

Introduction to Computer Science

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What is Computer Science?

The definition of *computer science* could be derived from many sources, each of which could sound somewhat different but all of which will probably include similar main points. Jennifer Streubel, Program Coordinator of the Department of Computer Science at Boston University (2003) defines the term as:

Computer Science is the systematic study of the feasibility, structure, expression, and mechanization of the methodical processes (or algorithms) that underlie the acquisition, representation, processing, storage, communication of, and access to information, whether such information is encoded in bits and bytes in a computer memory or transcribed in genes and protein structures in a human cell. The fundamental question underlying all of computing is: what computational processes can be efficiently automated and implemented?

Peter Denning (2005) explained the term as:

Computer science is a discipline that spans theory and practice. It requires thinking both in abstract terms and in concrete terms. The practical side of computing can be seen everywhere. Nowadays, practically everyone is a computer user, and many people are even computer programmers. Getting computers to do what you want them to do requires intensive hands-on experience. But computer science can be seen on a higher level, as a science of problem solving. Computer scientists must be adept at modeling and analyzing problems. They must also be able to design solutions and verify that they are correct. Problem solving requires precision, creativity, and careful reasoning.

Computer science also has strong connections to other disciplines. Many problems in science, engineering, health care, business, and other areas can be solved effectively with computers, but finding a solution requires both computer science expertise and knowledge of the particular application domain. Thus, computer scientists often become proficient in other subjects.

Finally, computer science has a wide range of specialties. These include computer architecture, software systems, graphics, artificial intelligence, computational science, and software engineering. Drawing from a common core of computer science knowledge, each specialty area focuses on particular challenges.

Both of these definitions include the concept of diversified application of logic and technology. So, a computer scientist could be an expert in any of a myriad of specialties.

A web page listing of some careers in computer science appears on the next page. It is plain to see that, as computers permeate our everyday lives, they have given rise to numerous career possibilities.

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Computer Career Descriptions

[Animator - Computer](#)
[Business and Information Systems Careers](#)
[Careers in Computing](#)
[Careers in Information Technology](#)
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[Cisco Career Paths and Certification](#)
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[Computer Information Systems](#)
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[Computer Programmer](#)
[Computer Programmers](#)
[Computer Science and Engineering Careers](#)
[Computer Scientists - BLS](#)
[Computer Security Professional](#)
[Computer Service Technician](#)
[Computer Software Engineer](#)
[Computer Software Engineer](#)
[Computer Software Engineer - BLS](#)
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[Software Industry Careers](#)
[Systems Administrators Field](#)
[Systems Analyst](#)
[Systems Analyst](#)
[Systems Operators](#)
[Telecommunications Careers](#)
[Unmanned Vehicle Operations Specialist](#)
[Web Design](#)
[Web Developer](#)
[Web Developer](#)

As this course unfolds, we will attempt to expose students to several of these areas. Hopefully, students will come away with a rudimentary understanding of these areas.

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Parts of a Computer

Computer systems consist of components that provide these services:

- Input
- Output
- Storage
- Power

Input Devices

Input devices are those components that channel information into the computer.

Keyboard

Most keyboards are based upon the typewriter's *QWERTY* design for letters and numbers. Most keyboards also include function key, a number pad, and an editing pad with keys to navigate and edit documents.

Pointing Devices

Pointing devices allow the user to navigate the screen and perform tasks by choosing objects that appear there. Examples are the mouse, trackball, pointing stick, trackpad, and joystick.

Output Devices

Output devices can include monitors, printers, plotters, etc.

CRT

A *CRT* (cathode ray tube), commonly called a monitor, uses the same technology as a standard television. The image is created by "spraying" electrons on specific areas of the tube. It is an inexpensive, dependable option but uses more power than other options.

LCD

A *LCD* (liquid crystal display) produces an image by manipulating light within a layer of liquid crystals. This is the standard display type on notebooks. LCD monitors or *flat screens* are also available for desktop computers. Though more expensive than CRT monitors, they are clearer, emit less radiation, and are more lightweight.

Plasma Screens

With a plasma screen, the image is created by using miniature colored fluorescent lights in a panel-like screen. The term *plasma* refers to the type of gas that fills the fluorescent lights and causes them to light.

