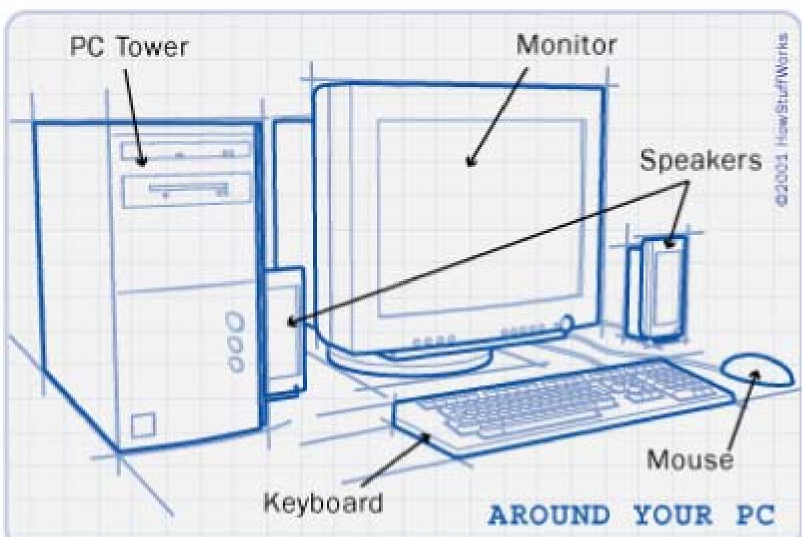
How PCs Work

by Jeff Tyson

When you mention the word "technology," most people think about **computers**. Virtually every facet of our lives has some computerized component. The appliances in our homes have microprocessors built into them, as do our televisions. Even our cars have a computer. But the computer that everyone thinks of first is typically the **personal computer**, or **PC**.



Click on the various parts of the PC to learn more about how they work.

A PC is a general purpose tool built around a microprocessor. It has lots of different parts -- memory, a hard disk, a modem, etc. -- that work together. "General purpose" means that you can do many different things with a PC. You can use it to type documents, send e-mail, browse the Web and play games.

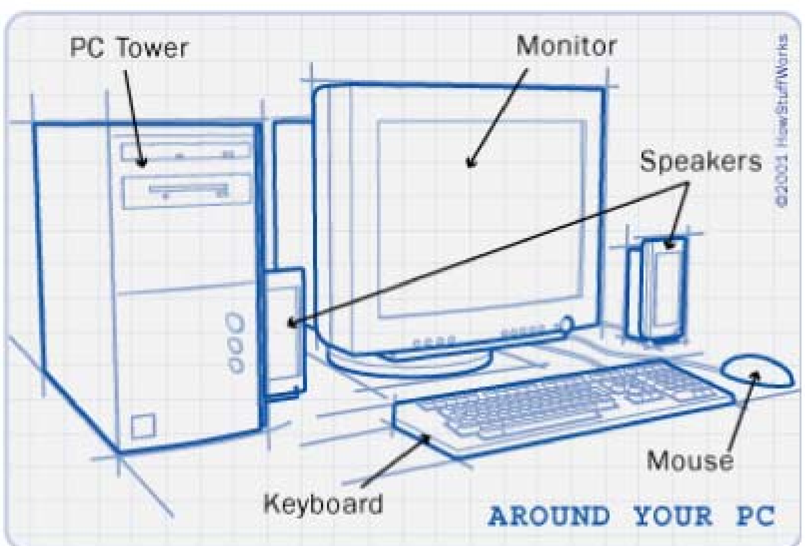
In this edition of **HowStuffWorks**, we will talk about PCs in the general sense and all the different parts that go into them. You will learn about the various components and how they work together in a basic operating session. You'll also find out what the future may hold for these machines.

On the Inside

Let's take a look at the main components of a typical desktop computer.

- Central processing unit (CPU) - The microprocessor "brain" of the computer system is called the central processing unit. Everything that a computer does is overseen by the CPU.

