75 - 85 HZ</td>
</tr>
<tr>
<td>SVGA</td>
<td>1024 x 728</td>
<td>786,432</td>
<td>17&quot;, 19&quot;</td>
<td>75 - 85 HZ</td>
</tr>
<tr>
<td>XGA</td>
<td>1152 x 864</td>
<td>995,328</td>
<td>17&quot;, 19&quot;, 21&quot;</td>
<td>75 - 85 HZ</td>
</tr>
<tr>
<td>XGA</td>
<td>1280 x 1024</td>
<td>1,310,720</td>
<td>19&quot;, 21&quot;</td>
<td>75 - 85 HZ</td>
</tr>
<tr>
<td>XGA</td>
<td>1600 x 1200</td>
<td>1,920,000</td>
<td>21&quot;</td>
<td>75 - 85 HZ</td>
</tr>
</tbody>
</table>
Monitors/Display Devices (cont.)

The following terms relate to monitors.

• Pixels are picture elements, Dot pitch, refresh rate, Color depth, Video RAM (VRAM)
• Resolution varies based on the number of pixel
• Monitor screen sizes are measured in inches, just like televisions. The most common sizes are 14", 15", 17", 19", and 21" screens
• Most PCs display many colors on the screen. A summary of the most commonly used color depths:
  
  256 colors (8-bit color)
  65,536 colors (16-bit color, also called 65K or HiColor)
  16 million colors (24-bit color, also called True Color)
  4 billion colors (32-bit color, also called True Color)
Video Cards

- The video card or video adapter is the interface between the computer and monitor.
- The video card tells the monitor which pixels to light up, what color the pixels should be and the intensity of the color.
- The display capabilities of a computer depend on both the video adapter and the monitor.
Serial and Parallel Ports

- All peripheral devices that connect to the computer use connectors on the back of the computer known as ports.

- A serial port can be used to connect devices that use a serial interface such as a modem, scanner, mouse, etc.

- A parallel port is a socket on the computer that is used to connect a printer or other peripheral device such as a portable hard disk, tape backup, scanner, or a CD-ROM.
PS/2 Ports/ 6-pin Mini DIN, 5-pin DIN

- PS/2 keyboard or PS/2 mouse ports are used to connect the PC to its keyboard and mouse.
Universal Serial Bus (USB) and FireWire

- The Universal Serial Bus (USB) is an external port and allows user to connect up to 127 external PC peripherals, including USB keyboards, mice, printers, modems, scanners, and external disk drives.

- FireWire, also known as i.LINK or IEEE 1394 is a high-speed, platform-independent communication bus that interconnects digital devices such as digital video cameras, printers, scanners, digital cameras, and hard drives.
IDE and SATA

- The internal hard drive is connected to a disk controller with a cable.
- The hard drive and other devices can use one of two types of interface controllers to work with the computer.
- These include the Enhanced Integrated Drive Electronics (EIDE), and Serial ATA.
- Integrated Drive Electronics (IDE) is a type of hardware interface widely used to connect hard disks, CD-ROMs, and tape drives to a PC.
IDE, SATA (cont.)

- Serial ATA (SATA) is a new standard that will eventually replace IDE.
- IDE transfers data at a max. 100MB/s, and current SATA standards transfer at 150MB/s, with higher speeds on the horizon.
- SATA uses a smaller cable and uses less power than IDE.
- IDE and SATA are compatible with the use of adapters.
Floppy Drives

• A Floppy Disk Drive (FDD) magnetically reads and writes information onto floppy diskettes, which are a form of removable storage media.

• The main drawback to the floppy diskette is that it only holds 1.44 MB of information, although most PCs still have a floppy drive.
The Hard Drive

- The typical HD in a new system is >80GB, 500GB drives are available now
- It stores programs and files, as well as the operating system.
- The HD is being used more and more as an external device for transferring files, or for use in portable devices. (iPod)
The Hard Drive (cont.)

- Disk platters are the actual media on which data is stored in the hard disk drive.

- A hard disk drive typically has two to ten platters. They are usually either 2 ½” or 3 ½” in diameter and are typically constructed of aluminum or a glass-ceramic composite material.

- Platters are stacked with spaces between them on a hub that holds them in position, separate from one another.

- The hub is also called the spindle.
The Hard Drive (cont.)

- There are four important things to look at when purchasing a HD.

  Storage capacity vs. price. Give yourself room for growth, but don’t go for the largest available.

  Speed and buffer size. You should typically go for the fastest standard speed available, such as 7200RPM. The HD should have at least an 8MB buffer.

  Interface. If your motherboard supports SATA, go with a SATA drive.

