

Hardware, Software and Data Communications

CPU

The CPU is the brain of the computer where data is manipulated. In the average microcomputer the entire CPU is a single unit called a microprocessor.

Most microprocessors are single chips mounted on a piece of plastic with metal wires attached to it. Some newer microprocessors include multiple chips and are encased in their own cover and fit into a special socket on the motherboard.

Every CPU has at least 2 basic parts

1. The control unit
2. The arithmetic logic unit

The Control Unit

All the computers resources are managed from the *control unit*. It is the logical hub of the computer.

The CPU's instructions for carrying out commands are built into the control unit. The *instruction set* lists all the operations that a CPU can perform and is expressed in *micro code* (a series of basic directions telling the CPU how to execute more complex operations).

The Arithmetic Logic Unit

Computers data stored as numbers → much of the processing involves comparing numbers or carrying out mathematical operations.

The computer can perform 2 types of operations

1. *Arithmetic operations*
2. *Logical operations*

Arithmetic → Addition

Subtraction

Multiplication

Division

Logical → Comparisons such as Equality

Greater than

Less than

Every logical operator has an opposite.

Some of the logical operations can be done on text, e.g. searching for a word in a document means that the CPU carries out a rapid succession of *equals* operations to match the sequence of ASCII codes making up the search word.

Many instructions carried out by the control unit involve moving data. When the control unit encounters an instruction involving logic or arithmetic it passes this to the *ALU (arithmetic logic unit)*

The ALU includes a group of *registers* (high speed memory locations built directly into the CPU). These are used to hold the data currently being processed.

E.g. Control unit loads 2 numbers from memory to registers in the ALU. Control unit tells ALU to divide the 2 numbers (arithmetic) or compare to see if they are equal (logic).

CPUs Used in Personal Computers

Intel Processors

Intel Corporation is the largest manufacturer of microchips in the world and is historically the leading provider of PC chips. Intel invented the microprocessor in 1971 with the 4004 model. This led to the first microcomputers in 1975. Intel's success in this market was not guaranteed until 1981 when IBM released the first IBM PC based on the Intel 8088 processor. The 8088 was the first chip used in an IBM PC but they then went back to the 8086 and this design standard was used in all further chips – 80286, 80386, 84086, Pentium, Pentium Pro, Pentium II, Pentium III, Celeron and Xeon – often referred to as the 80x86 line. The basic structural design (*architecture*) of each chip has become more sophisticated and complex.

Pre-Pentium Processors

Intel's first processors were simple by today's standards but provided a level of computing never seen before in a single processing chip. A major improvement that came with the 80386 is called virtual 8086 mode. In this mode a single 80386 chip could achieve the processing power of 16 separate 8086 chips each running a separate copy of the operating system. This capability enabled the chip to run different programs at the same time – a technique known as *multitasking*. All the chips following the 386 had this capability.

In 1989 the 80486 released didn't feature any radically new processor techniques. Instead it combined a 386 processor with a math coprocessor and a cache memory controller all on the one chip. These chips now no longer needed to communicate via the bus so increasing the speed of the system dramatically.

The Pentium

Introduced in 1993. Intel broke with its tradition of numeric names – partly to prevent other manufactures using similar numeric names. It is still considered part of the 80x86 family. It runs applications approx 5 times faster than the 486 at the same clock speed. Part of the speed of the Pentium comes from a *superscalar* architecture – allows the chip to process more than one instruction in a single clock cycle.

The Pentium Pro

Introduced in 1995, it reflected more design breakthroughs. It can process 3 instructions in a single clock cycle and can achieve faster clock speeds than the Pentium. The phrase *dynamic execution* was used by Intel to describe the capability of executing the programs instructions most efficiently but not necessarily in the order in which they were written. The out of order execution of instructions means that the instructions not being processed immediately are put aside while the chip begins processing the other instructions.

Pentium with MMX technology

MMX includes 3 primary architectural design enhancements,

1. new instructions
2. SIMD process
3. additional cache

MMX includes a set of 57 instructions that increase the multimedia capabilities of a chip. These instructions process audio, video and graphical data more efficiently than non MMX processors.

MMX *single instruction multiple data (SIMD)* process enables one instruction to perform the same task on multiple pieces of data so reducing the number of loops required to handle audio, video, animation and graphical data.

The Pentium II

Released in Summer 1997. It has 7.5 million transistors and execution ranges of up to 450MHz. It supports MMX technology and dynamic execution.

Differs from other Pentium models due to the fact that it is encased in a plastic and metal cartridge rather than the wafer format used for other chips. It needs this casing because of the *single edge connector* connection scheme. Instead of plugging into the regular slot on the motherboard the Pentium II plugs into a special slot called Slot One which requires a different motherboard. Enclosed within the cartridge is the core processor and the L2 cache chip.

In 1998 the Pentium II family was expanded with the release of the *Celeron* and *Xeon* which adapted the Pentium II technology for new markets.

The Celeron has many of the features of the Pentium II but runs at slower speeds and is designed for entry level PC's in the \$1000 range.

The Xeon incorporates a larger L2 cache and features enhanced multiprocessing capabilities. It is designed for use in network server computers and workstations.

Another advantage of the P II is the ability to work with a 100MHz data bus. Prior to the P II data buses typically ran at 66MHz or less. Improved data bus speeds means faster overall performance.

The Pentium III

Released in 1999 the P III features several enhancements. With speeds that reached 1 GHz in March 2000 the P III includes 70 new built in instructions and improved multimedia handling features.

Its single most biggest enhancement is *streaming SIMD extension (SSE)* – an improved version of the MMX technology resulting in faster video and graphics handling.

Uses a cartridge and slot configuration like the P II and early releases took advantage of the 100MHz bus. Shortly after its release Intel announced a 133MHz bus improving the performance further.

The Xeon version of the P III was released in late 1999 and provided faster performance like its P II version by offering larger L2 cache.

Advanced Micro Devices (AMD) Processors

In 1988 AMD emerged as a primary competitor to Intel. Until then AMD were usually found in low end, low priced home and small business computers.

K6 Processors

Was not entirely compatible with Intel processors and initially performed at slower speeds. AMD continued to improve and began to overtake Intel in some markets.

K6-2 processor released in 1988. Speed range, 300 → 475 MHz and 100MHz data bus, L2 cache sizes up to 2 MB (compared with P II 512KB). Also features 64-bit registers and can address 4GB of memory.

K6-III released in 1999. Speeds of 400 → 450 MHz, smaller L2 cache but features a new L3 cache (up to 2MB) not found in the P III.

K6 feature MMX technology, they do not offer SSE but use AMD's 3DNow! Providing enhanced multimedia performance.

