

Hardware and Software

A computer system is made up of a combination of hardware and software.

Hardware:

All of the electronic and mechanical equipment in a computer is called the hardware. Examples include:

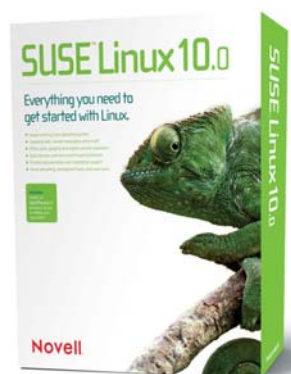
- **Motherboard**
- **Hard disk**
- **RAM**
- **Power supply**
- **Processor**
- **Case**
- **Monitor**
- **Keyboard**
- **Mouse**



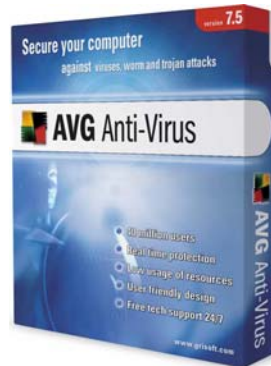
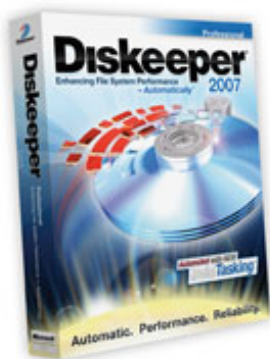
Software:

The term software is used to describe computer programs that perform a task or tasks on a computer system. Software can be grouped as follows:

- **System software:** These are the programs that control the operation of the computer system. Operating systems and utility programs are the most common. The Operating System starts the computer, provides a user interface, manages the computer memory, manages storage, manages security and provides networking and internet facilities to mention a few of its capabilities. There are many OS's on the market including Microsoft Windows XP, Microsoft Windows Vista, Apple OS X, Unix and Linux. Windows is by far the most commonly used OS in the world, but Linux in particular, is making inroads into this dominance.

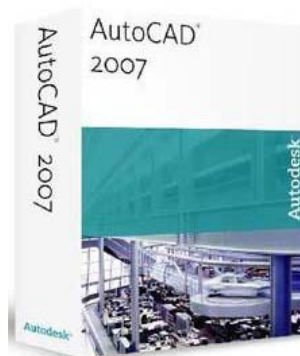


Utility programs perform maintenance tasks on the computer system. This includes file management programs, uninstall programs, disk scanners and defragmenters, backup utilities, antivirus etc. These can be included in the OS or purchased separately.



Device drivers are programs that control particular hardware devices. They are supplied with new hardware and must be run so they the hardware can communicate with the OS. They are supplied with printers, graphics cards, scanners etc.

- **Application Software:** This software is used to do non-system based tasks. Categories include business software, engineering software, medical software, games etc.



- Sometimes, application software packages are grouped together to form **productivity suites**. Examples include Microsoft Office and OpenOffice. These combine word processing, spreadsheet, database and presentation software with a common interface making them easier to learn. The Adobe Creative suite combines Adobe Photoshop, Adobe Illustrator, Adobe InDesign etc. as an all-in-one graphics and web design suite. As well as common interfaces, these suites offer great compatibility between the applications.

PC Components

A **computer system** is a collection of electronic and mechanical devices operating as a unit. These devices can be sorted according to the role they play in the computer system. The main device categories are:

Input devices	These devices are used to get data into the computer system
Processing devices	These manipulate the data using to a set of instructions called a program
Output devices	These are used to get data out of a computer system
Storage devices	The can store the data for use at a later stage
Communications devices	These can send the data to another computer system

The main parts of a computer system are:



1	System Unit	The container for the motherboard, disk drives etc.
2	Monitor	The main output device for the system.
3	Keyboard	The main input device for the system
4	Mouse	An input device allowing interaction with the system using pointing and clicking
5	Speakers	Used to output sounds and music from the system

System Unit Devices and Peripherals

The **system unit** is the main container for system devices. It protects the delicate electronic and mechanical devices from damage. Typical system unit devices include:

- Motherboard
- CPU (Processor)
- Memory
- Disk drives
- Expansion cards - sound card, graphics card, network card etc.
- Ports - USB etc.
- Power supply



Peripherals are devices that connect to the system unit using cables or wireless technologies. Typical peripherals include:

- Monitor
- Keyboard
- Mouse
- Speakers
- Printer
- Plotter
- Scanner

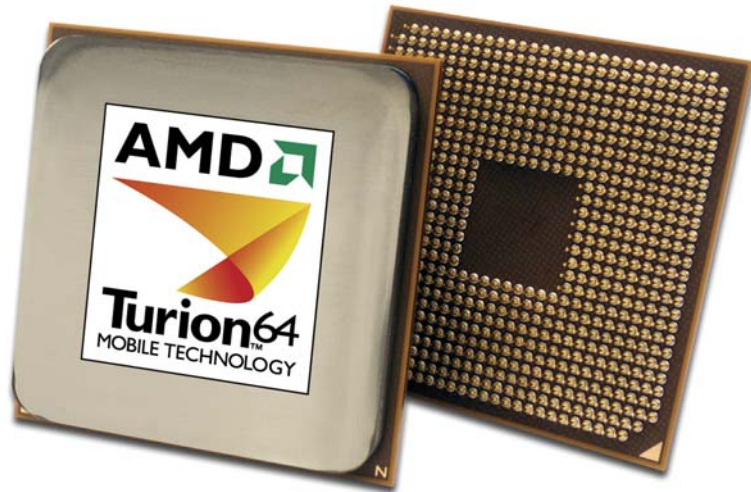


Plotter

System Unit Devices

The Processor (CPU)

A processor is an **integrated circuit (IC)** supplied on a single silicon chip. All of the components and pathways necessary for the movement of data around the processor are etched on this single chip.



**AMD
Processor**

The processor's function is to control the activities of the computer system. A computer program is made up of instructions and when the program is run, the processor is responsible for carrying out these instructions in an orderly fashion. The type of instructions the processor can execute includes:

- Arithmetic instructions - It carries out all the addition, subtraction, multiplication and division requested by computer programs.
- Logical instructions - It can make decisions by comparing data and acting in a particular way depending on the result.
- Move operations - It can move data from place to place within the computer system. This could be from memory to the processor for addition or from memory to a printer or disk drive etc.

The speed of a processor is measured in megahertz (**MHz**) or Gigahertz (**GHz**). This is the speed of the system clock (**clock speed**) within the processor and it controls how fast instructions can be executed:

- 1 MHz - One **million** clock ticks every second
- 1 GHz - One **billion** clock ticks every second

This means that if one instruction was executed every clock tick, a **3GHz** processor could execute **three billion** instructions every second.

The two main computer processor manufacturers are **Intel** and **Advanced Micro Devices (AMD)**. These two companies produce almost all of the processors used in desktop and notebook computers.

- **Intel** - Intel makes the **Pentium** and **Centrino** ranges of processors.
- **AMD** - AMD makes the **Athlon** and **Turion** ranges of processors.

The performance of these chips relative to each other is forever changing and it would be difficult to claim one is better than the other in the long term.

The latest trend in processor manufacture is to essentially put more than one processor on a silicon chip. These **multi-core** processors can have two, three or four processor cores on a single chip. This obviously vastly increases the performance of the computer system as long as the programs run on the systems can take advantage of the multi-cores.