NTSC and HDTV Screens

LCD and Plasma screens can be fitted with NTSC (standard TV) and HDTV (High Definition TV) circuitry to accept TV signals from cable or an antenna to show both data and TV.

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Which Display Type to Choose

Monitor quality is a function of these factors:

- **Dot Pitch** (dp) is the distance between pixels (the dots on the screen that compose the image) on the screen. The smaller the dot pitch, the crisper the image. Today's monitors utilize a dot pitch of between .23 and .26 millimeters.
 - **Viewable Image Size** (vi) is the size of the area of the screen in which the image exists. The image on most displays does not go all the way to the edge of the screen and so the viewable image size is the **diagonal measurement** in inches from the bottom of the image on one side to the top of the image on the other side.
 - **Viewing Angle Width** is an indication of how far to the side you can stand without experiencing difficulty in seeing the image. Graphic designers prefer CRT monitors because they offer the best viewing angle width. Plasma screens are the next best with regard to this factor.
 - **Refresh Rate** (vertical scan rate) is the speed at which a CRT will refresh its image and is measured in **Cycles Per Second** (or Hertz). A refresh rate of at least 75 hertz will result in a relatively "flicker-free" image. The refresh rate is adjustable with the **Control Panel** in *Windows*.
 - **Color Depth** is the number of colors that a monitor can display. A 24-bit color depth can display over 16 million different colors and is considered photograph quality.
 - **Resolution** is the number of pixels on the screen and is expressed in the number of pixels wide by the number of pixels high. The standard resolution is 1024 x 768. *Windows* allows the user to choose the color depth as well as the resolution from the Control Panel.
 - **VGA** – Video Graphics Array – Used in earlier PCs
 - **SVGA** – Super VGA
 - **XGA** – Extended Graphics Array
 - **SXGA** – Super XGA
 - **UXGA** – Ultra XGA
- } The higher the resolution, the smaller the image appears.
This is because the screen contains more pixels.

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Graphics Card

The connection between the monitor and the computer is the graphics card. Many computers have an *on-board* graphics card that is built into the main (mother) board. Others have a graphics card installed in one of the expansion slots.

Graphics cards include:

- **Graphics Processing Unit (GPU)** – This is the brain that creates the image on the screen
- **Video Memory** – Stores the images before they are displayed
- **Graphics Accelerator** - Assists in speeding up the graphic rendering

Intense gaming and 3-D graphics require plenty of memory. More memory and inclusion of a graphics accelerator will make the graphics card more expensive.

Printers

Ink Jet

- A nozzle-like print head that sprays ink onto the paper
- Use a combination of CMYK colored (Cyan, Magenta, Yellow, and Black) inks
- Outsell all other types of printers because they are relatively inexpensive and create a decent color document
- The usual choice for home computing

Laser

- Paints dots of light on a light-sensitive drum which attracts electrostatically charged ink that is transferred to the paper (Just like a photocopier)
- Most are black and white with colored models available at a slightly higher price
- More expensive than comparably sized ink jets
- Usual choice for business applications

Dot Matrix

- Older technology that uses fine wires to press on an inked ribbon creating characters using these dots
- Most are black and white but some color models are available with a multi-colored ribbon
- Inexpensive to buy and use
- Lower print quality especially with graphics

Solid Ink

- Melts crayon-like ink sticks and sprays it on the paper
- Good colors
- Sometimes used in professional graphic applications

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Thermal Transfer

- Tiny heating elements melt wax from a page-size ribbon onto specially coated paper or transparency film
- Great for overhead transparencies

Dye Sublimation

- Similar process to thermal transfer but uses ink instead of wax
- Probably the best color quality of any type of printer
- Typical cost is \$3 to \$4 dollars per page