Athlon Processor

Released in 1999, the Athlon was the fastest processor available operating at speeds up to 650 MHz. In March 2000 it was the first PC class processor to achieve speeds of 1GHz. Designed to work with buses of 200 MHz. Includes 64KB of L1 cache, 512 L2 cache. Capable of addressing 64GB of memory and features 64-bit registers.

Cyrix Processors

The company began as a maker of specialised chips but in mid 1990's began to produce processors to rival Intel. Focuses on PC's that sell for < \$1000. 1997 – Introduced the **MediaGX** processor, Pentium compatible microprocessor that integrated audio and graphics functions, operating at speeds of 233 MHz and higher. 1999 – Cyrix was sold to VIA technologies Inc. which continued the **MII** line. This PII class operates at speeds of 433 MHz and can be found in PC's from various manufacturers.

Motorola Processors

Apple Macintosh computers use Motorola processors. Other manufacturers, including workstation manufacturers such as SUN Microsystems rely heavily on Motorola chips. They were an early favourite among companies building large UNIX-based computers.

Offers 2 families of processor chips.

1. 680x0 family
2. MPC, has different architecture and is known as the PowerPC family.

680x0 series

Best known as the foundation of the original Macintosh. Actually predates the Mac. IBM considered using the 68000 in its first PC. The 68000 (released in 1979) was more powerful than Intel's 8088 but the improvements were slower. By the time Motorola released the 68060 chip in 1993, Intel were already promoting the Pentium.

PowerPC series

1991 – IBM and Apple joined forces with Motorola to dethrone Intel from pre-eminence in PC chip market. Hardware portion focused on the PowerPC chip, first of which was the 601. Followed soon by the 603, a low power processor suitable for notebooks. 604 and 604e, high power chips designed for high-end desktops. 620 introduced in 1995 established a new performance record for microprocessors. 750 chip (266 MHz) was released for desktop and mobile computers needing high performance but low voltage.

The **G3** released in 1998 provides even more power. Apple's iMac and Power Mac built around the G3 offer better performance and speed than the PII system at a lower cost.

1999 Apple released the **G4**, operating speeds of 500MHz and higher, the 128-bit processor is capable of performing 1 billion floating point operations (1 gigaflop) per second. Also features 1MB of L2 cache, bus speed of 100MHz.

RISC Processors

Both Motorola 680x0 and Intel 80x86 families are **complex instruction set computing (CISC)** processors. Instruction sets are large, typically containing 200 → 300 instructions. Newer theory – if the instruction set is small and simple, each instruction will execute quicker, thus allowing processor to complete more instructions during a given period. These type of CPU's are called **reduced instruction set computing (RISC)** processors. RISC design – used in the PowerPC but first implemented in mid 80's – results in faster cheaper processor.

Machine Cycles

A CPU executes an instruction by taking a series of steps. The complete series of steps is called a *machine cycle*.

Machine cycle can be broken down into

1. *Instruction cycle*

2. *Execution cycle.*

The instruction cycle has 2 steps

1. *Fetching*

Before the CPU executes an instruction the control unit must retrieve (*fetch*) a command or data from the memory.

2. *Decoding*

Before the command can be executed the control unit must break down (*decode*) the command into instructions corresponding to those in the instruction set.

The CPU is now ready to begin the execution cycle.

1. *Executing*

When the command is executed the CPU carries out the instructions in order by converting them to microcode.

2. *Storing*

CPU may be required to store the results of an instruction in memory (not always required).

The type of processor being used determines the number of steps in a machine cycle.

Although the process is complex the computer can accomplish it incredibly fast. CPU performance is often measured in *millions of instructions per second (MIPS)*.

Newer microprocessors perform faster by using a process called *pipelining*. The control unit begins a new machine cycle – i.e. begins executing a new instruction – before the current cycle is completed. Executions are performed in stages, when the first instruction completes the fetching stage, it moves to the decode stage and a new instruction is fetched. Using this technique some microprocessors can execute up to 6 instructions simultaneously.

Input Devices

Input device → enables you to input information and commands into the computer.

Standard

- Keyboard
- Mouse

Non-standard

Hand

- Pens
- Touch screen
- Game controllers

Optical

- Bar code readers

- Image scanners and optical character recognition

Audio visual

- Microphones and speech recognition
- Video input
- Digital cameras

Output devices

Monitor:

2 basic types of monitors used with pc's

- *CRT Cathode Ray Tube* – works in the same way as a TV screen using a large vacuum tube.
- *Flat Panel Display* – primarily used with portable computers and are becoming more popular with desktops.

Monitors can be categorised by the way they display colours,

- *Monochrome monitors* – one colour displayed against a contrasting background.
- *Greyscale monitors* – display various intensities of grey against a white background.
- *Colour monitors* – display anywhere from 16 to 16million colours.

PC Projectors

More common now to use software to create presentations directly to the screen. A pc projector plugs into one of the computer's ports and projects the video output onto an external surface.

Sound Systems

Speakers and their associated technology are now important output devices.

Printers

2 categories:

1. Impact
2. Non Impact

Impact

Creates an image by pressing an inked ribbon against paper using pins or hammers to shape the image e.g. typewriter.

Most common type of impact printer → Dot matrix.

Other types of impact printers

- Line Printers
- Band
- Daisy wheel Printers

Non-impact

Use other means to create an image.

Most popular types → Inkjet printers, Laser printers.

Other types of non-impact printers

- Snapshot Printer
- Thermal wax printers
- Dye – sub printers
- IRIS printers
- Plotters

Magnetic Disks

Diskette drives and hard disk drives are the most commonly used storage devices in PCs. Both fall into the magnetic storage category because they record data as magnetic fields.

Fundamental differences and similarities between the two:

- A diskette contains a single flat piece of plastic (the disk) coated with iron oxide enclosed in vinyl or plastic cover. A hard disk contains one or more rigid metal platters coated with iron oxide permanently enclosed in a hard disk drive.
- Diskettes are small and portable (they can be removed from diskette drives). Hard disks are usually built into the computer and are not portable (unless the computer is). Exceptions are removable hard disks and external hard drives which can be detached from the system.
- Floppy disks store only 1.44 MB although special floppy disks offer higher capacity. New hard disks can store several thousand times as much data as a diskette.
- Hard drives are much faster than diskettes, their disks spin faster and they locate data on the disks surface in much less time.

Almost all PCs sold today come with a hard disk and one disk drive. Some computers also feature a third built in magnetic device – a device that uses high capacity floppy disks.

Tape Drives

Read and write data to the surface of a tape the same way as an audiocassette – difference is that a computer tape drive writes digital data.

Optical Storage Devices

The most popular alternative to magnetic storage systems is optical storage media. The most widely used type of optical storage medium is the compact disk (CD), which is used in CD-ROM, DVD-ROM, CDR, CDRW and PhotoCD systems.