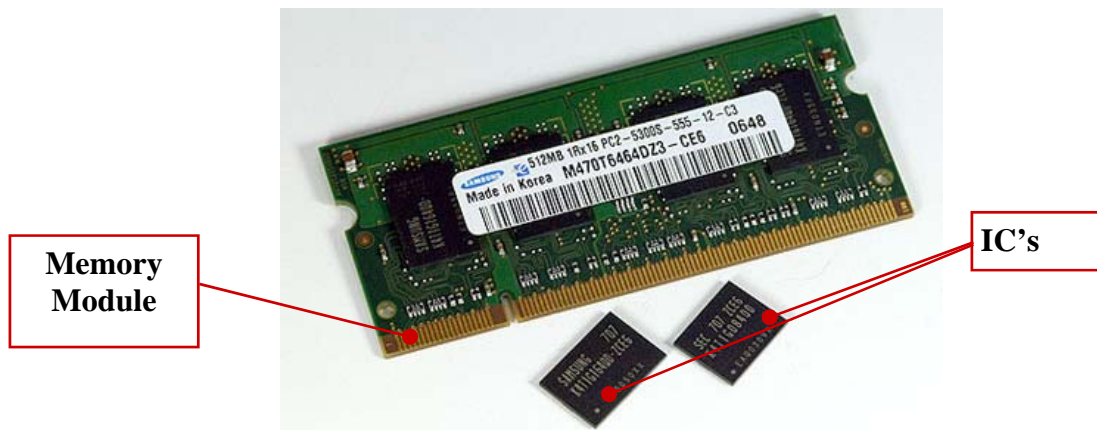
Another important factor in processor choice is the amount of power a processor consumes. This is not critical on a desktop computer but is critical on a notebook computer. AMD and Intel have developed a range of processors optimised for mobile computers. The **Turion** and **Centrino** processors use very little power to maximise battery life and are optimised for wireless networking, factors that are very important in mobile computing. They also use **Speedstep** or **PowerNow** technology to regulate the processor power to the system requirements. Wordprocessing needs less processor power than CAD and the system can adjust the processor speed to suit the program being run. This saves power and produces less heat. In a notebook computer, this is a huge advantage.



Random Access Memory (RAM)

Known as **primary storage**, it is the main working memory of the computer system. Data and programs currently in use are held in RAM. It is called random access because data can be accessed in any order. If you are working on a drawing in Solidworks, the Solidworks program and the drawing under construction are both held in RAM. RAM is **volatile** which means that when the computer is turned off, the contents of RAM are lost. This is why it is essential to save your work on a regular basis. Because of the volatility of RAM, most software programs have an **autosave** feature to prevent the total loss of your work.

RAM is made in the form of **integrated circuits** (IC's) in the same manner as a processor. These IC's are placed on a circuit board to produce a **memory module**. The most common RAM technology is **dynamic random access memory** (DRAM).



In this technology, a **transistor** and a **capacitor** are paired to store **one Bit** (binary digit) of data. In essence, if the capacitor is charged, a **binary 1** is stored and if it is discharged, a **binary 0** is stored. (see the section on data representation for more on binary data). The transistor acts as a switch to allow the capacitor's state to be changed as required.

There is a problem with this technology. As soon as the capacitor is charged, it begins to leak. As a result, the charge in the capacitors must be continually refreshed or they would leak to binary 0's resulting in corrupted data. This continuous refreshing is performed about 80 times per second and drastically slows down the speed at which main memory can be written to and read from.



DRAM is sold in modules called **DIMM**'s (dual inline memory module) for desktop computers and in modules called **SODIMM**'s (small outline dual inline memory module) for notebook computers.



DIMM's and SODIMM's are sold in modules with capacities of 256MB, 512MB, 1GB, 2GB. The current technology is called **DDR** (double data ram) and there are three types. Any particular computer system can only use one of the three type. The types are:

1. DDR	Transfers/second	Module Name	Transfer Rate
DDR - 200	200 Million	PC-1600	1600 MB/s
DDR - 266	266 Million	PC-2100	2100 MB/s
DDR - 333	333 Million	PC-2700	2700 MB/s
DDR - 400	400 Million	PC-3200	3200 MB/s

2. DDR2	Transfers/second	Module Name	Transfer Rate
DDR2 - 400	400 Million	PC2-3200	3200 MB/s
DDR2 - 533	533 Million	PC2-4200	4266 MB/s
DDR2 - 667	667 Million	PC2-5300	5333 MB/s
DDR2 - 800	800 Million	PC2-6400	6400 MB/s

3. DDR3	Transfers/second	Module Name	Transfer Rate
DDR3 - 800	800 Million	PC3-6400	6400 MB/s
DDR3 - 1066	1066 Million	PC3-8500	8533 MB/s
DDR3 - 1333	1333 Million	PC3-10600	10667 MB/s
DDR3 - 1600	1600 Million	PC3-12800	12800 MB/s

As can be seen from the above tables, the type of memory in a computer can have a massive impact on the overall performance of the computer system. At the extremes, DDR-200 can be accessed 200 million times per second while DDR3-12800 can be accessed 1600 million times per second.

Cache memory

If a computer system has a Pentium IV processor running at 3GHZ and 512MB PC-2100 DRAM installed, every time the processor requires data from RAM it will have to slow down to the speed of the RAM (PC-2100 = 266MHz) to access the data. As the processor continually accesses RAM, the effective speed of the processor for these transfers will be 266MHz. This is called **latency** and would effectively ruin the performance of the computer system if allowed to continue.

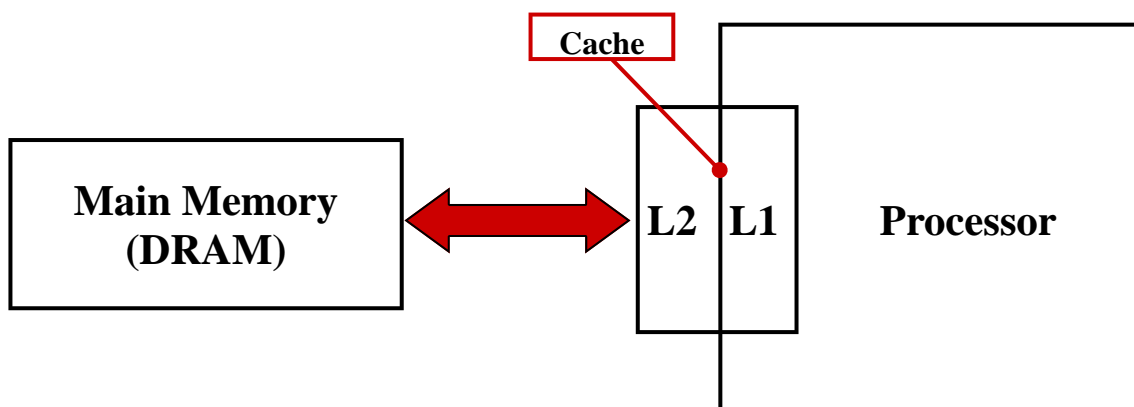
To overcome this problem, a small amount of fast **static RAM** is included in the processor. Static RAM does not use capacitors and as a result does not need to be refreshed. Static RAM is much more expensive to produce than Dynamic RAM and as a result is not suitable for use as main memory in a computer.

When the processor wants to read from a memory location, it first checks the cache for the location. If the location is in the cache, the processor can access the data without accessing main memory - the location is accessed at the speed of the processor. This is called a **cache hit**. If the location is not in the cache, then main memory must be accessed at the slower speed and this is called a **cache miss**.

This small cache memory (typically 128KB) is called **Level 1 cache (L1)** and is on the processor. A second cache called **Level 2 cache (L2)** is situated on the motherboard near the processor and can be from 1MB to 8MB in size. This cache is slower than level 1 cache but still much faster than main memory.