Features to Look For In a Printer

- Resolution (density of the dots printed per linear inch)
 - The more dots per inch (dpi) the sharper the image
 - 900 dpi results in a solid appearing image at normal reading distance
 - Book quality resolution is 2400 dpi or greater
- Print Speed
 - Measured in pages per minute (ppm) or characters per minute (cpm)
 - Text pages print more quickly than those with graphics
 - Typical home printer speed is between 6 and 30 pages per minute
- Duty Cycle (How many pages the printer can turn out)
 - Measured in pages per month
 - Typical home laser printer does about 3000 pages per month (ppm)
 - Use this to determine if the printer is heavy duty enough for an application
- Operating Costs
 - The cost of ink, toner, ribbons, paper stock, etc.
 - Projected amount of media and its cost indicates the operating costs
- Duplex Capability (Can it print on both sides of the paper?)
- Memory
 - Computer sends data to the printer including instructions on how to print it
 - Uses Printer Control Language (PCL) or PostScript language
 - Memory determines how much information the printer can store before requiring the next set of commands and data
 - Some printers allow you to add memory

Installing Peripheral Devices

Many devices are connected to the computer via the USB (Universal Serial Bus) port. Most modern computers have at least four of these. Sometimes they are located at the front and sometimes at the back of the computer. Some computers have USB ports at both the front and rear of the box.

Some devices required connection to a card in an **expansion slot** on the bus. There are several types of expansion slots that require their own type of card:

- **AGP** (Accelerated Graphics Port) – Used to insert accelerated graphics cards
- **PCI** (Peripheral Component Interconnect) – Offers speeds of 32 bits or 64 bits. Usually, these are graphics, sound, video, modem, or network interface (NIC) cards.
- **ISA** (Industry Standard Architecture) – Older technology used for older modems and slower devices. Many new computers no longer include ISA slots.



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Storage Components

Storage components hold the data needed or created by the computer. These components include hard disk drives, CDs, DVDs, USB Flash Drives, RAM memory, ROM memory, etc.

RAM (Random Access Memory) Memory

- Temporary storage for data, applications, program instructions, and the operating system
- Typically listed in a computer's specifications when being bought
 - For example: 1 GB 533 MHz SDRAM (max 4GB) – This means that the computer comes with 1 gigabyte of synchronous dynamic RAM operating at 533 megahertz. It has enough RAM slots to accommodate up to 4 gigabytes of RAM.
- RAM is measured either in **megahertz** (higher number is faster than smaller) where 533 MHz is faster than 400 MHz, or it is measured in **nanoseconds** (1 billionth of a second) where a smaller number is faster than a larger number (8 nanoseconds is faster than 10 nanoseconds).
- Types of RAM
 - SDRAM (synchronous dynamic RAM) is the most popular in personal computers that is available in a small circuit board called a DIMM (dual inline memory module)
 - RDRAM (rambus dynamic RAM) which is usually used in high power, high speed computers or video games.
- Computer speed is faster with faster RAM modules and higher amounts of RAM
- RAM is **volatile** which means its contents can change and is lost when power is discontinued

ROM (Read Only Memory) Memory

- ROM holds the computer's startup routine
- It is permanent and not volatile
- Contains a small set of instructions for the computer upon powering up called the ROM BIOS (Basic Input/Output System)
- Is needed because RAM is emptied when power is turned off and the computer needs some instructions to get started

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CMOS (Complementary Metal Oxide Semiconductor Memory) Memory

- Stores the computer's hardware settings
 - Hard drive size
 - Amount of RAM
 - Boot order
 - etc.
- Is not volatile like RAM but is not permanent like ROM either
 - Stored on a small chip
 - Powered by a small battery
 - Settings are lost when the battery is removed or wears out

Magnetic Storage

- Stores data by magnetizing microscopic particles on a tape or disk
- Hard Disk Drives (HDD)
 - **Size** measured in gigabytes (billions of bytes)
 - **Access time** measured in milli-seconds (millionth of a second)
 - Less is faster (Generally 6 – 10 ms.)
 - **Revolutions per Minute** (RPM) measures the time required to position the readers for data writing or retrieving
 - Higher is faster (Generally 7200 RPM is standard)
 - Contain varying types of **controllers** that run drive
 - SATA
 - Ultra ATA
 - EIDE
 - SCSI

} Generally, the manufacturer dictates the controller.
- Floppy Disks
- Backup Tapes
- Data is lost if exposed to magnets, humidity, heat, or human touch
- Data is reliably stored for about 3 years and should be re-saved within this time to avoid losing it
- Data is stored and retrieved with **Read / Write Heads**