DVD-ROM

Digital video (or versatile) disk read only memory, is a high-density medium capable of storing a full-length movie on a single disk the size of a CD.

CD-R, CD-RW, PhotoCD

CD-R allows you to create your own CD-ROM disks that can be read by any CD-ROM drive. After the information has been written to the CD it cannot be changed.

Using CD-RW drives the user can write and overwrite data onto CDs. With a CD-RW data can be revised in the same manner as a floppy disk.

One popular form of recordable CD is PhotoCD, a standard developed by Kodak for storing digitised photographic images on a CD. Many film-developing stores now have PhotoCD drives that can store your photos and put them onto a CD.

Classifying Computers

Mainframe – the largest type of computer in common use is the mainframe. Mainframe computers are used in large organisations where a computer must handle massive amounts of data and many complicated processes. Mainframes are being used more as specialised servers on the www, enabling companies to offer secure transactions with customers over the Internet. In this type of application the mainframe system may be referred to as an enterprise server or an e-commerce server.

Midrange computers – less powerful, less expensive and smaller than mainframes but capable of supporting the computer needs of a smaller organisation or managing networks.

Workstations - are specialised single user computers with many of the features of PCs but with the processing power of a minicomputer. These powerful machines are popular amongst scientists, engineers, graphic artists, animators and programmers – users who need a great deal of processing power. Workstations typically use advanced processors, more RAM and storage capacities than PCs.

Minicomputers – A PC is one that can be placed on a desktop or can be carried from room to room. PCs are used as personal machines as well as for business.

Computer networks and client/server computing

The use of multiple computers linked by a communications network for processing is called **distributed processing**. In contrast to **centralising processing** where the processing is accomplished by one large central computer. Distributing processing distributes the processing work among PC's, midrange computers and mainframes that are linked together.

One widely used form of distributed processing is **client/server computing**. This splits the processing between “clients” and “servers”. The client is the user point of

entry for the required function and is normally a desktop computer, workstation or laptop. The user generally interacts directly only with the client portion of the application. The server provides the client with services.

In some firms client/server networks with PCs have actually replaced mainframes. The process of transferring applications from large computers to smaller ones is called downsizing. This can potentially reduce computing costs.

Network computers and peer to peer computing

In one form of client/server computing, client processing and storage capabilities are so minimal that the bulk of computer processing occurs on the server. Clients with minimal memory, storage and processing power which are designed to work on networks are called **network computers (NCs)**. NCs download software or data needed from a central computer.

Peer – to – peer computing

Another form of distributed computing puts processing power back onto users desktops, linking computers so they can share processing tasks. This model stands in contrast to the NCs because processing power resides on the individual desktop and these computers work together without a server or any central controlling authority.

Software

There are 2 major types of software – system software and application software.

System software is a set of generalised programs that manage the computers resources.

Application software describes the programs that are written to apply the computer to a specific task.

System software and PC Operating systems

System software co-ordinates the various parts of the computer system and mediates between application software and computer hardware.

Functions of the OS:

1. Provides instructions to display the on screen elements with which you interact. Collectively, these elements are known as the user interface.
2. Loads programs into the computers memory so that you can use them.
3. Co-ordinates how programs work with the CPU, RAM, keyboard, mouse, printer and other hardware as well as with software.
4. Manages the way information is stored on and retrieved from disks.

The OS provides an interface between programs and other computer resources. Programmers write programs with built in instructions called **system calls** that request services from the OS.

Some services that an OS provides to programs

- List all the files in a particular folder so as to retrieve a file to open.
- Saving the contents of a file from the disk onto memory.
- Reading the contents of a file from disk into memory.
- Sending a document to the printer and activating the printer.
- Providing resources that let you copy or move data from one document or program to another.
- Allocating RAM among various programs that you may have open.
- Recognising keystrokes or mouse clicks and displaying characters or graphics on the screen.

Multiprogramming/multitasking – the computer's ability to handle many different tasks and users at the same time. Permits multiple programs to share a computer's resources at any one time through the concurrent use of a CPU.

Software engineers use 2 methods to develop multitasking OS. The first requires cooperation between the OS and application programs. Programs that are currently running will periodically check the OS to see whether any other programs need the CPU. If any do, the running program will relinquish control of the CPU to the next program. This method is called **cooperative multitasking** and is used to allow activities such as printing while the user continues to type or use the mouse to input more data.

The second method is called **pre-emptive multitasking**. With this method the OS maintains a list of programs that are running and assigns a priority to each program in the list. The OS can intervene and modify a program's priority status by rearranging the priority list. With pre-emptive multitasking the OS can preempt the program that is running and reassign the time to a higher priority task at any time. Pre-emptive multitasking thus has the advantage of being able to carry out higher priority programs faster than lower priority programs.

Virtual storage – handles programs more efficiently because the computer divides the programs into small fixed or variable length portions storing only a small portion of the program in primary memory at one time. Only a few statements of a program actually execute at any one time. This permits a very large number of programs to reside in primary memory. All other program pages are stored on a peripheral disk unit until they are ready for execution.

Time-sharing – is an OS capability that allows many users to share computer processing resources simultaneously. It spends a fixed amount of time on one program before moving to another. Thousands of users are each allocated a tiny slice of computer time. This arrangement permits many users to be connected to a CPU simultaneously with each receiving only a tiny amount of CPU time.

Multiprocessing – an OS capability that links together 2 or more CPUs to work in parallel in a single computer system. The work can be divided between the CPUs.

Language translation and utility software – system software includes special language translator programs that translate high level language programs written in

programming languages into machine language called source code. A compiler translates source code into object code that can then be executed by the program.

Because they aid the inner workings of the computer systems utilities are grouped with the OS under the category of system software.

Popular utilities range from programs that can organise or compress the files on a disk to programs that help you remove programs that you no longer use from your hard disk. Some of the major categories of utilities include,

- File defragmentation
- Utilities
- Data compression programs
- Backup utilities
- Antivirus computers
- Screen savers.

With an OS you see and interact with a set of items on the screen, the **user interface**. In the case of most current OS the user interface looks like a collection of objects on a coloured background. Most current OS provide a graphical user interface (GUI). Apple computer introduced the first GUI with its Macintosh computer in 1984. GUIs are so called because you use a mouse (or other pointing device) to point at graphical objects on the screen.