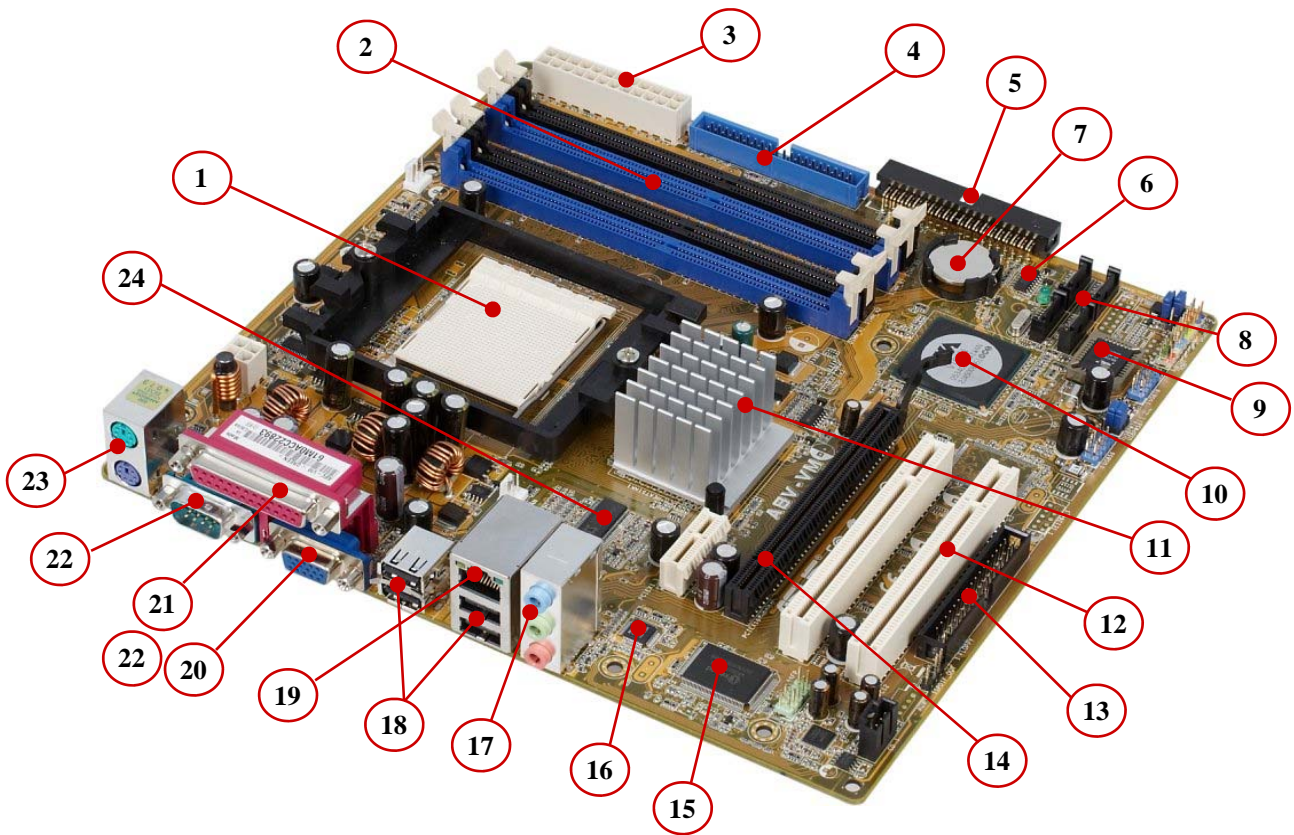
If a processor requires data from a location in RAM, the level 1 cache will be searched first. If the location is not in level 1 cache, level 2 cache will be searched. Only if the location is not in level 2 cache must the slow main memory be accessed.

Modern computer systems have cache hit rates in excess on **90%** and this has a huge bearing on the overall performance of the computer system.



The Motherboard

Often called the **mainboard** or **system board**, it is the main circuit board for the computer system. Every device in the computer system will either be part of the motherboard or connected to it.



The motherboard shown above is an **Asus A8V-VM**. This board is designed for **AMD** processors. The main parts of the motherboard are:

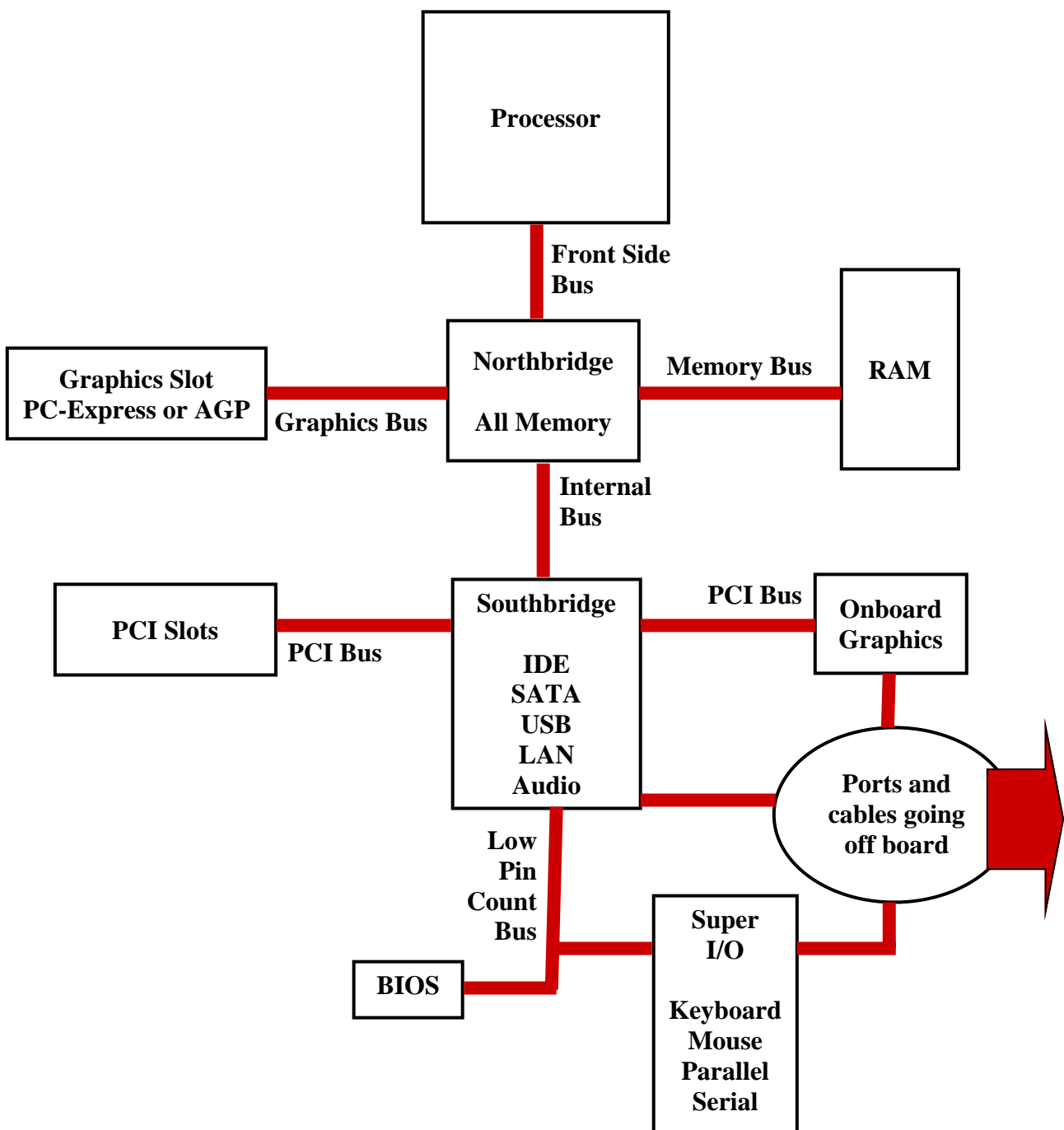
1	Processor socket	This socket is an AMD 939 pin socket. It is designed for the Athlon X2 processor. Different processors require different sockets and a motherboard must be chosen to suit the processor intended for use.
2	Memory sockets	The board has four memory sockets and accepts DDR 266/333/400MHz memory up to a total of 4GB
3	Power connector	The power supply connects here and supplies appropriate power to the different components on the motherboard.
4	Primary IDE	Hard drives can be either IDE (Integrated Drive Electronics) or SATA (Serial Advanced Technology Attachment). If an IDE hard drive is being used, it should connect to this socket.
5	Secondary IDE	This could be used to connect a second IDE drive. This could be a second hard drive or an Optical drive - DVD or CD drive.
6	CMOS RAM chip	A DRAM chip used to store the date and time and any user settings added to the setup screen. Complementary metal oxide semiconductor is the material the chip is made from.