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Optical Storage

- Stores data as microscopic light and dark spots
 - Dark spots are called **pits**
 - Light spots are called **lands**
- CDs (700 mb capacity) and DVDs (4.7 gb)
 - CD-DA (Compact Disc – Digital Audio) Typical music CD that cannot be changed by the user
 - DVD-Video (Digital Versatile Disc – Video) Commercial DVDs
 - CD-ROM (Compact Disc – Read Only Memory) Data can be read but is stamped on the disk and cannot be changed
 - DVD-ROM (Digital Video Disc – Read Only Memory) Video data stamped on the disc and cannot be changed
 - CD –R (Compact Disc – Readable) Data can be written to the disc but once written, cannot be changed. Many drives also allow multiple recording sessions on one CD-R disc.
 - DVD+R or DVD-R (Digital Versatile Disc Recordable) Data can be written as CD-R but with the larger DVD capacity
 - CD-RW (Compact Disc – Rewritable) Data can be written, erased, or added to several times
 - DVD+RW or DVD-RW (Digital Versatile Disc Rewritable) Rewritable as per CD-RW but with DVD capacity
- Double Layered DVDs have a capacity of 8.5 gb
- HD-DVDs can store 15 gb
- Blu-Ray DVDs can store 25 gb
- Much less susceptible to data loss than magnetic media
- Data is written and read using a low-power laser
- Estimated data storage of 30 years

Solid State Storage

- Non-volatile, erasable, extremely durable storage
 - USB Flash Drives
 - Card Readers
 - Stores data using pairs of transistors that, like gates, allow or disallow low voltage to flow through them (Presence of power = 1 : Lack of power = 0)
- When unplugged and power is lost, data is permanent but powering up allows editing
- Is more expensive and requires more physical size per unit of data than other types

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Power

The power pack supplies the electrical power to run the computer. It takes 120vac current and transforms it to low voltage dc current. In addition, computers have a battery (usually lithium) that keeps the internal clock and CMOS from losing its information when the power is disconnected.



Processor

The processor executes commands in this order: 1) Fetch the Instruction, 2) Interpret the Instruction, 3) Execute the Instruction, 4) Move pointer to the next instruction.

- Cycle speed may be designated in megahertz (millionth of a second) or gigahertz (billionth of a second)
 - A 3.2 GHz processor operates at 3,200,000,000 cycles per second
- Some chips may designate speed in processor number (PN)
 - A Pentium 570 is faster than a Pentium 560
 - But the PN only takes effect in the same family so an Intel M 755 is not faster than a Pentium 560 because they are in different families
- **Word Size** – The number of bits processed at a time
 - **32 bit** or **64 bit**
 - The processor has either 32 or 64 bit registers

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- **Cache Size** – Amount of quickly accessed data on the processor
- **Instruction Set** – The complexity of the executions
 - **CISC** (Complex Instruction Set Computer) – Includes more complex instructions in its instruction set
 - **RISC** – (Reduced Instruction Set Computer) – Faster processing speed but less complex instructions
 - Some processors have extended instruction sets such as **MMX**, **3DNow**, or **SSE-3**
- Processor Execution Types
 - **Serial Processing** – One instruction at a time
 - **Pipelining** – Begins one instruction before the previous one is completed
 - **Parallel Pipelining** – Multiple instructions are processed at a time
 - **Dual Core Processor** – One chip has circuitry for two processors
- **Celeron vs Pentium** – Celeron is not a powerful but does a decent job at several hundred dollars less
- **AMD Athlon and Opteron** – AMD’s competition to Intel’s Pentium family
- **Which one to choose** – More powerful processors are required for graphics, gaming, etc.

The Processor and Binary Math

Based upon what we know from the IP address subject above, we can now use our binary knowledge and apply it to the way the processor works.

The processor “thinks” in base 2 (binary) math. It can be compared to a series of switches that are either in a state of “on” or “off”. These switches are referred to as **registers**. A register in the *on state* would have a value of one (1). A register in the *off state* would have a value of zero (0). If each character is given an 8-bit binary value, pressing the keyboard key for that character would send this value to the processor which places that character on the screen.