Leading PC OS

- **Windows XP**
(eXPerience) combines reliability and robustness of Windows 98/Me with an improved GUI. It is meant for powerful new PCs with at least 400MHz of processing power and 128MB of RAM.
- **Windows 98**
Genuine 32 bit OS providing a streamlined GUI. Features multi-tasking and powerful network capabilities. It can support additional hardware technologies.
- **Windows Me**
Enhanced version of Windows 98. It has tools for working with photos and video recordings and tools to simplify networking. It also has a media player bundled with it.
- **Windows 2000**
Another 32 bit system with features that make it appropriate for applications in large networked organisations. Earlier versions of this were Windows NT.
- **UNIX**
An interactive, multiuser, multitasking OS developed by Bell labs in 1969 to help scientific researchers share data. UNIX can run on many different types of computers and can be easily customised. It is considered very powerful but very complex.

- **Linux**
A UNIX like OS that is free, reliable, compactly designed and capable of running on many different hardware platforms. It is an example of open-source software which provides all computers access to its program code so that they can modify it to fix errors or make improvements.
- **DOS**
16 bit OS for older PCs based on the IBM PC standard. Does not support multi-tasking and limits the size of a program in memory to 640kB.
- **Mac OS**
OS for the Mac featuring multi-tasking, powerful multimedia and networking capabilities and a mouse driven GUI.

Application Software

A software package is a prewritten precoded commercially available set of programs that eliminates the need for individuals or organisations to write their own software.

Word processing software

Stores text data electronically as a computer file. Allows the user to make changes electronically in memory eliminating the need to re-type the whole page to incorporate corrections. Software has formatting options to allow changes to elements such as line spacing and margins. The most popular packages are Microsoft Word and WordPerfect. Most word-processing packages has advances features that automate other writing tasks such as spelling checks.

Spreadsheets

Provides computerised versions of traditional modelling tools. Organised into a grid of columns and rows. The power of the spreadsheet lies in the ability of the program to recompute all associated values when you choose to change one. Useful for applications requiring modelling or what-if analysis. Many spreadsheet packages include graphics functions that can present the data in a variety of charts. The most popular packages include Microsoft Excel and Lotus 1-2-3.

Data Management Software

More suitable for creating and manipulating lists and for combining information from different files. PC database management packages have programming features and easy to learn menus that enable non specialists to build small information packages. Typically have facilities for creating files and databases and for storing, modifying and manipulation data for reports and queries. Popular packages include Microsoft Access.

Presentation graphics

Allows users to create professional quality graphics presentations. This software can convert numeric data into charts and other types of graphics and can include

multimedia displays of sound, animation, photos and video clips. Microsoft PowerPoint and Lotus Freelance Graphics are popular packages.

Integrated Software packages and Software suites

Combine the functions of the most important PC software packages such as word processing, spreadsheets, presentation graphics and data management. Provides a general purpose software tool and eliminates redundant data entry and data management. These packages do not generally have the same power and depth as single purpose packages.

Email software

Used for computer to computer exchange of messages and is an important tool for communication and collaborative work. A person can use a networked computer to send notes or longer documents to a recipient. Web browsers and the PC software suites have email capabilities but specialised email software packages are also available for use on the Internet.

Web browsers

Easy to use software tools for displaying Web pages and accessing the web and other Internet resources. Browsers can display or present graphics, audio and video information as well as traditional text. They have become the primary interface for accessing the Internet or for using networked systems based on Internet technology. The two leading commercial web browsers are Microsoft's Internet Explorer and Netscape Navigator.

Groupware

Provides functions and services to support the collaborative activities of work groups. Groupware includes software for group writing and commenting, information sharing, electronic meetings, scheduling and email and a network to connect the members of the group as they work. Any member can review the ideas of others and add to them or individuals can post documents for others to comment on or edit. Leading commercial software include Lotus notes and Opentexts Livelink.

Data Communications

Communications channels

The means by which data is transmitted from one device to another. A channel can use different kinds of telecommunications transmission media

- Twisted wire
- Coaxial cable
- Fibre optics
- Wireless transmission

Twisted-Pair Cable

Normally consists of 2 wires individually insulated in plastic and then twisted around each other and bound together in another layer of plastic.

Except for the plastic nothing shields the wire from outside interference so it is sometimes called UTP (unshielded twisted-pair). Some wires are encased in a metal sheath and are therefore called STP (shielded twisted-pair).

This type of wire is also sometimes called telephone wire as it is used for indoor telephone wiring. Today most twisted-pair wire used for network communication is made to more demanding specifications than voice grade wire.

Network media are sometimes compared by the amount of data that they can transmit per sec. The difference between the highest and lowest frequencies of a transmission channel is known as **bandwidth** – the higher the bandwidth the more data that can be transferred at any one time. Networks based on twisted-pairs now support transmission speeds of up to 1Gbps.

Coaxial Cable

Sometimes called **coax** is similar to cable used in cable television systems. There are 2 conductors in a coaxial cable – one is a single wire at the centre of the cable and the other is a wire mesh shield surrounding the first wire with an insulator in between.

It can support transmission speeds up to 10 Mbps and so can carry more data than older types of twisted-pair wiring. It is more expensive and less popular than the newly improved twisted-pair technology. 2 types of coaxial cable are used

- Thick – old and seldom used in new networks.
- Thin

Fibre-Optic Cable

A thin strand of glass that transmits pulsating beams of light rather than electric frequencies. The strand carries the light all the way from one end to the other bending around corners on the way. Light travels at much greater speeds than electrical signals → fibre-optic cables can carry data at more than a billion bps. Speeds are now approaching 100Gbps.

Fibre-Optics offer extraordinary bandwidth and are a very secure transmission medium. It is however relatively expensive and difficult to install.

Wireless Links

Wireless communication relies on radio signals or infrared signals for transmitting data.

4 common uses

1. Office LANs can use radio signals to transmit data between nodes.
2. Laptops can be equipped with cellular phone equipment and a modem.
3. Corporate WANs often use microwave transmission to connect 2 LANs within the same area. Requires unobstructed line of sight between 2 antennas.
4. WANs that cover large distances often use satellites and microwave communication.

Network Topologies

The topology – the physical or logical layout of the cables and devices that connect the nodes of the network. The 3 basic topologies are,

- Bus
- Star
- Ring

A lesser used technology

- Mesh

Factors in determining the topology or combination of topologies to use include

- Type of computers currently installed
- Type of cabling (if any) currently installed
- Cost of components and services required to implement the network
- Distance between each computer
- Speed with which the data must travel around the network.

The Bus Topology

A **bus** network uses a single conduit to which all the nodes and peripheral devices are attached.

Each node is connected in series to a single cable, at the cables start and end points a special device called a terminator is attached. This stops the network signals so they do not bounce back down the cable.

The disadvantages

- Keeping data from colliding requires extra circuitry and software.
- A broken connection can bring down or crash all or part of the network.

Primary advantage

- Uses the least amount of cabling of any topology.