7	CMOS battery	Because the CMOS chip is a DRAM chip, it is volatile and would lose data when the computer is switched off. The battery preserves the data in the CMOS RAM chip when the computer is powered down.
8	SATA connectors	Used to connect SATA hard drives and optical drives
9	BIOS chip	Basic Input/Output System. A chip holding the start-up routine for the computer system. It runs a program to test the hardware of the system. If the test is successful, a single beep is sounded. If not, a series of beeps are sounded and these beep patterns can be used to identify the failing component.
10	Southbridge chip	Forms the chipset with the northbridge. Between them they control the buses on the motherboard. Buses are the data pathways between the motherboard components. The southbridge controls the slower buses like the IDE bus, SATA bus, USB bus etc.
11	Northbridge chip	Controls the faster buses on the motherboard. These include the front side bus (between the processor and main memory) and the graphics bus.
12	PCI sockets	Peripheral Component Interconnect sockets used to connect expansion cards like modems, network cards, TV tuner cards etc.
13	FDD connector	For connecting a floppy disk drive.
14	PCI-Express	The graphics card connects here. Other motherboards have an AGP (accelerated graphics port) slot.
15	Super I/O chip	Controls the serial, parallel, mouse and keyboard ports at the back of the computer system.
16	Network chip	Controls the network port at the back of the computer
17	Audio ports	For connecting speakers, microphones etc.
18	USB ports	The current standard for connecting peripherals.
19	Network port	Used to connect the computer to a network
20	Video port	Connect the monitor to this port if a PCI-Express graphics card is not being used.
21	Parallel port	Largely obsolete. Used to connect printers and scanners.
22	Serial port	Largely obsolete. Used to connect external modem etc.
23	PS2 ports	The keyboard connects to the purple port and the mouse connects to the green port. Largely replaced by USB.
24	Audio chip	Controls the onboard audio system.

Chipset

The flow of data around the computer is controlled by the **Chipset**. This consists of two chips:

- **Northbridge:** This chip controls the flow of data between memory and the processor. It also controls the flow of data between the processor and the graphic's card.
- **Southbridge:** This chip controls the flow of data to the slower devices. These include USB, IDE, SATA, LAN and Audio devices. It controls the PCI slots and the onboard graphics chip. It delegates control of the keyboard, mouse, parallel and serial ports to the Super I/O chip.



Buses

A bus is a set of wires through which data can be sent to the different parts of the computer system. Buses connect the major computer derives to each other. The chipset uses the buses to send data around the motherboard. The main buses are:

- **Front side bus:** Connects the processor to the northbridge.
- **Memory bus:** Connects the northbridge to the main memory.
- **Graphics bus:** Connects the northbridge to the PCI-Express or AGP graphics slot.
- **Internal bus:** Connects the northbridge to the southbridge
- **PCI bus:** Connects the PCI slots and the onboard graphics to the southbridge
- **LPC bus:** Connects low bandwidth devices to the southbridge. These include the BIOS chip and the Super I/O chip which controls the keyboard, mouse, parallel, serial ports etc.

Motherboards are processor specific. The main types available are:

- **Socket 478:** Intel Pentium IV processors
- **Socket 775:** Intel Dual Core and Core Duo processors
- **Socket 754:** AMD Athlon processors
- **Socket 939:** AMD Athlon 64 processors
- **Socket AM2:** AMD Athlon X2 processors

The Power Supply

The power supply can be seen from the back of the system unit. The mains cable is plugged into the power supply. A computer power supply has a number of functions:

- It converts the power from **Alternating current (AC)** as supplied by the electric supplier to **Direct current (DC)** as required by the computer system.
- It transforms the 240 Volts supplied by the electric supplier into the voltages required by the computer system. The main voltages are:
 - **12 volts** for the disk drives as they have motors
 - **3.3 and 5 volts** for the circuit boards in the computer.
- It uses advances power management (**APM**) to allow the computer go into a standby mode.
- Some have a switch to toggle between 240 volt supplies and 110 volt supplies.

The power supply has a number of connectors to connect to the motherboard, drives etc. The main connectors are:

1	Main connector	Connects to the motherboard and supplies the 3.3 and 5 volt supply for the board.
2	Molex connector	Connects IDE hard drives and optical drives.
3	Berg connector	Connects floppy disk drives
4	SATA connector	Connects SATA drives



Power supply

Power supplies are rated in watts. They vary in size from 350 watts to 1000 watts. Using too small a power supply of a low quality one can lead to serious computer problems. Below is shown typical power usage for a number of computer devices:

- Motherboard: 60 watts
- Processor: 90 watts
- Memory: 10 watts/128MB
- Processor fan: 5 watts
- Graphics card: 40 watts
- Hard disk: 25 watts
- Optical drive: 30 watts

As can be seen, a large power supply (at least 400 Watts) is preferable and does not use more energy as it only supplies power on demand.

Ports

Computer ports are interfaces between peripheral devices and the computer system. They are hardware devices built into the motherboard or on expansion cards. They are often built into the front of the computer chassis for easy access but will be cabled back to the motherboard.

Ports at the rear of the computer

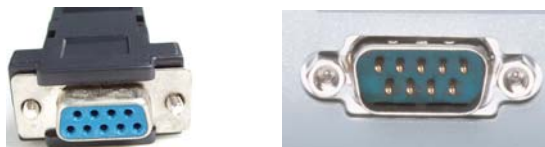


Ports at the front of the computer



Serial port

Although more or less obsolete, they are still included in new systems. The serial port is a 9-pin port. Windows calls them Com ports - Com1, Com2 etc. Mice and external modems were connected to these ports. They are **turquoise** in colour.



Parallel port

This 25-pin port is used to connect printers, scanners, external hard disks, zip drives etc. to the computer. It is **burgundy** in colour and windows refers to them as LPT ports - LPT1, LPT2 etc. The original port only supported single direction communication but the modern parallel ports can support bi-directional communications. This is essential for reporting ink levels etc. in printers.



Video port

Used to connect a monitor to the computer system. There are two types:

- **VGA port:** This is a 15-pin port and is **blue** in colour. It is an analogue port and is being replaced by the DVI port.



- **DVI port:** This is **white** in colour and is a digital port. This means that no conversion is necessary between the computer and the monitor and that means that images can be produced more quickly on the monitor.



PS/2 port

PS/2 ports are used to connect keyboards and mice to the computer. The keyboard port is **purple** and the mouse port is **green**.



USB port

The universal serial bus was intended to replace Serial, Parallel and PS/2 ports with a single standard. 127 devices can be connected to a single USB port and computers are often supplied with six to ten ports. USB is **hot swappable** which means that devices can be connected and disconnected without turning off the computer system, something that should never be attempted with parallel or serial devices.



There are different USB standards in use:

- **USB 1:** This is the original standard and can transfer data at **1.5MBps**. This is too slow for external hard disks with capacities of 500GB or more.
- **USB 2:** This is forty times faster than USB1 and has a data transfer rate of **60MBps**. This is the current standard.
- **USB3:** this is ten times faster than USB2 and 400 times faster than the original USB1. it has a data transfer rate of **600MBps** and will be common on new computer systems in 2009.

Firewire port

FireWire (IEEE 1394) is a technology introduced to the computer world by Apple. There are two versions available and a third is planned:

- **FW 400:** This can transfer data at 400Mbps which is **50MBps**. This makes it similar in speed to USB2.
- **FW 800:** This can transfer data at 800Mbps which is **100MBps** making it considerably faster than USB2.
- **FW S3200:** This will transfer data at 3200Mbps which is **400MBps**. It is intended to compete with USB3.



The main difference between USB and FireWire is that USB is **host based** and FireWire is not. USB devices must be connected to a host computer while FireWire devices can be connected to each other without using a computer.

Modem port

Technically known as an **RJ11** port, it is the common telephone socket used in Ireland. Modems will usually have 2 ports side by side. The port marked **Line** should be connected to the wall socket while the port marked **Phone** can be used to connect a telephone. The phone can then be used when computer is offline or if a V92 modem is used, the Internet can be put on hold while the **incoming** call is taken.