  Some drives have only a 1 year warranty. Try to find a drive with 2 or 3 years.
CD-ROMs

- A CD-ROM drive is a secondary storage device that reads information stored on a compact disc. The CD-ROM is an optical media.

- They are used for installing programs, running applications that install some of the files to the hard drive, and executing the program by transferring the data from the CD-ROM to memory while the program is running.

- The major components within a CD-ROM drive are the optical head assembly, head actuator mechanism, spindle motor, loading mechanism, connectors and jumpers, and logic board.
CD-ROMs (cont.)

- Data is stored in the form of indentations and bumps on the reflective surface of every CD-ROM disk.
- The indentations are called pits, and the bumps are called lands.
- The most important specification for a CD-ROM drive is its speed, or how fast the disc will spin. The faster the disc spins, the faster the data can be transferred to the computer’s memory.
- Two other important specifications to consider are the access time and data transfer rate.
• The DVD looks like a CD, but the storage capacity is significantly higher.

• For this reason, many software manufacturers are starting to put programs, manuals, and other documentation on one DVD instead of multiple CDs.

• Recordable DVD drives have become standard on computer systems just like the CD drive did.
Backup Hardware

• Tape drives are most commonly used as the device for data backup on a network server disk drive. There are a variety of tape devices that use different tape formats for storing data.

• New USB storage devices can easily save and access 1GB and beyond.
Modems

- Modems are used to connect to remote networks and the internet through dial up networking.
- A modem is a device that converts the digital data used by computers into analog signals that is suitable for transmission over a telephone line, and converts the analog signals back to a digital signal at the destination.
Network Interface Card (NIC)

- A Network Interface Card (NIC), is used to connect a local computer to a group of other computers so they can share data and resources in a networked environment.

- The only NICs that most people will deal with are designed to work with Ethernet protocols.
Network Interface Card (NIC) cont.

- NICs come in form of expansion cards (PCI or ISA) that can be installed in one of the computers expansion slots.
- The network cable plugs into the computer through the adapter card or NIC.
- These network cables, or patch cables, have 8 conductors and RJ-45 connectors at each end.
Firewalls/Routers

• A hardware firewall is a device that sits between your computer and your internet provider.

• The firewall essentially makes your computer invisible to any computers that it hasn’t initiated contact with.

• Without a firewall, your computer can be compromised literally seconds after being connected to the internet.
Wireless Access Points

- Radio signals are used in wireless networking technologies to enable computers to broadcast their information to one another using.
- A wireless access point is utilized so that computers in a client/server network communicate.
- You can purchase hardware firewalls that have built in wireless connectivity, as well as built in print servers.
Purchasing a new PC

• You have three options:
  Buy a pre-built (OEM) PC
  Buy the components and build your own PC
  Buy a barebones PC and add hardware
OEM PC

- Very little research is required.
- PC should work “out of the box”
- Full system warranty
- You don’t have to worry about compatibility
- The components may not be high quality
- You don’t always know what you’re getting
- Dealing with tech support can be frustrating
Build Your Own PC

- You can select all of the components yourself, so you know what you’re getting
- You won’t be spending money on features you don’t want or need
- You will learn more about PCs
- Lots of research is required
- Warranty may be on individual components and not the entire system
- You have to worry about compatibility
- You generally spend more money overall.
Barebones PC

• You can select a basic configuration without too much research

• Options and suggestions are provided that are compatible with your system

• You still have the option of learning the specs of the individual components

• You can still customize certain components, memory, HD, CPU
Which option is best?

- It really depends on you and what you want to use your PC for.
- For a simple PC that will only be used for office applications, a simple OEM PC will usually suffice, and be your cheapest option.
- For a midrange user you may want to go with a barebones PC with some low cost hardware, and choose a suitable HD and amount of RAM.
- For a gaming PC you would want to do a lot of research, and most likely build completely from scratch.
Lets go through the BYO process

• Go to a site such as www.ncix.com or www.tigerdirect.ca

• Start with a PC builder or Bare Bones PC, and get familiar with the options

• Research the technologies and read the reviews

• If you aren’t sure what something is or if it’s important, search Google and Wikipedia, or ask in a forum.
• Figure out which features are important to you, and spend your money there
• Make sure the components are all going to work together – don’t be afraid to ask
• You either assemble the components yourself, or you can pay a small fee to have the system built and tested for you
• Enjoy!
Links

- http://www.ncix.com/
- http://www.pctechguide.com
- http://www.tomshardware.com
- http://www.wikipedia.com

- people.okanagan.bc.ca/cmyers/pcinfo.pdf