The Star Topology

The **star** network is the most commonly used topology today. A device called a **hub** is placed in the centre of the network so all nodes are connected to the central hub and communicate through it.

Some hubs known as intelligent hubs can monitor traffic and help prevent collisions. A broken connection does not affect the rest of the network. If you lose the hub however all nodes connected to that hub are unable to communicate.

The Ring Topology

The **ring** topology connects the nodes of a network in a circular chain with each node connected to the next. The final node in the chain connects to the first one to complete the ring.

With this methodology each node examines data sent through the ring. If the data (known as a **token**) is not addressed to the node examining it, it passes it along to the next node in the ring.

There is no danger of collisions because only one packet of data may traverse the ring at a time. If the ring is broken the entire network is unable to communicate until the ring is restored.

The Mesh Topology

The **mesh** topology is the least used topology and the most expensive to implement. A cable runs from every computer to every other computer.

Advantage

- The data can never fail to be delivered, if one connection goes down there are other routes available.

This topology is impractical for most working environments but is ideal for connecting routers on the Internet.

How networks are structured

2 main types of networks distinguished mainly by geography,

- Local Area Network
- Wide Area Network

Local Area Networks

A **local area network (LAN)** is a network of computers located relatively near to each other and connected in a way that enables them to communicate with each other. A LAN can consist of just 2 or 3 PCs connected together to share resources or can include hundreds of different computers. Any network that exists within a single building or group of adjacent buildings is considered a LAN.

It may be helpful to connect different LANs together. To understand how this may be possible there is a need to understand how networks transmit data and how different types of networks share data.

On a small network data is broken into small groups called packets before being transmitted from one computer to another. A **packet** is a data segment that includes a header, payload and control elements that are transmitted together. The receiving computer reconstructs the packet into the original structure.

The payload is the part of the packet that contains the actual data being sent. The header contains info about the type of data in the payload, the source and destination of the data and a sequence number so that data from multiple packets can be reassembled at the receiving computer in the proper order.

Each LAN is governed by a **protocol**, which is a set of rules and formats for sending and receiving data and an individual LAN may utilise more than 1 protocol.

Some of the mail protocols in use today include

- **TCP/IP**
Originally associated with UNIX hosts, this is the protocol of the Internet and is required on every client machine for direct communication across the Internet to occur. TCP/IP is now the default networking protocol on Win. 2000 and many other OS.
- **IPX/SPX**
A proprietary protocol of Novell and has been used in most versions of the Netware network OS for networking offices throughout the world.
- **NetBEUI**
Relatively simple protocol with no real configurable parameters. Sends messages through broadcasts to every computer that can receive it. It is an

excellent protocol for networking small offices or homes but does not expand well into larger environments. NetBEUI was the default networking protocol of Win 3.11, Win 95 and other Microsoft client OS.

- **DLC**

Originally a protocol used with large mainframe computer systems, it is now used to control communications with network printers. It allows the printers to be configured remotely and to send status messages.

If 2 LANS are built around the same communication rules then they can be connected with one of 2 devices

1. **Bridge**

A device that looks at the information in each packet header and forwards the data that is travelling from one LAN to another.

2. **Router**

More complicated device that stores the routing info for networks. Like a bridge a router looks at the packet header to determine where the packet should go and then determines a route for the packet to take and thus reach its destination.

If you need to create a more sophisticated connection between networks you need a **gateway**, a computer system that connects the 2 networks and translates information from one to the other. Packets from different networks have different types of information in their headers and the info can be in various formats. The gateway can take a packet from one type of network, read the header, encapsulate the whole packet into a new one, adding a header that is understood by the second network.

Wide Area Network

A **wide area network (WAN)** is 2 or more LANs connected together generally across a wide geographical area. Each site needs resources, data and programs locally but it also needs to share data with the other site. To accomplish this routers can be connected over public utilities (such as phone lines) to create a WAN. A WAN does not have to include any LAN systems e.g. 2 distant mainframe computers can communicate through a WAN even though neither is part of a LAN.

Geographical distance aside the main difference between a WAN and a LAN is the cost of transmitting data. In a LAN all components are typically owned by the organisation that owns them. To transmit data across great distances a WAN based organisation typically lease many of the components used for data transmission – such as high speed phone lines or wireless technologies such as satellite.

Internet Basics

The Beginning

Seeds of the Internet were planted in 1969 when the Advanced Research Projects Agency (ARPA) of the US department of defence began connecting computers at different Universities and defence contractors. Goal → To create a large computer network with multiple paths that could survive a nuclear attack or other disaster.

Soon after the first links in **ARPANET** were in place engineers and scientists began exchanging data beyond the scope of the defence department's original objectives. The users convinced ARPA that the unofficial uses were helping to test the capacity of the network.

Initially the network included 4 primary host computers. A **host** is like a network server providing services to other computers that connect to it. ARPANET's host computers provided file transfer and communication services and gave connected systems access to the network's high-speed data lines. The system grew quickly and spread widely as the number of hosts grew.

It jumped across the Atlantic to Norway and England in 1973 and it never stopped growing. In the mid 80s another federal agency the National Science Foundation (NSF) joined the project after the DoD dropped its funding. NSF established 5 supercomputing centres that were available to anyone who wanted to use them for academic research purposes.

The NSF expected the supercomputers users to use ARPANET to obtain access but quickly discovered that it could not handle the load. NSF created a new higher capacity network called **NSFnet** to complement the older overloaded ARPANET. The link between ARPANET, NSFnet and other networks was called the **Internet**.

NSFnet made Internet connections widely available for academic research but did not permit users to conduct private business over the system. Therefore several telecommunications companies built their own network backbones that used the same protocols as NSFnet. A network's **backbone** is the central structure that connects other elements of the network. These private portions of the Internet were not limited by NSFnet's appropriate use restrictions so it became possible to use the Internet to distribute business and commercial information.

Interconnections (known as gateways) between NSFnet and the private backbones allowed a user on any one of them to exchange data with all others. Other gateways were created between the Internet and other networks, some that used completely different network protocols.

The original ARPANET was shut down in 1990 and government funding for NSFnet was discontinued in 1995 but the commercial Internet backbone services have easily replaced them. By the early 90s interest in the Internet began to expand dramatically. The system that had been created as a tool for surviving nuclear war found its way into businesses and homes.

Today

Today the Internet connects thousands of networks and more than 100 million users around the world. It is a huge cooperative community with no central ownership. This lack of ownership is an important feature of the Internet because it means that no single person or group controls the network. Although there are several organisations (such as the Internet Society and the WWW Consortium) that propose standards for Internet related technologies and guide lines for appropriate use, these organisations almost universally support the Internet's openness and lack of central control.