Ethernet port

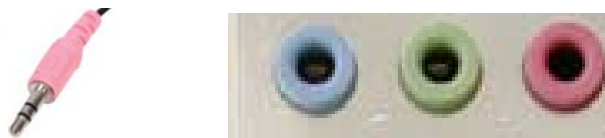
This port is used to connect to a network. Technically known as RJ45, it is physically bigger than the modem port. They can either be part of the motherboard or on an expansion card.



Audio ports

These ports are used to input and output audio from the computer system. The standard is three mini jack ports but there may be more. The three ports are:

- **Light blue:** Line in - this is used for connecting stereo systems, tape cassette players, record players, radios etc. You can record what is being played on the connected device.
- **Lime:** Connect the speakers to this port.
- **Pink:** Connect a microphone to this port.

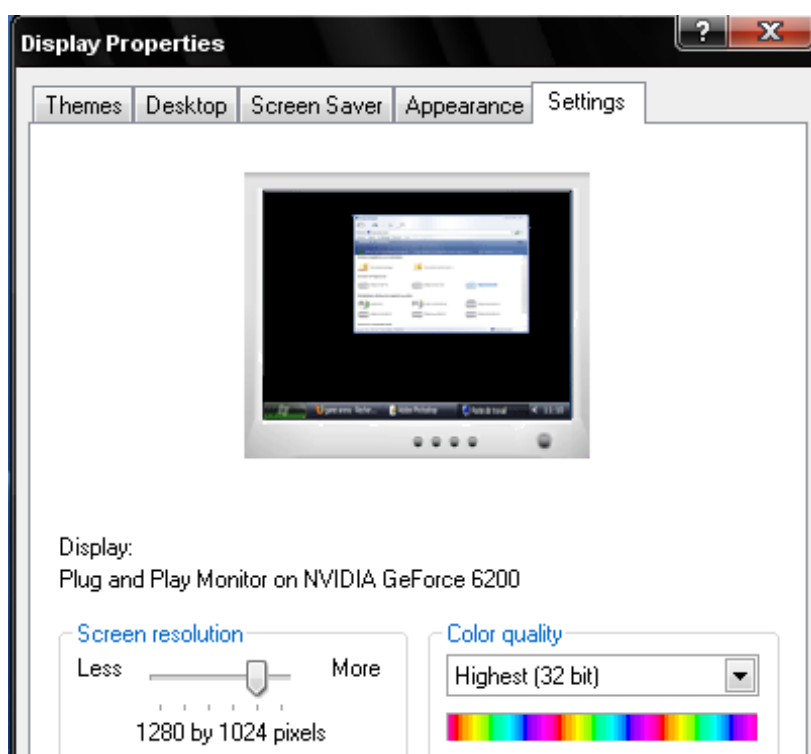


Graphic card

Images displayed on a monitor are made up of dots called **pixels** (picture elements). The graphics card has to decide what to do with each one of these pixels in order to create the required image. In the case of a moving image as in a video file or a game, the task becomes more complex.

The resolution of a screen is the number of pixels being displayed. Typical resolutions include:

- **800 x 600:** 480,000 pixels
- **1024 x 768:** 786,432 pixels
- **1280 x 1024:** 1,310,720 pixels
- **1600 x 1200:** 1,920,000 pixels

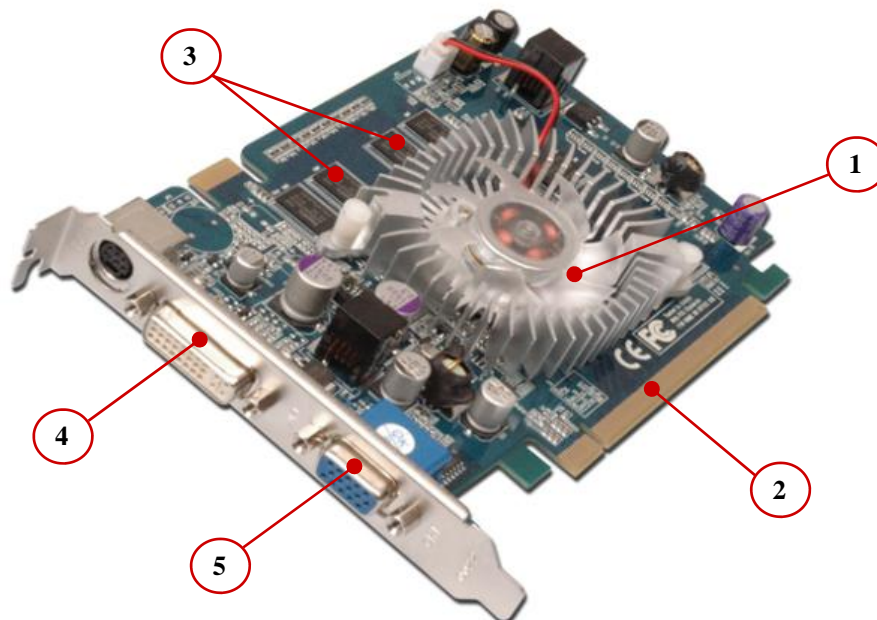


The graphics card must handle each pixel to maintain the image and refresh each pixel 60 to 100 times every second. There are two types of graphic card available:

- **AGP** (accelerated graphics port). This is the older technology but is still available. Depending on the card, it can output in analogue or digital or both.
- **PCI-Express**. This is the newer technology and is faster than AGP. It also allows for the use of two graphics cards working in tandem to improve the performance. This is called **Scalable Link Interface (SLI)** and it allows the two graphics cards to produce a single output. PCI-Express can also output in analogue or digital or both.

These cards are mutually exclusive and the choice is made according to the graphics slot on the motherboard.

A graphics card will have it's own processor and memory built in. The faster the processor and the more memory a graphics card has, the faster and more even the display will be. If the on screen image is jerky or blurred, the graphics card is not good enough for the job. The main parts of a graphics card are:

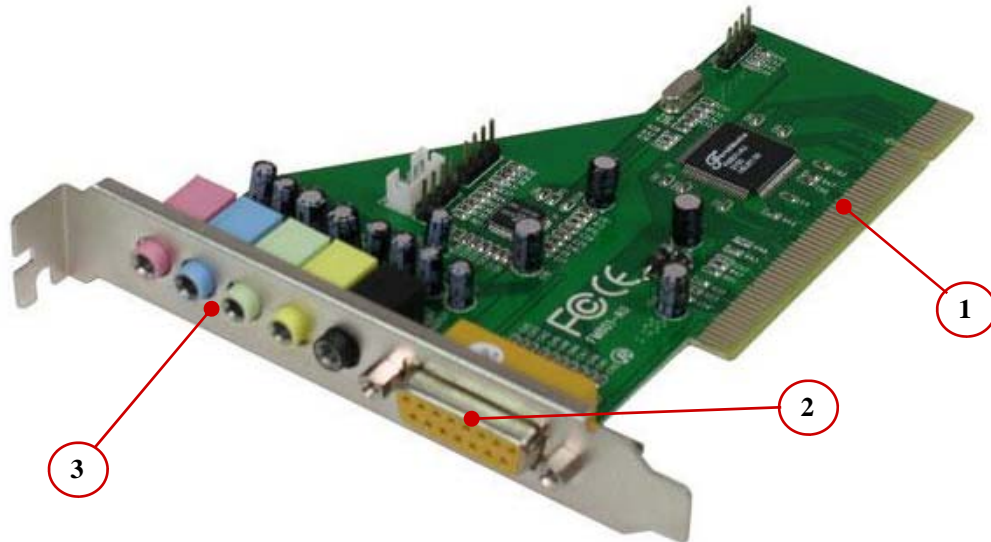


1	Processor and fan	This allows the graphics card to manage it's own processing and makes it almost independent of the main computer processor.
2	Board connector	This will be either AGP or PCI-Express
3	Memory	The graphics card does not need to use any main memory as it has it's own. This makes it much faster. Most new graphics cards use DDR3 memory. Up to 1GB of DDR3 memory is now available on graphics cards although this makes them as expensive as most computer systems.
4	DVI connector	Digital output is supplied through this port. If a digital monitor is present, this is the best option as no conversion is required.
5	VGA connector	Analogue output is provided through this port. If you have an analogue monitor, you must use this port. If you have a digital monitor, it is best to use the DVI port as the graphics card works in digital and must convert to analogue to use the VGA port.