Example:

The letter capital A has a binary value of 65. So, pressing the **shift-A** key combination sends that message to the processor. It turns the registers in the processor holding this character to:

| | | | | | | | |
|------------|-----------|-----------|-----------|----------|----------|----------|----------|
| 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |

Adding up the bits that were turned on (64 and 1) results in a 65.

Networking

A computer network is a number of computers that are connected together. These computers are connected in order to share each other's resources. Resources that could be shared include hard disk drives, CDROM drives, and even diskette drives.

Things that can be shared on a computer network include:

- **Hardware** – The physical machinery involved such as computers and printers etc.
- **Software** – Programs and applications written for use by the hardware.
- **Groupware** – Software accessible to more than one user at a time.
- **Communication** – Email and instant messaging.

Brief History of Computer Networks

The first computer networks created in the 1940's utilized a large computer called a **mainframe**. The mainframes were extremely large, expensive, and slow by today's standards. They did, however allow users to share their computing power so that many users had access to computerized computations. Users sent tasks to the mainframe in the form of **programs**, which are encoded instructions to be carried out. An operator queued or lined these tasks up, submitting them one by one to limit the **downtime** of the mainframe. This worked well to maximize the use of this expensive equipment but was frustrating to **programmers** who sent these jobs because a small error in the code necessitated the resending of the program and thus, another queued wait for a response.

Minicomputers came on the scene in the early 1960's. These computers offered a smaller, cheaper alternative to the mainframe. Though smaller and less expensive to purchase, they were nonetheless very powerful. The minicomputer used a technique called **time sharing** where several tasks were processed simultaneously by allowing small amounts of time to one task, moving to another task and allowing a small amount of time there, and so on until each task was completed. The minicomputer did this so rapidly that the switching of tasks was invisible to the users. It looked to them like the computer was working exclusively on their individual task.

In the late 1970's the **microcomputer** or **PC** was developed. These computers were small enough to sit on a desktop and were as powerful as the first mainframes. As time went by, they became and are still becoming less and less expensive while becoming more and more powerful.

With PCs proliferated throughout desktops everywhere, people gradually harnessed their power to create "personalized" software collections to suit their individual needs. They thought it would be good to be able to share their resources with others as well. Thus was born the **Local Area Network** or **LAN**.

Topologies

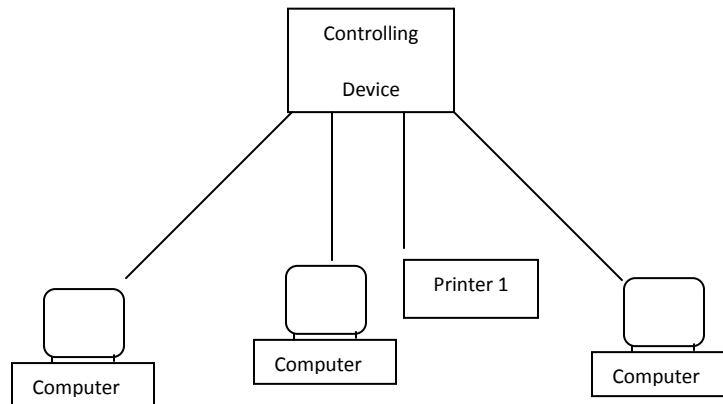
The topology of a network is its physical layout. It depicts the devices on the network and how each is connected via cables.

Multipoint Star Topology

In this topology, each device is attached to a controlling device. This device may be a **hub** or a **switch** and serves to distribute packets to the devices connected to it.

A hub will send packets it receives to **all of the devices** connected to it and all of the devices ignore them **except the device for which they were intended**.

A switch “knows” which device should get the packet and also knows which of its ports is connected to this device. It will send packets **only to that device**.



This type of topology is easiest to troubleshoot and manage. It is also easy to add additional devices and one malfunctioning device will not shut down the entire network. On the other hand, if one of the controlling devices goes down, the entire network or at least an entire portion of the network will go down. It requires a great deal more cable and cable installation is more difficult.

Configuring a PC

Virtually all computers purchased commercially will come with the **operating system** (Windows, Mac, Linux, etc.) already installed. Unfortunately, things happen to computers that require the re-installation of the operating system. One example would be a damaged hard drive. In this case, a new hard drive will have to be partitioned, installed, and the operating system added to it. If your computer is still on warranty, this will be done by a technician designated by the computer company to do this for you. If the computer is no longer on warranty, you will either have to pay to have this done or do it yourself.