As a result the Internet is open to anyone who can access it. If you can use a computer and it is connected to the Internet you are free not only to use the resources posted by others but to create resources of your own, that is you can publish documents on the World Wide Web, exchange email messages and perform many other tasks.

How the Internet works

The single most important fact to understand about the Internet is that it can potentially link your computer to any other computer. Anyone with access to the Internet can exchange text, data files and programs with any other user. For all practical purposes almost everything that happens on the Internet is a variation of one of these activities. The Internet itself is the pipeline that carries the data between computers.

TCP/IP: the Universal Language of the Internet

The Internet works because every computer connected to it uses the same set of rules and procedures (protocols) to control timing and data format. The protocols used by the Internet are called **Transmission Control Protocol/Internet Protocol** universally abbreviated as **TCP/IP**.

These protocols include the specifications that identify individual computers and that exchange data between computers. They also include rules for several categories of application programs so programs that run on different kinds of computers can talk to one another.

TCP/IP software looks different on different types of computers but it always presents the same appearance to the network. It does not matter if the system at the other end of a connection is a supercomputer, pocket size PC or anything in between – as long as it recognises TCP/IP protocols it can send and receive data through the internet.

Routing Traffic Across the Internet

Most computers are not connected directly to the Internet. Rather they are connected to smaller networks that connect to the Internet backbone through gateways. This is why the Internet is sometimes described as a *network of networks*. The core of the Internet is the set of backbone connections that tie the local and regional networks together and the routing scheme that controls the way each piece of data finds its destination.

The Internet includes many thousands of servers each with its own unique address. These servers in tandem with routers and bridges do the work of storing and transferring data across the network.

Because the Internet creates a potential connection between any 2 computers the data may be forced to take a long circuitous route to reach its destination. Suppose for example you request data from a server in another area,

1. Request must be broken into packets

2. Packets are routed through your local network and possibly through one or more subsequent networks to the Internet backbone.
3. After leaving the backbone the packets are routed through one or more networks until they reach the appropriate server and are reassembled into the complete request.
4. Once the destination server receives your request it begins sending you the requested data which winds its way back to you possibly over a different route.

Between the destination server and your PC the request and data may travel through several different servers each helping to forward the packets to their final destination.

Addressing Schemes – IP and DNS Addresses

Internet activity can be defined as computers communicating with each other using the common language of TCP/IP. Examples are

- Client system communicating with an Internet server.
- Internet server computer communicating with a client computer.
- 2 server computers communicating with each other.
- 2 client computers communicating via one or more servers.

The computer that originates a transaction must identify its intended destination with a unique address. Every computer on the Internet has a four part numeric address called the **Internet protocol address (IP address)** which contains routing information that identifies its location. Each of the four parts is a number between 0 and 255 so an IP address looks like 194.145.128.14

Computers have no problems working with long strings of numbers but we are not so skilled! Most computers on the Internet also have an address called a **domain name system (DNS)** address, an address that uses words rather than numbers.

Domains and Sub domains

DNS addresses have 2 parts

- Host name – name for a computer connected to the Internet
- **Domain** – generally identifies the type of institution that uses the address.

This type of domain name is often called a **top-level domain**.

Most common types of Internet domains,

Domain	Type of Organisation	Example
.com	Business (commercial)	ibm.com
.edu	Educational	centre.edu
.gov	Government	whitehouse.gov
.mil	Military	Navy.mil
.net	Gateway or host	Oceanfree.net
.org	Other organisation (typically non profit)	isoc.org

Some large institutions and corporations divide their domain addresses into smaller **sub domains**.

In 1996 the Internet Assigned Numbers Authority (IANA) and the Internet society began an organised movement to create an additional set of top-level Internet domains. The action was necessary because many companies and private groups were finding it difficult to devise suitable domain names for their Internet sites. There was only so much room in the .com domain and some companies found that their mane or product name was already in use.

The group's goal was to expand the list of top-level domains to make it easier for organisations of all kinds to create an Internet domain for themselves. The group developed the Generic Top-Level Domain Memorandum of Understanding (TLD-MoU) which spells out proposals for the future management of Internet domains and proposes 7 new top-level domains for future use

Domain	Types of Organisation
.firm	Businesses or Firms (equivalent to .com)
.shop	Businesses offering purchases over the Internet
.web	Organisations involved in web related activities
.arts	Organisations promoting artistic or entertainment activities over the Internet
.rec	Organisations promoting recreational activities over the Internet
.info	Organisations providing information services over the Internet
.nom	Individual, family or personal nomenclature

Major Features of the Internet

The popularity of the Internet is due more to content than connectivity.

As a business tool it has many uses. Email is an efficient and inexpensive way to send and receive messages and documents around the world. The www is becoming an important advertising medium and channel for distribution. Databases and online information archives are often more up to date than any library. The Internet also has virtual communities made up of people who share interests.

Most individual users connect the computers modem to the phone line and set up an account with an **Internet Service Provides (ISP)** providing local and regional access to the Internet backbone. Many others connect through a school or business LAN.

The World Wide Web

The web was created in 1989 at the European Particle Physics Lab in Geneva as a method for incorporating footnotes figures and cross-references into online hypertext documents. A hypertext document is a specially encoded file that uses the **hypertext markup language (HTML)**. This language allows a documents author to embed **hypertext links** (called **hyperlinks** or **links**) into the document.

As you read a hypertext document (**web page**) on screen you can click on an encoded word or picture and immediately jump to another location. A collection of web pages is called a **web site**, and these are housed on a **web server**. Copying a page to the server is called posting the page (or publishing or uploading).

Popular web sites receive millions of **hits** (or **page views**) per day. Many web masters measure their sites success by the number of hits in a given timeframe. A **Webmaster** is the person or group responsible for designing and maintaining a website. The terms www and Internet are used interchangeably however the www is just one part of the Internet.

Web browsers and HTML tags

Mosaic, a point and click web browser was developed at the University of Illinois in 1993. A **web browser** is a software application designed to find hypertext documents on the web and open them on the users computer. A web browser displays a web page as specified by the pages underlying HTML code. The code provides the browser with

- Fonts and font sizes
- Where and how to display graphics
- If and how to display sound, animation or other special content.
- Location of links and where to go if they are clicked.
- Whether special programming codes, which the browser needs to interpret, are used in the page.

HTML tags which are enclosed in angle bracket (<>) tell the browser how to display individual elements on the page. They are placed around the portions of the document that they affect. Most tags have a starting tag such as <H1> and an ending tag such as </H1>. A slash indicates a finishing tag.

HTTP and URLs

The internal structure of the World Wide Web is built on a set of rules called **hypertext transfer protocol (HTTP)**. HTTP uses Internet addresses in a special format called a **uniform resource locator (URL)** that look like, type://address/path. Type specifies type of server on which the URL is located. Address is the address of the server. Path location within the file structure of the server.