Computers are often supplied with **integrated graphics cards**. This means that the main memory must be used to control the graphics system and the main processor must supply most of the processing power. This is perfectly OK on an office computer where word-processing etc ate the main activities. Introduce CAD etc. and the system becomes unusable.

Sound card

In recent years, computers have become entertainment centres with media centre operating systems controlling TV and video. The need for good quality sound and even surround sound has made it almost standard on most computers. Most computers are supplied with an integrated sound system and this is sufficient for most applications. A sound card can be fitted to an empty PCI slot and the integrated chip turned off if the extra features of a card are required.



1	PCI connector	Used to connect the sound card to a PCI slot on the computer motherboard.
2	MIDI socket	Musical Instrument Digital Interface port is used to connect digital musical instruments to the computer. This port is no longer supplied on integrated systems and if one is needed, the only option is to fit a sound card to the computer system.
3	Audio jacks	These are used to connect microphones, speakers, stereo systems etc to the computer.

The main functions of a sound card are:

- To use a **DAC** (digital to analogue converter) to prepare audio for speakers etc.
- To use an **ADC** (analogue to digital converter) to convert the audio coming into the computer.

A sound card can be connected to the following:

- Analogue input devices - Microphone, Radio, Tape deck, Record player etc
- Headphones and speakers
- Output to tape etc.

Network card

A network card is designed to allow computers participate in a computer network. This can simply be a home computer connected to a **Broadband** connection or a number of computers connected together to share resources. Network capability is included on most new motherboards, but a different network card can be added if required.

Network cards can offer wired or wireless connection. They can fit into a PCI slot on the motherboard or even connect to a USB socket. Modern notebook computers have an internal wireless network card as well as the standard wired card.

The standard used in the majority of networks is called **Ethernet**. This covers wired and wireless networks. Ethernet is controlled by the Institute of Electrical and Electronic Engineers (**IEEE**) and there are a number of standards in use in wired networks:

- **Fast Ethernet:** A wired standard with a transmission speed of **100Mbps**. This is the most common standard and integrated network chips are usually of this standard.
- **Gigabyte Ethernet:** A wired standard with a transmission speed of **1000Mbps**. This is 10 times faster than fast Ethernet and is becoming more common.

Wired Ethernet is available as a PCI card for desktop computer systems, a PC card version for notebook computers and a USB version for either of the above.



PCI



PC card



USB

The wireless standards include:

- **The B standard:** Introduced in 1999, this standard offers a transmission speed of **11Mbps**. It has an effective range of **30 Metres**.
- **The G standard:** This was introduced in 2003 and offers a transmission speed of **54Mbps**. It has a useful range of approximately **30 Metres**.
- **The N standard:** Introduced in 2006, this is the latest wireless standard and it offers a transmission speed of **540Mbps**. It has an effective distance of **50 metres**.

Wireless Ethernet is available as a PCI card for desktop computer systems, a PC card version for notebook computers and a USB version for either of the above.



While it is perfectly OK to mix Fast Ethernet and Gigabyte Ethernet in a network situation, it is strongly advised that a single standard is chosen for wireless.

Modem

A modem is necessary to access the internet using a standard telephone line. Because a standard telephone line is analogue, a modem must convert the digital computer data to analogue before transmission across the telephone line and convert the analogue data in the telephone line to digital before transmission to the computer.

As digital to analogue conversion is called **MO**dulation and analogue to digital conversion is called **DE**Modulation, the device gets its name from these two terms.

The standard transmission speed of a modem is **56Kbps**. This speed is rarely achieved because of line conditions. Modems are available in PCI, external serial and USB versions. The **V.92** standard allows users to answer a phone call without losing the Internet connection. A large number of users in Ireland still depend on modems for Internet access.



Hard disk drive

The **primary storage** (main memory) of a computer system is volatile. This means that when the computer is switched off, the contents of primary storage are erased. A system was needed whereby work could be saved for use at a later time. The hard disk drive is the accepted solution to this problem.

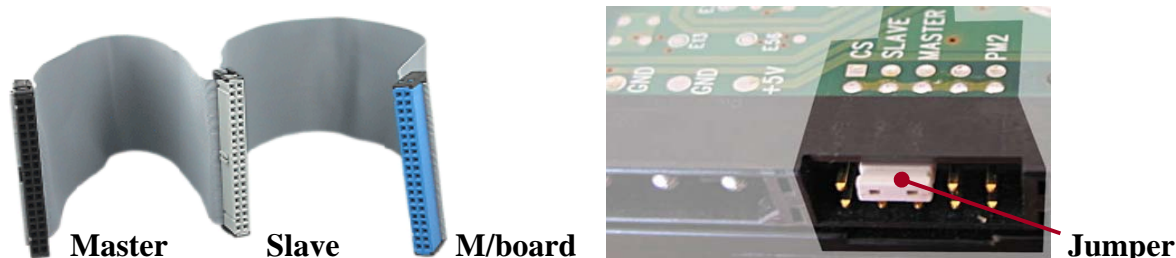
The problem with main memory is that data is stored as electric charges and could not be maintained without electric power. A different approach was needed for **secondary storage** (non-volatile storage). In main memory, different voltages are used to store a binary 1 and a binary 0. It was decided to mimic the situation for secondary storage using **magnetism** instead of electrical voltages to represent the binary data.

To achieve this, a metal disk (**platter**) was coated with millions of tiny iron particles. These particles could then be magnetised to **magnetic north** and **magnetic south** to represent the binary digits 0 and 1. A **read-write head** is used to magnetise the particles on the disk surface and so represent the data held in RAM. The computer can now be switched off and a copy of the data is safe for later use.



Hard disk drives can be **internal** or **external** in type. For internal drives, the two standards are:

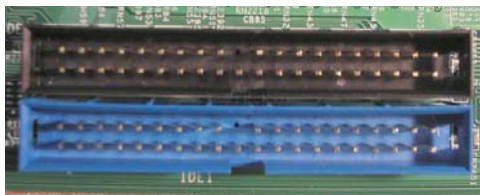
- **IDE** (Integrated Drive Electronics). The disks connect to the motherboard using a ribbon cable. This cable is actually a bus extension from the motherboard. Each ribbon cable can hold two IDE drives set up as **master** and **slave**. The drive is set as master or slave by positioning a **jumper** switch on the back of the drive. As there are two IDE connectors on a motherboard, a total of four drives can be connected.



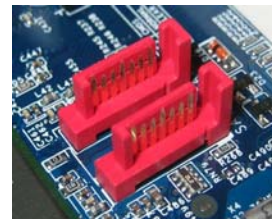
- **SATA** (Serial Advanced Technology Attachment) allow faster data transfer speeds than IDE drives and as such, will eventually replace them. There is no master/slave arrangement with SATA and each drive has it's own cable. The cables are much smaller and allow better air circulation in the system unit.



The motherboard connectors are shown below.



IDE



SATA

Hard disk capacities range from **100GB** to **500GB** and some computer manufacturers are now offering computers with SATA drives of **1TB** (Terabyte - 1000GB). Hard disks have rotational speeds of between **7,200rpm** and **15,000rpm**. This effects the **transfer rate** - the amount of data that can be written or read from a disk per second. Transfer rate varies from **50MB/s** for the 7,200rpm drive to **200MB/s** for the best 15,000rpm drives.

External hard disk drives are available as IDE or SATA and can be **mains powered** or **host powered**. Host powered drives receive their power from a USB port and are useful with notebooks as well as desktop computers.



Mains Powered



Host Powered

Hard disk drives are also now found in video recorders, digital music players, digital camcorders, digital cameras and mobile phones.