- Memory - This is very fast storage used to hold data. It has to be fast because it connects directly to the microprocessor. There are several specific types of memory in a computer:
  - Random-access memory (RAM) - Used to temporarily store information that the computer is currently working with
  - Read-only memory (ROM) - A permanent type of memory storage used by the computer for important data that does not change
  - Basic input/output system (BIOS) - A type of ROM that is used by the computer to establish basic communication when the computer is first turned on
  - Caching - The storing of frequently used data in extremely fast RAM that connects directly to the CPU
  - Virtual memory - Space on a hard disk used to temporarily store data and swap it in and out of RAM as needed



Click on the various PC part labels to learn more about how they work.

- Motherboard - This is the main circuit board that all of the other internal components connect to. The CPU and memory are usually on the motherboard. Other systems may be found directly on the motherboard or connected to it through a secondary connection. For example, a sound card can be built into the motherboard or connected through PCI.

- Power supply - An electrical transformer regulates the electricity used by the computer.

Defining a PC

Here is one way to think about it: A PC is a **general-purpose** information processing device. It can take information from a person (through the keyboard and mouse), from a device (like a floppy disk or CD) or from the network (through a modem or a network card) and process it. Once processed, the

- Hard disk - This is large-capacity permanent storage used to hold information such as programs and documents.
- Operating system - This is the basic software that allows the user to interface with the computer.
- Integrated Drive Electronics (IDE) Controller - This is the primary interface for the hard drive, CD-ROM and floppy disk drive.
- Peripheral Component Interconnect (PCI) Bus - The most common way to connect additional components to the computer, PCI uses a series of **slots** on the motherboard that PCI cards plug into.
- SCSI - Pronounced "scuzzy," the **small computer system interface** is a method of adding additional devices, such as hard drives or scanners, to the computer.

information is shown to the user (on the monitor), stored on a device (like a hard disk) or sent somewhere else on the network (back through the modem or network card).

We have lots of special-purpose processors in our lives. An MP3 Player is a specialized computer for processing MP3 files. It can't do anything else. A GPS is a specialized computer for handling GPS signals. It can't do anything else. A Gameboy is a specialized computer for handling games, but it can't do anything else. A PC can do it all because it is general-purpose.

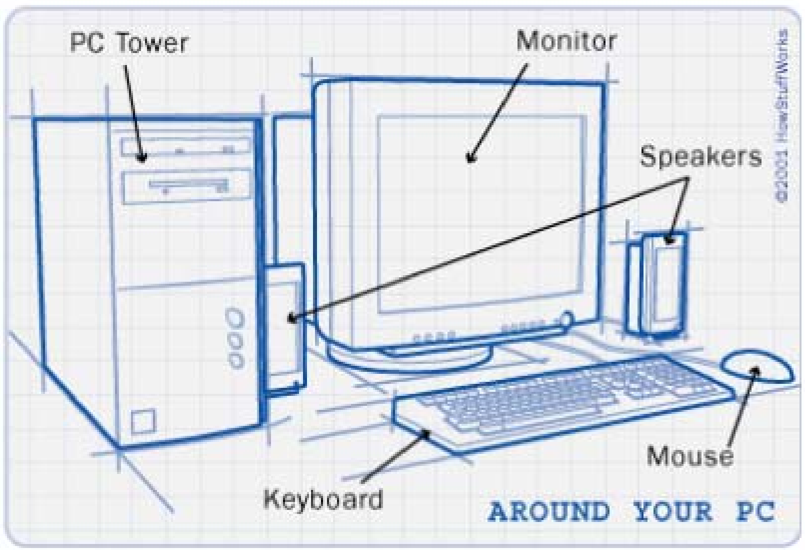
- AGP - **Accelerated Graphics Port** is a very high-speed connection used by the graphics card to interface with the computer.
- Sound card - This is used by the computer to record and play audio by converting analog sound into digital information and back again.
- Graphics card - This translates image data from the computer into a format that can be displayed by the monitor.