Home Pages

- Personalised start page
On your browser you can choose a web page that opens immediately when you launch the browser.
- Web site home page
A web sites primary page is also called a home page. This is the first page that you see when you type the sites basic URL.

Helper Applications and multimedia content

Large files such as audio and video require special applications in order to be played in real time across the Web. These applications are called **helper applications** or **plugins**.

Plugins are used to support several types of content including **streaming audio** and **streaming video**. One of the most commonly used plugin applications is macromedias Shockwave, enabling web designers to create high quality animation or video with sound that plays directly within the browser window.

Finding content with a search engine

Specialised Web sites called **search engines** use powerful data searching techniques to discover the type of content available on the Web. By using a search engine and specifying your topic of interest you can find the right site of information.

Popular Search Engines

- Alta vista – <http://www.altavista.com/>
- Excite – <http://www.excite.com/>
- Hotbot – <http://www.hotbot.com/>
- Webcrawler – <http://www.webcrawler.com/>
- Yahoo! – <http://www.yahoo.com/>
- Google – <http://www.google.com/>
- Metacrawler – <http://www.metacrawler.com/>

Electronic Mail

Popular Internet email programs include

- Eudora
- Microsoft Outlook
- Netscape Messenger

If you have an account with an ISP then you can establish an email address. This unique address allows other users to send messages to you and allows you to send messages to others. A user can set up an account by specifying a unique **user name**. When you send a message you must include a persons username in the address e.g. nora@maths.tcd.ie

When you send email the message is stored on a server until the recipient retrieves it. This type of server is called a **mail server** and many use the **post office protocol** and are called **POP servers**.

Listserv systems

One type of mailing list that uses email is an automated list server or **listserv**. Users on the list can post their own messages so the result is an ongoing discussion.

News

The Internet supports a form of public bulletin board called **news**. Many of the most widely distributed **newsgroups** are part of a system called **Usenet**. Users post **articles** about the groups topic and as others respond they create a thread of linked articles. A newsreader program obtains articles from the **news server** using the **network news transfer protocol (NNTP)**. To see articles posted on a specific topic you subscribe to the newsgroup addressing that topic.

Major Usenet domains

- Comp – computer related
- Sci – science and technology (not computers)
- Soc – social issues and politics
- News – topics related to Usenet
- Rec – arts hobbies and recreational activities
- Misc – all other topics.

Telnet – Remote Access to distant computers

This is the Internet tool for using one computer to access a second computer. You can send commands that run programs and open text or data files. Connecting to a Telnet host is easy, enter the address and the telnet program establishes a connection.

FTP

File Transfer Protocol is the Internet tool used to copy files from one computer to another. When a user has accounts on more than one computer FTP can be used to transfer data or programs between them.

Internet Relay Chat (IRC)

Internet Relay Chat, or just chat is a popular way for Internet users to communicate in real time with other users. Chat does not require a waiting period between the time you send a message and the time the other party receives it. IRC is often referred to as the CB radio of the Internet because it enables few or many people to join a discussion.

Accessing the Internet

- Direct Connection
Programs run on the local computer which uses TCP/IP protocols to exchange data with another computer through the Internet. An isolated computer connects to the Internet through a serial data communications port using SLIP (serial line interface protocol) or PPP (point to point protocol).
- Remote Terminal Connection
Exchanges data and commands in ASCII format with a host computer that uses UNIX or similar OS. TCP/IP application programs and protocols all run on the host. This is known as a shell account as the command set in UNIX is called a shell.
- Gateway Connection

Even if a LAN does not use TCP/IP commands and protocols it may provide some Internet services. Such networks use gateways that convert commands and data to TCP/IP format.

- **Connecting Through a LAN**

If a LAN uses TCP/IP protocols for communication within the network it is simple to connect to the Internet through a router, another computer that stores and forwards data to other computers on the Internet.

- **Connecting Through a Modem**

If there is no LAN on site a stand alone computer can connect to the internet through a serial data communications port and a modem using either a shell account and a terminal emulation or a direct connection with a SLIP (serial line interface protocol) or PPP (point to point protocol) account.

- **High Speed Data Links**

Using fibre optics, microwave and other technologies it is entirely practical to establish an Internet connection that is at least 10 times faster than a modem connection.

- ISDN service
- xDSL services
- Cable modem service

Working on the Internet

Businesses and Firewalls

A firewall is set up to control access to a network by people using the Internet. Firewalls act as barriers to unauthorised entry into a network that is connected to the Internet, allowing outsiders access to public access areas but preventing them from exploring proprietary areas of the network.

A firewall system can be hardware, software or both. It works by inspecting requests and data that travel between the private network and the Internet. If the request or data does not pass the firewalls security inspection it is stopped from travelling any further.

Intranets and Extranets

An intranet is a LAN or WAN that uses TCP/IP protocols but belongs exclusively to a corporation, school or organisation. It is accessible only to the organisation's workers. If it is connected to the Internet then it is secured by a firewall to prevent unauthorised access.

An extranet is an intranet that can be accessed by outside users over the Internet. To gain entrance an external user typically must log on to the network by providing a valid user ID and password.

Intranets and Extranets are popular for several reasons including

- Use standard TCP/IP protocols → simpler and less expensive to install and configure.
- Enable users to work in standard web browsers providing a consistent interface.
- Function readily with firewalls and other standard security technologies.

Issues for Business Users and Telecommuters.

- Ownership
Any piece of text or graphic retrieved from the Internet may be covered by trademark or copyright law making it illegal to use it without the owners consent.
- Libel
If email messages are sent through an employers network then the employer may become involved if the sender is accused of libel.
- Appropriate use
When using a business network to access the Internet users must be careful to use network resources appropriately.

Commerce on the www

Using an e-commerce site is like browsing through an online catalogue. When you are ready to make your purchases you can pay in several ways,

- One time credit card purchases
Provide your personal and credit card information each time you make a purchase.
- Set up an online account
If you think you will make more purchases with the online vendor you can set up an account at the web site. The vendor stores your personal and credit card information on a secure server and a cookie is placed on your computer disk. Later when you access your account using a user ID and password the site uses the information in the cookie to access your account.
- Use electronic Cash
Also called digital cash. Takes the form of a redeemable electronic certificate which can be purchased from a bank that provides electronic cash services. Not all e-commerce web sites accept digital cash yet.
- Electronic wallet
Program on your computer that store credit card information, a digital certificate that verifies your identity and shipping details. Not accepted by all e-commerce sites.

Security

Reputable e-commerce sites use sophisticated measures to ensure that customer information cannot fall into the wrong hands. One way is to use **secure web pages**.