2½ inch Notebook Drive



1 inch Microdrive

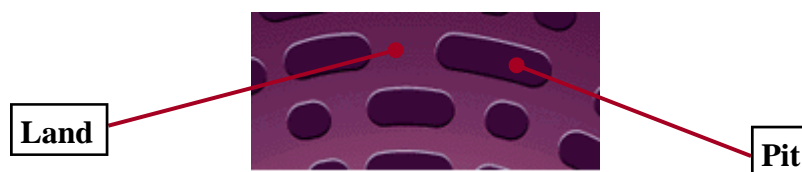


Microdrive



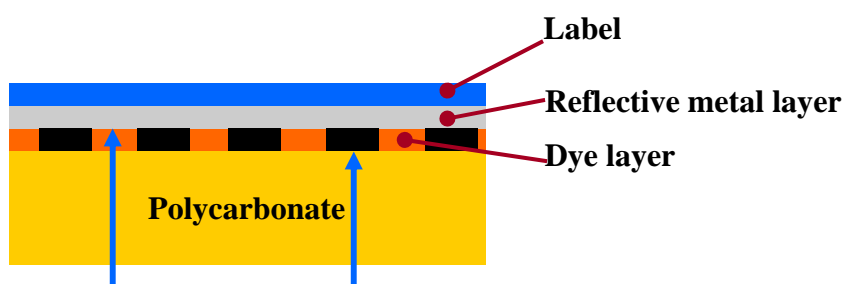
Optical drives

Optical drives use laser technology to sense **pits** and **lands** mechanically pressed into a polycarbonate disk. These pits and lands represent the binary 0's and 1's and so can store computer data.



A thin layer of metal is added to the polycarbonate disk to reflect the laser light. As the disk rotates, the laser senses the pits and lands and reads the data from the disk. The laser only needs to operate at a **single intensity** as it only scans the surface of the disk to detect the pits and lands. This is the system used on all mass produced optical disks.

CD-R (blank CD's) disks obviously cannot be mechanically pressed in a computer and as a result, a different method must be used to encode data onto these disks.



In a CD-R (write once) disk, a layer of **Dye** is used to encode the binary data. The optical drive must have a laser with **two intensities**. The dye layer in it's natural state can be penetrated by the laser light and the reflective layer reflects the light back to the sensor in the optical drive. If the laser is set to the higher intensity, it will turn areas of the dye layer opaque on contact (**burn**) and these areas will not allow laser light to penetrate. This situation mimics the pits and lands produced on the mechanically pressed disk and data can be stored on the disk.

The CD-RW (re-writable) disk is similar but the laser must have **three light intensities**. The third and highest intensity is required to turn the burned areas of the dye layer back to their original condition. The dye layer can now be re-burned to hold new data. The three laser intensities are:

- **Intensity 1:** Read data
- **Intensity 2:** Burn data
- **Intensity 3:** Erase data

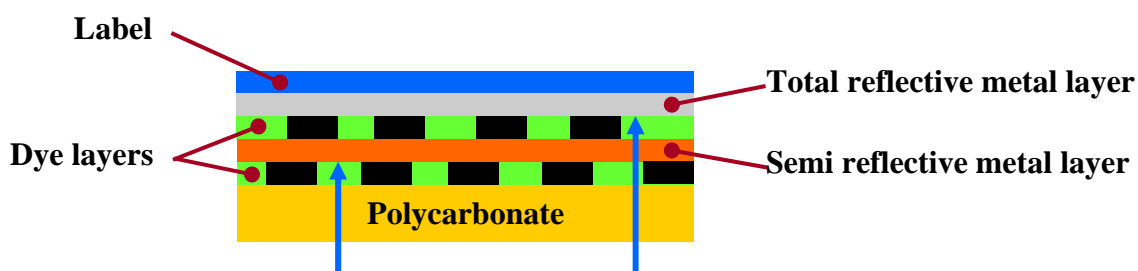
In actual fact the laser can be set at multiple intensities depending on the disk type being burned. The CD-R disk has a capacity of between 650MB and 800MB.

DVD disks are similar to CD disks except that they can store a lot more data. DVD has several formats and compatibility issues. DVD also introduces **layers** and **sides**, where more than one dye layer is formed on the disk, and sides, where the disk can hold data on both sides.

Each layer of a DVD can hold **4.7GB** of data. The possibilities are:

Number of sides	1	1	2	2
Number of layers	1	2	1	2
Disk capacity	4.7GB	8.5GB	9.4GB	17GB

To make double layer disks work, two metal reflective layers are used. The first is gold based and can be penetrated by the laser once a certain intensity is reached. Below this intensity it reflects. The second reflective layer is aluminium based and is totally reflective. By varying the laser intensity, either layer can be read or burned. The double sided disk is two of the above glued back to back.



DVD formats:

1	DVD-ROM	Digital versatile disks are read only. These disks are mechanically stamped and can be manufactured as single or double layer and as single sided or double sided.
2	DVD-R	These are single or dual layer disks and can be single or double sided. They can be written to only once.
3	DVD-RW	These are the same as DVD-R only that they can be written to several times.
4	DVD+R	These are single or dual layer disks and can be single or double sided. They can be written to only once.
5	DVD+RW	These are the same as DVD+R only that they can be written to several times.

There are significant differences in the DVD-R standard and the DVD+R standard making them incompatible with each other. They vied with each other to become the standard and neither has won. The result has been that manufacturers have produced **DVD±R** drives capable of reading and writing to both standards.

A number of new high capacity formats have come onto the market. These are:

1	HD-DVD	High Definition DVD uses a new laser technology and the result is that each layer can now hold 15GB of data instead of the 4.7GB capacity on standard DVD. This gives a total capacity of a double sided and double layered disk as 60GB.
2	Blu-Ray	This has a higher capacity than HD-DVD as a single layer can hold 25GB of data. A dual layer disk can hold 50GB. Technically, a double sided and double layered disk can hold 100GB of data.



Blu-Ray



HD-DVD

Optical drives fit into 5¼ inch bays on the system unit. They are also available as external drives.

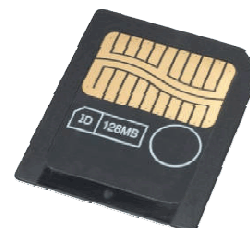
Card reader drive

These drives have replaced floppy disk drives in the majority of new computer systems. They can read media cards from most digital cameras:

- **Compact flash:**
- **Microdrive:**
- **Smartmedia:**
- **SD memory card:**
- **Memory stick/Duo/Pro:**
- **xD picture card:**



Card reader drive



Computer Monitor

A computer monitor displays images generated by the computer system. Like main memory, it is a volatile device. When the power is removed, the image is lost.

Monitors nowadays, are almost exclusively **LCD** (Liquid Crystal Display). **CRT** (Cathode Ray Tube) monitors are rare and are now as expensive as LCD monitors. Their physical size, weight and power consumption has made them unpopular.



19 inch Widescreen LCD

The **aspect ratio** of a computer monitor is the ratio between the width and height of the screen. The aspect ratios are:

- **Standard monitor:** 4:3
- **Widescreen monitor:** 16:9

The **resolution** of a monitor is the number of pixels a monitor can display. It is normally expressed as the number of pixels in one horizontal row multiplied by the number of rows - **1024 x 768** etc. A number of display standards are used when advertising monitors:

Standard monitor

- **XGA** (Extended Graphics Array): **1024 x 768**
- **SXGA** (Super Extended Graphics Array): **1280 x 1024**
- **UXGA** (Ultra Extended Graphics Array): **1600 x 1200**
- **QXGA** (Quad Extended Graphics Array): **2048 x 1536**

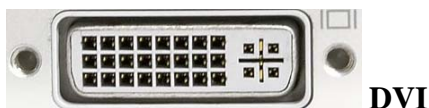
Widescreen

- **WXGA** (Wide XGA): **1280 x 800**
- **WSXGA** (Wide SXGA): **1680 x 1050**
- **WUXGA** (Wide UXGA): **1920 x 1200**

The screen size of a computer is measured **diagonally** in inches. They vary in size from 15 inch to 24 inch although the 19 inch in standard and widescreen is the most common with new computer systems. Another important measurement is the **dot pitch**. This is the distance between the pixels on the monitor and **0.24mm** is considered adequate. Smaller dot pitches are available but at extra cost. The dot pitch controls the sharpness of the image.



