Definitional Concepts of Information Technology

First Authored:

Richard Heeks and Alemayehu Molla, IDPM, University of Manchester, 2004

Adapted for MIS Class in University of Ghana by

Dr Richard Boateng, ICITD, Southern University and University of Ghana Business School, 2009

Email:

Richard@pearlrichards.org

UNDERSTANDING INFORMATION TECHNOLOGY

This handout mainly deals with descriptions of data and information technology (IT) concepts and terminologies. Why is it important to understand these technical terms?

There are several answers. First, many of these terms come up in later sessions, and therefore need to be understood. Second, whilst you can, in theory, use computers without understanding the technology, in practice the more you understand, the better. The best racing drivers not only understand how to drive – they also understand how their cars work. The same is true of the best computer users – the more they understand about information technology, the more confident and competent they become. Third, understanding the technical terms enables you to talk to or understand IT specialists.

1. INFORMATION TECHNOLOGY

***Information Technology (IT)*:** describes an organization's computing and telecommunications hardware and software technologies that provide automatic means of handling and communicating information.

From the above definition, two possible divisions of IT could be drawn

- Computer (an electronic device that can process and store information) vs. telecommunications (transmission of information between devices in different locations).
- Hardware (the physical equipment) vs. software (the instructions)

It is the second categorisation that will be used for further exploration of IT below, together with exploring the data that is handled by IT.

2. DATA REPRESENTATION IN INFORMATION TECHNOLOGY

A computer is structured in such a way that it operates with devices having only two states: electric switches which are open or closed; electrical pulses high or not high; or magnetized elements having one of two directions or polarities. These two states are represented by 0 or 1 and are referred to as BINARY DIGITS or BITS. Internally, the microprocessor recognizes only these two symbols.

Human beings, however, use numbers, alphabetic and special characters when communicating with the computer. Therefore, the computer needs to represent these decimal numbers, alphabetic and special characters, using the binary digits " 0's" and "1's" by using a coding mechanism. The coding system defines the codes between a natural language and binary symbols. For example, one of the most widely used coding mechanisms is ASCII (American Standard Code for Information Interchange). Some examples of ASCII code are

Character	ASCII
A	0100 0001
Q	0101 0001
+	0010 1011
/	0010 1111
0	0011 0000
9	0011 1001

In addition documents, photographs, drawings, recordings of sound or video, etc. – have to be converted into this 0/1 data before IT can handle them. This conversion process is known as *digitisation* (i.e. converting into the digits 0 and 1). Digitised information can be numbers, text, images, audio or video. Digitisation is the key to making use of information technology: once information has been digitised it can be subjected to a wide variety of manipulations and transmissions that are not possible with manual systems. If information is not digitised, it cannot be handled by IT.

3. TIME AND SIZE IN THE COMPUTER WORLD

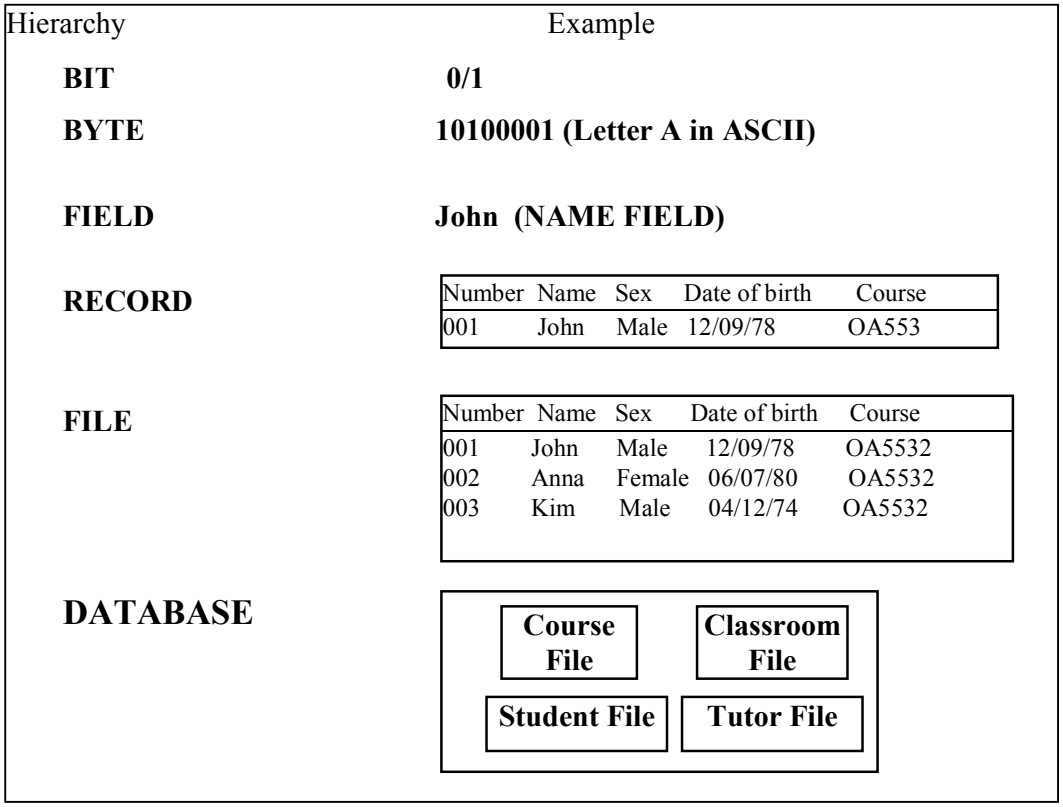
The following table summarizes some key levels of time and size that are useful in describing the speed and capacity of computers.