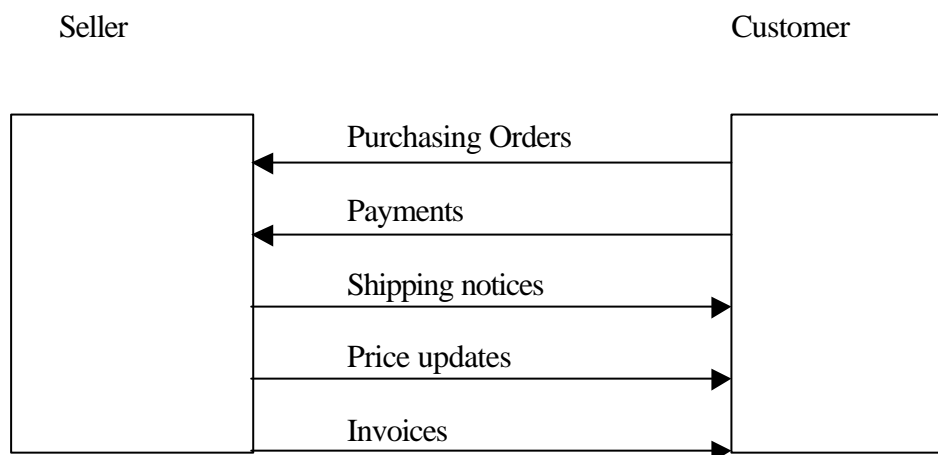
One way to provides secure websites is to encode pages using **secure sockets layer (SSL)** technology which encrypts the data. Another way is to use **secure HTTP (S-HTTP)**. SSL can be used to encode any amount of data, S-HTTP is used to encode individual pieces of data.

Electronic Data Interchange

EDI is a key technology for e-commerce as it allows the computer to computer exchange between 2 organisations of standard transaction documents such as

invoices, bills of lading or purchase orders. It lowers transactions costs because they can be automatically transmitted from one information system to another through a telecommunications network eliminating the printing and handling of paper at one end and the input of data at the other. EDI may also provide strategic benefits by helping a firm lock in customers making it easier for customers to order from them rather than competitors. It can curb inventory costs by minimising the amount of time components are in inventory.

EDI differs from email in that it transmits an actual structured transaction as opposed to unstructured text messages such as a letter.



Organisations can most fully benefit from EDI when they integrate the data supplied by EDI with applications such as accounts payable, inventory control, shipping and production planning and when they have carefully planned for the organisational changes surrounding new business processes. Management support and training in the new technology are essential. Companies must also standardise the form of the transactions that they use with other forms and comply with legal requirements for verifying that the transactions are authentic. Many organisations prefer to use private networks for EDI transactions but are increasingly turning to the internet for this purpose.

How Intranets support Electronic Business

Intranets are inexpensive, scalable to expand or contract as needs change and accessible from most computing platforms. Most companies must support a multiplicity of computer platforms that cannot communicate with each other. Intranets provide instant connectivity uniting all computers into a single virtually seamless network system. Web software presents a uniform interface which can be used to integrate many different processes and systems.

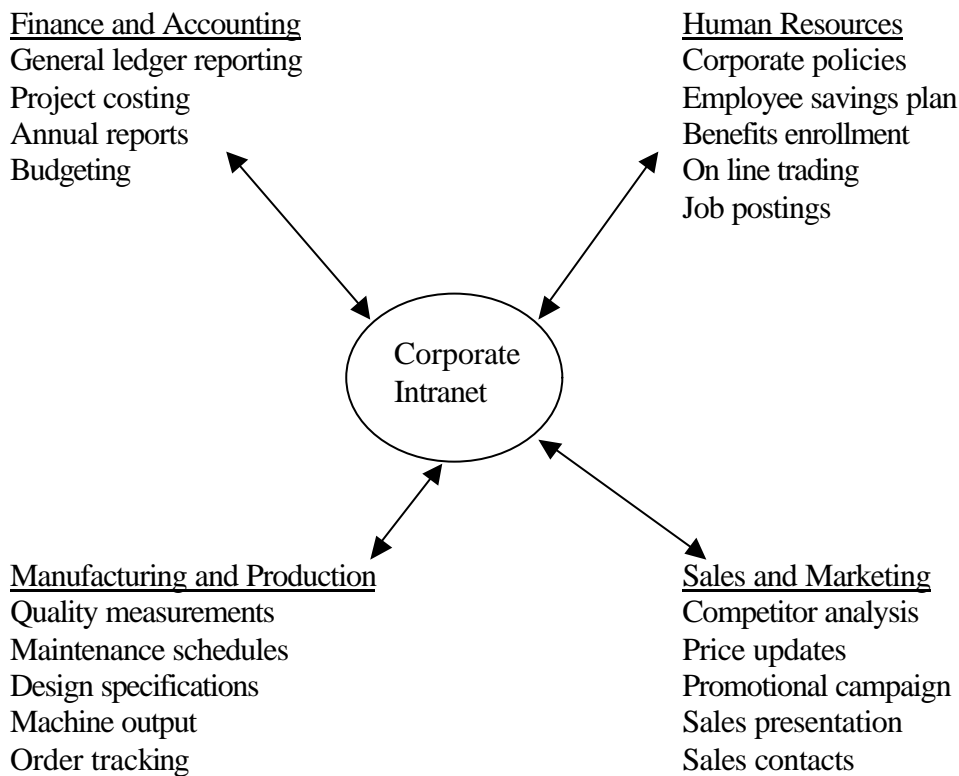
Intranets can help organisations create richer more responsive information environments. Internal corporate applications based on the web page model can be made interactive using a variety of media. A principle use of intranets has been to create on line repositories of information that can be updated as often as required.

This event driven publishing allows organisations to respond more rapidly to changing conditions.

Intranets and group collaboration

Intranets provide a rich set of tools for creating collaborative environments where members of an organisations can exchange ideas, share information and work together on common projects regardless of their physical location.

Intranet applications for ebusiness



See the tables 4-5 – 4-8 in the handout.

Intranets can be used to simplify and integrate business processes spanning more than one functional area. These cross functional purposes can be co-ordinated electronically increasing organisational efficiency and responsiveness and can be co-ordinated with the business processes of other companies. Using Internet technology all members of the supply chain can instantly communicate with each other using up to date information to adjust purchasing, logistics, manufacturing, packaging and schedules.

Table 4-9
Figure 4-9.

Management challenges and opportunities

Managers need to carefully review strategy and business models to determine how to maximise the benefits of Internet technology. Managers should anticipate making organisational changes to take advantage of this technology including business processes, new relationships with the firms value partners and customers and new business designs. Determining how and where to digitally enable the enterprise with Internet technology is a key management decision.