Most LCD monitors offer a **VGA** and a **DVI** connection to connect to the graphics card of the computer system.



DVI



VGA

The VGA connector is used if an analogue signal is being sent from the graphics card and the DVI connector is used if the signal being sent is digital. Obviously, as the computer is a digital machine, it is best if no conversion is required and so the best option is the DVI connection.

LCD monitors have a **native resolution** at which the image is crisp and clear. Other resolutions are possible but the image quality decreases.

Keyboard

The keyboard is the primary input device for the computer system. The board is divided into a number of sections:

- **Typing keys:** This section contains the letter and number keys. The shift keys, spacebar, return key etc. are also included in this section.
- **Numeric keypad:** These keys are arranged as on a calculator and are used in Banks etc. They allow numeric data to be entered much more quickly than using the numbers at the top of the typing keys.
- **Function keys:** These are programmable keys used by software for special functions. E.g. - F1 is always used for help.
- **Control keys:** The control keys are used for screen and cursor control. The arrow keys control the cursor. The Home, End, Page up etc. keys control cursor in software applications.

The most common typing key arrangement is called **QWERTY** after the first six keys. Other typing key arrangements are available including **Dvorak**, **ABCDEF**, **AZERTY** etc. These are common in other countries but the qwerty keyboard has maintained dominance in Western Europe.



QWERTY



Dvorak

Keyboards are available wired or wireless:

- **Wired:** These are either **PS/2** or **USB**.
- **Wireless:** A wireless keyboard has two components. The keyboard and a receiver that connects to a USB port. The keyboard uses batteries.



Wireless keyboard

A full size rubber keyboard is useful for people who use notebook computers. Because the notebook keyboard leaves users more prone to **RSI** (Repetitive Strain Injury), a full size keyboard that rolls up to fit into a notebook carry case is an advantage.



Mouse

A mouse is an input device that uses point and click technology to interact with software applications. There are two main types:

- **Ball mouse:** This uses a ball to roll across the surface and move rollers attached to sensors inside the mouse that reflect the ball movement as cursor movement. These are efficient devices but the ball picks up dust and loses friction with the rollers. As a result, the cursor movement becomes erratic. A mouse mat is needed to aid friction between the ball and the surface.
- **Optical mouse:** This uses a camera to take thousands of images per second and send them for digital processing. The red LED lights up the surface for the camera. The digital processor compares images and can sense the movement of the mouse. This movement is reflected on the screen as cursor movement. The great advantage of the optical mouse is that it is not affected by dust as a ball mouse is and a mouse mat is not required. It does not work well on glass surfaces.



Optical mouse

Ball mouse



Both ball and optical mice are available as wireless. Batteries are required as for the wireless keyboard.

Graphics tablets are becoming popular as a replacement for a mouse as they offer much more control of cursor movement. This is important in applications such as Illustration Graphics, Image Editing and CAD. Software designed for use with graphics tablets can sense the pressure applied to the stylus as well as the tilt angle etc.



Printers

Printers are output devices which provide a **hardcopy** (permanent and readable) of computer data. They can print onto paper, transparency sheets, photographic paper, card etc. There are two main technologies involved:

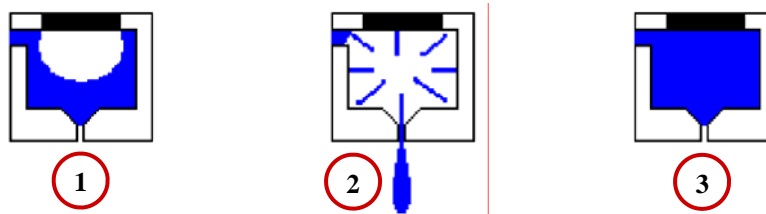
- **Inkjet (Bubblejet)**
- **Laser**

Inkjet and bubblejet printers use liquid ink dropped from ink cartridges onto the paper in pixel sized drops to produce the image. The difference between inkjet and bubblejet is the method used to force the ink out of the cartridge.

- **Inkjet:** This uses an electric charge to vibrate a membrane. When the membrane flexes downwards, it ejects an ink droplet through the nozzle (1). When it flexes upwards, it draws more ink into the reservoir (2).



- **Bubblejet:** In this technology, a heating element locally heats ink to form a bubble (1). As the bubble expands, it forces ink through the nozzle (2). When it bursts, it causes a vacuum which draws ink into the reservoir (3).

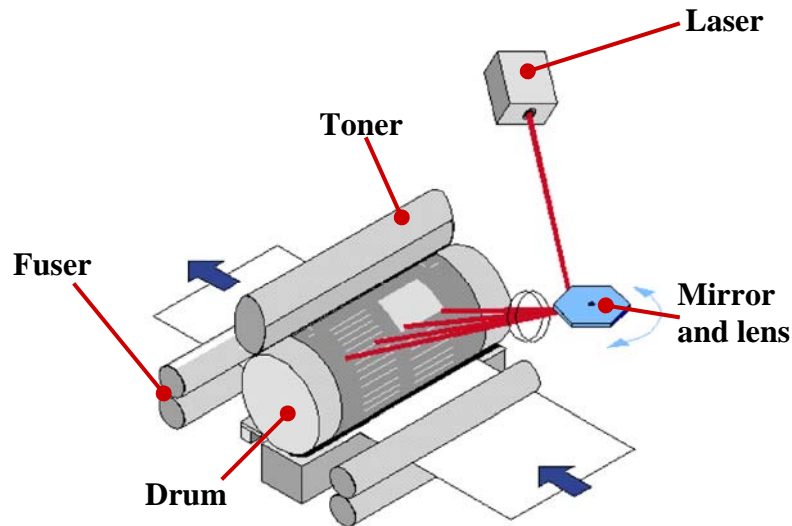


While inkjet printers are inexpensive to purchase, the real cost is in the consumables. Printers vary in the number of cartridges they use from - a tricolour and a black - to eight or ten separate colours in some photo printers. It is possible to buy cheaper refills but the quality is dubious. They are slow compared to laser printers but are the only option if photo paper is to be used.



Laser printers are used for high volume work. They are available in black and colour. **Toner** (powdered ink) is used instead of liquid ink as in inkjet printers. These operate in a similar manner to a photocopier.

Laser printers produce images using dots. The image is created using a **laser beam** and a **mirror - lens** arrangement on a **drum** which is coated with magnetically charged **toner** and then transferred from the drum to the paper. The paper is then fed through a heated **fuser** which fuses the toner to the paper as ink.



Laser printers are much faster than inkjet printers and much cheaper to run although they are more expensive initially. Toner cartridges are more expensive than inkjet cartridges but produce thousands of pages per cartridge compared to the hundreds produced by inkjet cartridges.

Printers can be purchased as **A4**, **A3** and even **A2**, but if larger drawings and images are required, a plotter is more suitable. These use inkjet technology and are available in **A3**, **A2**, **A1** and **A0**. They take up much less space than an equivalent inkjet or laser, but are more expensive.



Laser



Cartridges



Plotter

Computer Specification



- **Intel Core Duo Processor E6750**
(2.66MHz 64-Bit CPU, 128 KB L1 cache, 4MB L2 Cache, 1333MHz FSB)
- **Windows Vista Business**
- **4GB DDR2 Memory - 667MHz**
- **500GB SATA HDD 10,000rpm**
- **256MB DDR2 NVIDIA GeForce 8600GT PCI-Express Graphics**
- **19" Widescreen LCD Display - 0.22mm Dot Pitch, 1490 x 900 Resolution, Speakers**
- **7:1 Surround Sound Inc. Woofer**
- **PCI-E Mainboard - nForce SLI, Micro ATX**
- **6 x USB2 Ports - 2 Front**
- **2 x 1394 Ports - 1 Front**
- **Broadcom GB LAN Network Connection**
- **Multi Card Reader**
- **18X SATA Dual Format Dual Layer DVDRW Drive**
- **Aluminium ATX Midi Tower + 550W Power Supply**
- **Logitech Wireless Internet Keyboard and Wireless Optical Mouse**
- **1 Year Onsite Warranty**