Step 1 - Configuring and Installing the Hard Drive

- If the hard drive is new, you will need to **partition** it before it can be used
 - Using **FDISK**

```
FDISK Options

Current fixed disk drive: 1

Choose one of the following:

1. Create DOS partition or Logical DOS Drive
2. Set active partition
3. Delete partition or Logical DOS Drive
4. Display partition information
5. Change current fixed disk drive

Enter choice: [1]

Press Esc to exit FDISK
```

Run FDISK from a CD or, if the computer is older, a diskette.

- Use the options to create a DOS partition
- Then set that partition as active
- Then, restart the computer.

```
Windows XP Home Edition Setup

The following list shows the existing partitions and unpartitioned space on this computer.

Use the UP and DOWN ARROW keys to select an item in the list.

• To set up Windows XP on the selected item, press ENTER.
• To create a partition in the unpartitioned space, press C.
• To delete the selected partition, press D.

4095 MB Disk 0 at Id 0 on bus 0 on atapi [MBR]
  Unpartitioned space          4095 MB

ENTER=Install  C=Create Partition  F3=Quit
```

- Using the WINDOWS CD:
- Place the Windows XP CD in the CD drive and upon booting from the CD;
- Choose the option to **create a partition in the unpartitioned space**. Here, you can choose the size of the partition

Step 2 – Installing the Operating System on the Partition



The resulting dialog will keep you informed as to the progress of the Windows installation.



As the installation proceeds, you will need to enter the **key code** for your Windows installation

The key code will be found in or on the Windows CD jacket.

Without this key code, you cannot continue installing the operating system.

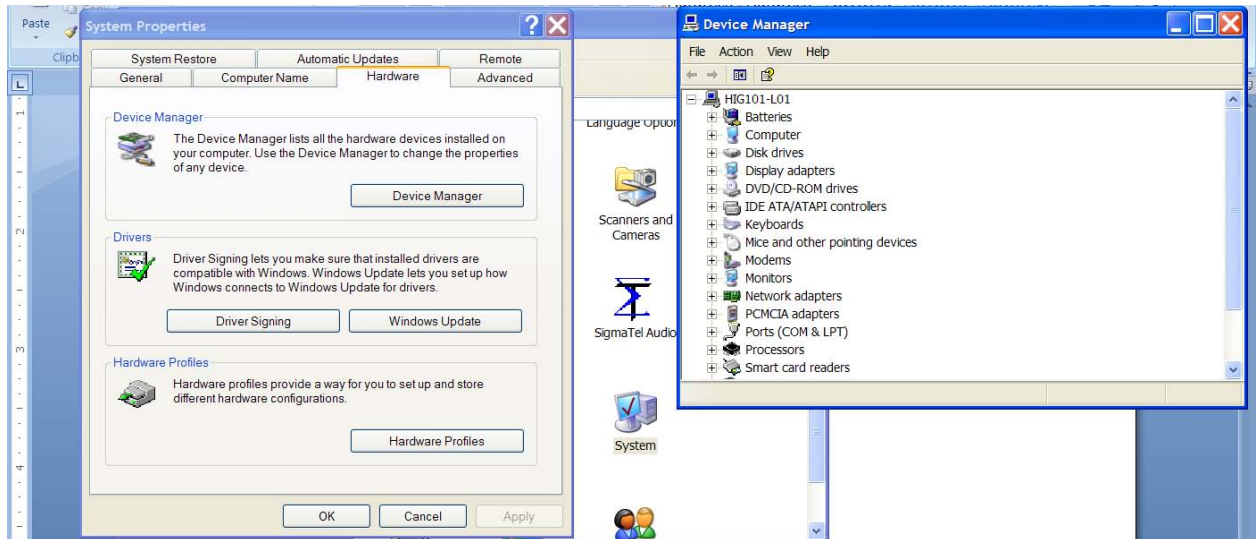
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Step 3 – Installing the Hardware Drivers

After Windows is installed, you will want to update drivers for your hardware. These files usually come on CD's that accompany the computer. Usually, inserting the CD into the drive will launch the installation program and the software will “talk” you through the steps.