Connections

No matter how powerful the components inside your computer are, you need a way to interact with them. This interaction is called **input/output** (I/O). The most common types of I/O in PCs are:

- **Monitor** - The monitor is the primary device for displaying information from the computer.
- **Keyboard** - The keyboard is the primary device for entering information into the computer.
- **Mouse** - The mouse is the primary device for navigating and interacting with the computer
- **Removable storage** - Removable storage devices allow you to add new information to your computer very easily, as well as save information that you want to carry to a different location.
  - Floppy disk - The most common form of removable storage, floppy disks are extremely inexpensive and easy to save information to.
  - CD-ROM - CD-ROM (compact disc, read-only memory) is a popular form of distribution of commercial software. Many systems now offer **CD-R** (recordable)

and **CD-RW** (rewritable), which can also record.
- Flash memory - Based on a type of ROM called **electrically erasable programmable read-only memory** (EEPROM), Flash memory provides fast, permanent storage. CompactFlash, SmartMedia and PCMCIA cards are all types of Flash memory.
- DVD-ROM - DVD-ROM (digital versatile disc, read-only memory) is similar to CD-ROM but is capable of holding much more information.



Click on the various PC part labels to learn more about how they work.

- **Ports**
  - Parallel - This port is commonly used to connect a printer.
  - Serial - This port is typically used to connect an external modem.
  - Universal Serial Bus (USB) - Quickly becoming the most popular external connection, USB ports offer power and versatility and are incredibly easy to use.
  - FireWire (IEEE 1394) - FireWire is a very popular method of connecting digital-video devices, such as camcorders or digital cameras, to your computer.

- **Internet/network connection**
  - Modem - This is the standard method of connecting to the Internet.
  - Local area network (LAN) card - This is used by many computers, particularly those in an Ethernet office network, to connected to each other.
  - Cable modem - Some people now use the cable-television system in their home to connect to the Internet.
  - Digital Subscriber Line (DSL) modem - This is a high-speed connection that works over a standard telephone line.
  - Very high bit-rate DSL (VDSL) modem - A newer variation of DSL, VDSL requires that your phone line have fiber-optic cables.

From Power-up to Shut-down

Now that you are familiar with the parts of a PC, let's see what happens in a typical computer session, from the moment you turn the computer on until you shut it down:

1. You press the "On" button on the computer and the monitor.

2. You see the **BIOS** software doing its thing, called the **power-on self-test** (POST). On many machines, the BIOS displays text describing such data as the amount of memory installed in your computer and the type of hard disk you have. During this boot sequence, the BIOS does a remarkable amount of work to get your computer ready to run.

   - The BIOS determines whether the video card is operational. Most video cards have a miniature BIOS of their own that initializes the memory and graphics processor on the card. If they do not, there is usually video-driver information on another ROM on the motherboard that the BIOS can load.

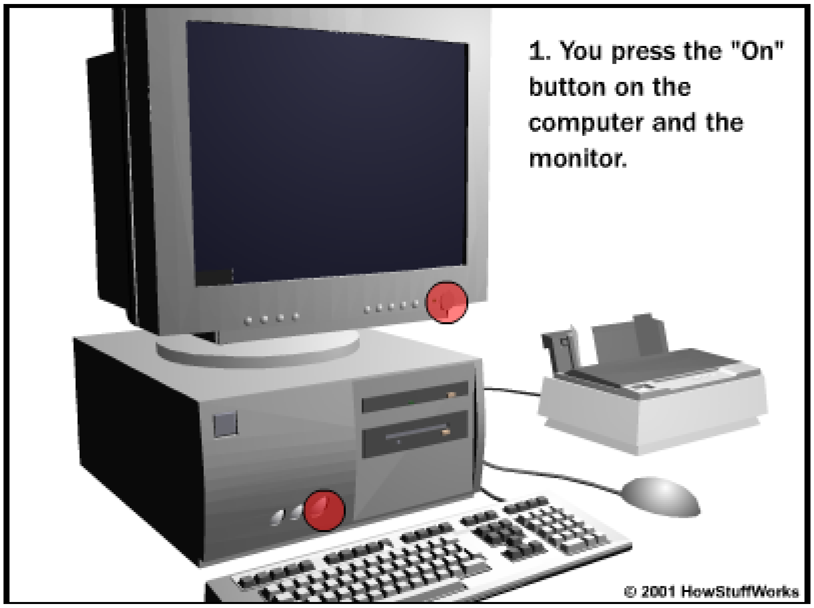
   - The BIOS checks to see if this is a cold boot or a reboot. It does this by checking the value at memory address 0000:0472. A value of 1234h indicates a reboot, in which case the BIOS skips the rest of POST. Any other value is considered a cold boot.