Time		Size	
Second		Byte	string of 8 bits
Millisecond	1/1000 second	Kilobyte	1000 bytes
Microsecond	1/1,000,000 second	Megabyte	1,000,000 bytes
Nanosecond	1/1,000,000,000 second	Gigabyte	1,000,000,000 bytes
Picosecond	1/1,000,000,000 second	Terabyte	1,000,000,000,000 bytes

4. DATA ORGANIZATION

When information is handled by information technology, it is often referred to as *data*, i.e. as unprocessed information. We can most usefully think of data as being organised in a hierarchy, as summarised in Figure 1.

Figure 1: The Data Hierarchy



- A **BIT** represents the smallest unit of data a computer can handle. A group of bits is called a **BYTE** and represents a single character, which can be a letter, number or other symbol. A grouping of character is called is called a **FIELD.**

- *Field*: an item of data about an *entity*.. Terms such as *attribute* or *data element* are sometimes used to represent the same thing as a field. An entity is any person, place, event or thing about which data is held. For example, in the figure above, "student" is an entity about which data is being kept, other entities include course, classroom and tutor. A student entity has several fields such as number, name, date f birth and so on. There should be a *primary key field* that uniquely identifies each entity. For example, in the above figure, student number would be a primary key field (not name since there could be two students with the same name).

  - *Record*: a grouping of related data elements that represents one specific entity. A record forms a single entry in a file or database. Each record consists of several fields, and shares field names in common with the other records.

  - *File*: a collection of related records. In some situations, this is called a *table*. For example, a student file in . Each file consists of several records.

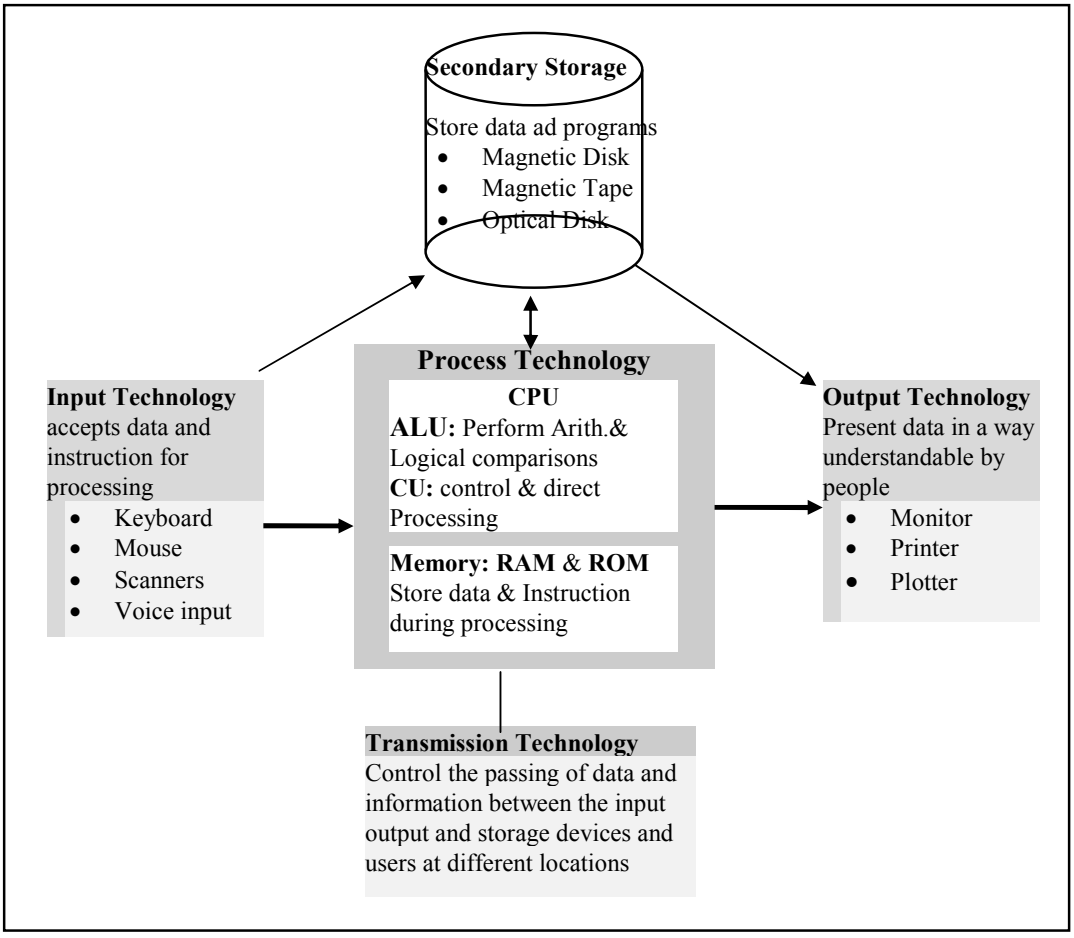
  - *Database*: a well-defined and managed collection of data. It may consist of a number of related files, such as for example student, course, tutor, classroom files.