Opening the **Control Panel – System Tool – Hardware Tab – Device Manager** will display all of the devices and tell you if any of them are not installed properly.

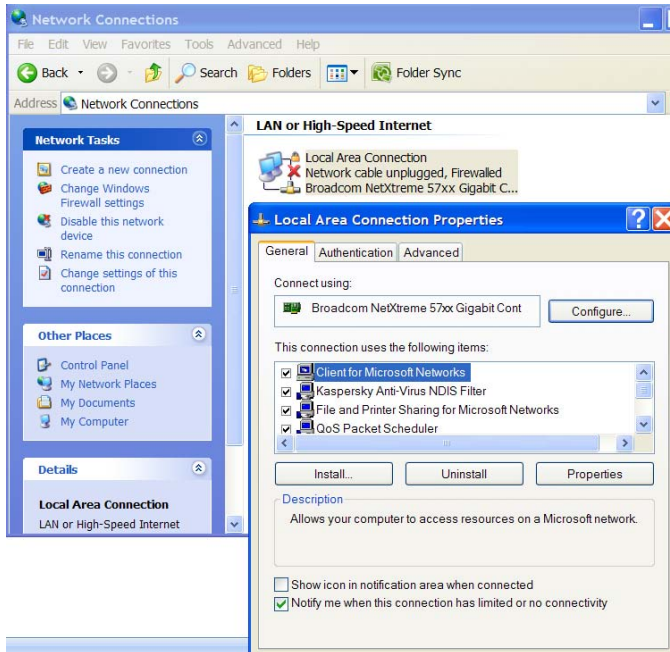


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Step 4 – Getting the Computer Ready for Networking

There are various ways of configuring a network. More experienced users may want to set up a TCP/IP network. Windows comes with its own networking protocol labeled *Client for Microsoft Networks*.

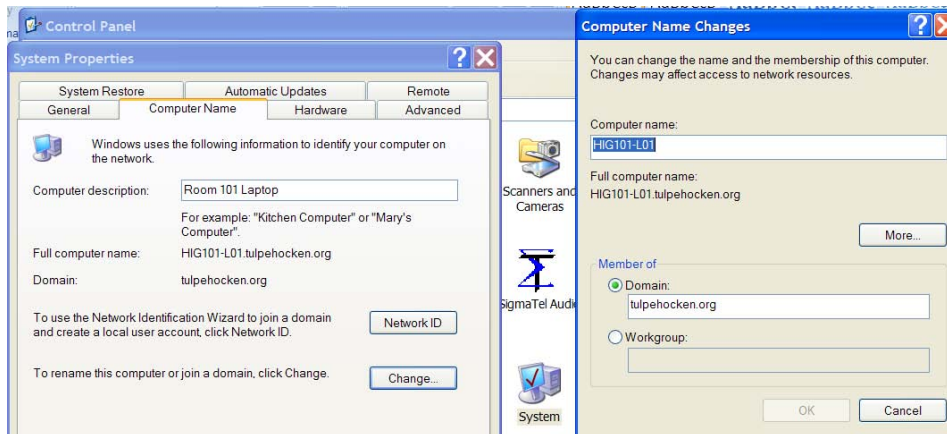


Use the **Control Panel – Network Connections** combination to access the network connections area.

Choose to **create a new connection** and name it.

Double clicking on the new connection makes the installed software for the connection appear. One of the tools should be the **Client for Microsoft Networks**.

In order for several computers to communicate with each other they **MUST BE ON THE SAME WORKGROUP**.



Choose the **Control Panel – System – Computer Name** options and then press the **Change** button. Choose the **Workgroup** option and name it. **ALL COMPUTERS IN THIS NETWORK MUST**

HAVE THE SAME WORKGROUP NAME.

Connecting to the Network

Now that the computer is set up, we need to connect it to the network. This can be done in several ways. Today, many home networks connect via a wireless system where the only “hard wired” connection is between the router and the modem connecting to the Internet.