   - If it is a cold boot, the BIOS verifies RAM by performing a read/write test of each memory address. It checks for a keyboard and a mouse. It looks for a PCI bus and, if it finds one, checks all the PCI cards. If the BIOS finds any errors during the POST, it notifies you with a series of beeps or a text message displayed on the screen. An error at this point is almost always a hardware problem.

   - The BIOS displays some details about your system. This typically includes information about the following:
     - Processor
     - Floppy and hard drive
     - Memory
     - BIOS revision and date
     - Display

   - Any special drivers, such as the ones for SCSI adapters, are loaded from the adapter and the BIOS displays the information.

   - The BIOS looks at the sequence of storage devices identified as boot devices in the CMOS Setup. "Boot" is short for "bootstrap," as in the old phrase "Lift yourself up by your bootstraps." Boot refers to the process of launching the operating system. The BIOS tries to initiate the boot sequence from the first device using the **bootstrap loader**.



This animation walks you through a typical PC session.

3. The **bootstrap loader** loads the **operating system** into memory and allows it to begin operation. It does this by setting up the divisions of memory that hold the operating system, user information and applications. The bootstrap loader then establishes the data structures that are used to communicate within and between the sub-systems and applications of the computer. Finally, it turns control of the computer over to the operating system.

4. Once loaded, the operating system's tasks fall into six broad categories:
   - Processor management - Breaking the tasks down into manageable chunks and prioritizing them before sending to the CPU
   - Memory management - Coordinating the flow of data in and out of RAM and determining when virtual memory is necessary
   - Device management - Providing an interface between each device connected to the computer, the CPU and applications
   - Storage management - Directing where data will be stored permanently on hard drives and other forms of storage
   - Application Interface - Providing a standard communications and data exchange between software programs and the computer
   - User Interface - Providing a way for you to communicate and interact with the computer

5. You open up a word processing program and type a letter, save it and then print it out. Several components work together to make this happen:
   - The keyboard and mouse send your input to the operating system.
   - The operating system determines that the word-processing program is the active program and accepts your input as data for that program.
   - The word-processing program determines the format that the data is in and, via the operating system, stores it temporarily in RAM.
   - Each instruction from the word-processing program is sent by the operating system to the CPU. These instructions are intertwined with instructions from other programs that the operating system is overseeing before being sent to the CPU.

- All this time, the operating system is steadily providing display information to the graphics card, directing what will be displayed on the monitor.
- When you choose to save the letter, the word-processing program sends a request to the operating system, which then provides a standard window for selecting where you wish to save the information and what you want to call it. Once you have chosen the name and file path, the operating system directs the data from RAM to the appropriate storage device.
- You click on "Print." The word-processing program sends a request to the operating system, which translates the data into a format the printer understands and directs the data from RAM to the appropriate port for the printer you requested.

6. You open up a Web browser and check out **HowStuffWorks**. Once again, the operating system coordinates all of the action. This time, though, the computer receives input from another source, the Internet, as well as from you. The operating system seamlessly integrates all incoming and outgoing information.

7. You close the Web browser and choose the "Shut Down" option.

8. The operating system closes all programs that are currently active. If a program has unsaved information, you are given an opportunity to save it before closing the program.

9. The operating system writes its current settings to a special configuration file so that it will boot up next time with the same settings.

10. If the computer provides software control of power, then the operating system will completely turn off the computer when it finishes its own shut-down cycle. Otherwise, you will have to manually turn the power off.