If you are going hard-wired, you need to buy or make **Ethernet** cables to connect all devices to a **hub** or **switch** that connects to the **router** and, in turn, connects to the Internet modem. The connections from each device are accomplished via a **Network Interface Card** or **NIC** card.

If you already have several computers networked in your home, you can create a wireless network with a wireless access point. If you have several computers that are not networked, or if you want to replace your Ethernet network, you'll need a wireless router. This is a single unit that contains:

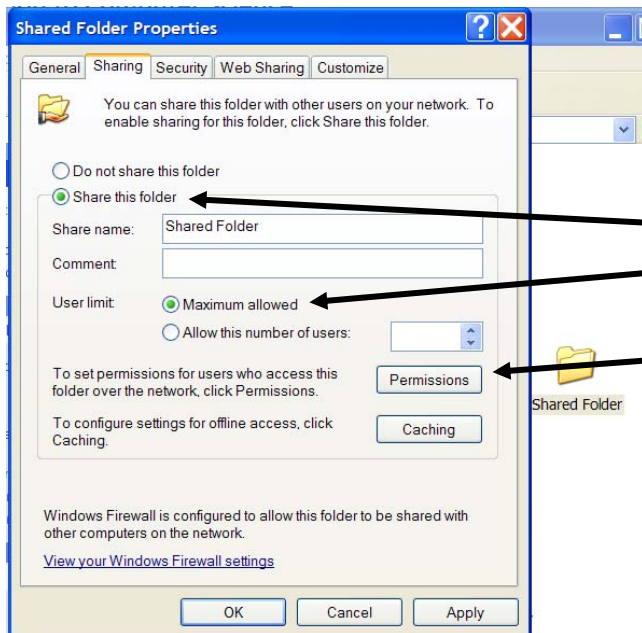
1. A port to connect to your cable or DSL modem
2. A router
3. An Ethernet hub
4. A firewall
5. A wireless access point

A wireless router allows you to use wireless signals or Ethernet cables to connect your computers to one another, to a printer and to the Internet. Most routers provide coverage for about 100 feet (30.5 meters) in all directions, although walls and doors can block the signal. If your home is very large, you can buy inexpensive range extenders or repeaters to increase your router's range.

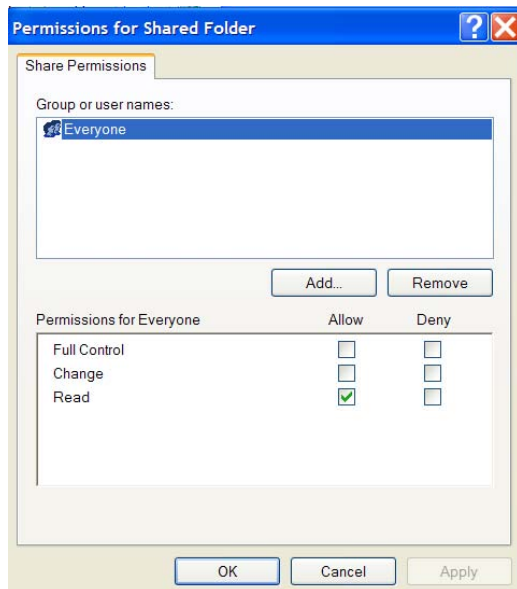
You need to have a **wireless transmitter** installed on any device that you wish to connect to the network.

Preparing a Shared Folder

To this point, we have built our computer, installed the operating system, and given it the same workgroup name as all of the computers in the network. Before anything can be shared within the network, it is necessary to designate a **SHARED FOLDER** and give permissions for others to access it.



- Create the folder
- Right-Click it and choose the **PROPERTIES** option
- Choose the **Share this folder** option
- Choose the **Number of users** you want
- Click the **Permissions** button to set permissions for others who share the folder



- Here, you can choose to give others any of the following permissions:
 - **Read** – Visitors can only see and open files but cannot change any of them (cannot write to the folder)
 - **Change** – Visitors can change any files in the folder
 - **Full Control** – Visitors can read, write, and delete anything in the folder and can add additional sub-folders and delete them as well

At this point, if the setup sequence was successful, the shared folders should be accessible to all devices in the workgroup and the Internet should be available (assuming Internet access has been previously purchased from an ISP such as Comcast, Netzero, AOL, etc.).