The Future of Computing

Silicon microprocessors have been the heart of the computing world for more than 40 years. In that time, microprocessor manufacturers have crammed more and more electronic devices onto microprocessors. In accordance with **Moore's Law**, the number of electronic devices put on a microprocessor has doubled every 18 months. Moore's Law is named after Intel founder Gordon Moore, who predicted in 1965 that microprocessors would double in complexity every two years. Many have predicted that Moore's Law will soon reach its end because of the physical limitations of silicon microprocessors.

The current process used to pack more and more transistors onto a chip is called **deep-ultraviolet lithography** (DUVL), which is a photography-like technique that focuses light through lenses to carve circuit patterns on silicon wafers. DUVL will begin to reach its limit around 2005. At that time, chipmakers will have to look to other technologies to cram more transistors onto silicon to create more powerful chips. Many are already looking at extreme-ultraviolet lithography (EUVL) as a way to extend the life of silicon at least until the end of the decade. EUVL uses mirrors instead of lenses to focus the light, which allows light with shorter wavelengths to accurately focus on the silicon wafer. To learn more about EUVL, see How EUV Chipmaking Works.

As the computer moves off the desktop and becomes our constant companion, augmented-reality displays will overlay computer-generated graphics to the real world.

Beyond EUVL, researchers have been looking at alternatives to the traditional microprocessor design. Two of the more interesting emerging technologies are **DNA computers** and **quantum computers**.

DNA computers have the potential to take computing to new levels, picking up where Moore's Law leaves off. There are several advantages to using DNA instead of silicon:

- As long as there are cellular organisms, there will be a supply of DNA.
- The large supply of DNA makes it a cheap resource.
- Unlike traditional microprocessors, which are made using toxic materials, DNA biochips can be made cleanly.
- DNA computers are many times smaller than today's computers.

DNA's key advantage is that it will make computers smaller, while at the same time increasing storage capacity, than any computer that has come before. One pound of DNA has the capacity to store more information than all the electronic computers ever built. The computing power of a teardrop-sized DNA computer, using the DNA logic gates, will be more powerful than the world's most powerful supercomputer. More than 10-trillion DNA molecules can fit into an area no larger than 1 cubic centimeter (.06 $inch^3$). With this small amount of DNA, a computer would be able to hold 10 terabytes (TB) of data and perform 10-trillion calculations at a time. By adding more DNA, more calculations could be performed.

Unlike conventional computers, DNA computers could perform calculations simultaneously. Conventional computers operate linearly, taking on tasks one at a time. It is parallel computing that will allow DNA to solve complex mathematical problems in hours -- problems that might take electrical computers hundreds of years to complete. You can learn more about DNA computing in How DNA Computers Will Work.

Today's computers work by manipulating bits that exist in one of two states: 0 or 1. Quantum computers aren't limited to two states; they encode information as quantum bits, or **qubits**. A qubit can be a 1 or a 0, or it can exist in a **superposition** that is simultaneously 1 and 0 or somewhere in between. Qubits represent atoms that are working together to serve as computer memory and a microprocessor. Because a quantum computer can contain these multiple states simultaneously, it has the potential to be millions of times more powerful than today's most powerful supercomputers. A 30-qubit quantum computer would equal the processing power of a conventional computer capable of running at 10 **teraops**, or trillions of operations per second. Today's fastest supercomputers have achieved speeds of about 2 teraops. You can learn more about the potential of quantum computers in How Quantum Computers Will Work.

Photo courtesy IBM

By the end of the decade, we could be wearing our computers instead of sitting in front of them.

Already we are seeing powerful computers in non-desktop roles. Laptop computers and personal digital assistants (PDAs) have taken computing out of the office. Wearable computers built into our clothing and jewelry will be with us everywhere we go. Our files will follow us while our computer provides constant feedback about our environment. Voice- and handwriting-recognition software will allow us to interface with our computers without using a mouse or keyboard. Magnetic RAM and other innovations will soon provide our PC with the same instant-on accessibility that our TV and radio have.

One thing is an absolute certainty: The PC will evolve. It will get faster. It will have more capacity. And it will continue to be an integral part of our lives.

For more information, check out the links on the next page.

Lots More Information!

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