5. HARDWARE

Hardware: the physical components that make up any set of information technology. More simply, hardware represents any part of information technology that you can drop on your foot: the keyboard, monitor, disks, processors, printers, network cables, etc.

To provide an understanding of the different types of IT hardware, a process view of an information system is relevant. Information systems involve the input, process, storage, output and transmission of data and information. In an IT based IS each of these activities are associated with a certain form of IT. Figure 2 provides a pictorial description of these technologies.

Figure 2: Components of IT Hardware



Each of the above components will now be described in turn. In each of the sections that follows, there are up to four sub-sections:

- *Technologies in Common Use*: these are technologies that typical users are likely to come across in their use of computers; they also recur throughout the book.
- *Other Technologies*: these are technologies that are not so commonly-used; they may be recent innovations or have only a specialised application.

- *Other Relevant Definitions*: these are technical terms that relate to the particular technologies.
- *Technology Trends*: these provide a quick summary of general ways in which particular types of technology are changing at the moment.

Input Technology

i. Input Technologies in Common Use

- *Keyboard*: used to input text or numerical data or commands to the computer.
- *Mouse*: a handheld device used to select objects or commands, or to draw images, via a pointer on the computer screen.
- *Scanner*: converts both text and images from paper into a digital form. Digitising text or marks on paper is often known as *optical character recognition (OCR).*
- *Bar Code Reader*: converts the printed lines of the bar code into digital form.

ii. Other Input Technologies

- *Voice Recognition System*: hardware that allows human speech to be understood and converted into digital form
- *Pen-based System*: hardware that allows human handwriting to be understood and converted into digital form by writing on a sensitive screen with a special pen.
- *Touch Screen*: a special screen that allows you to select on-screen objects or commands by pointing to them directly with your finger.
- *Digital Camera*: a camera that records its pictures as a digital image rather than as a photographic image on film.

iii. Input Technology Trends

The main trend in input technologies is *towards direct input devices that are easy to use.* It is becoming easier, quicker and cheaper to digitise data. There is also an increasing ability to digitise human outputs, such as speech and writing. This is helping increase the ability of computers to work with non-Roman script languages such as those used in Asia, the Middle East and some parts of Africa.

Process Technology

i. Process Technologies in Common Use

- *Central Processing Unit (CPU)*: the core of any computer, that manipulates data by performing arithmetic computations on the computer's 0/1 data, and which also controls the other parts of the computer system. Often called the computer *chip* because it is made from a single slice, or chip, of silicon. It works by following the instructions specified in the computer's software programs (see section on software for further explanation).

ii. Other Relevant Definitions

- *Megahertz (MHz)*: one million cycles per second. A measure of the speed of the 'internal clock' of the computer's CPU that synchronises the work of the CPU components. In very

basic terms, the faster the speed of the clock (i.e. the more megahertz), the faster the computer can process data.

- *Mips*: million instructions per second. A measure of the speed of processing of the CPU.

iii. Process Technology Trends

The overall trend is for cheaper, smaller, faster, more reliable processors. This has been partly based on developments in CPU component technology (the bits that make up the CPU). There have been five major generations (Table 1) in the history of processors development and over the past 40 years processing power has doubled approximately every 12 to 18 months, a phenomenon commonly known as Moore's law.

Table 1: Generations of Processor Technology

Generation	**Technology**	**Typical Cost**
First generation	Valves (Vacuum Tubes)	US$2,500,000
Second generation	Transistors (invented in 1947)	US$250,000
Third generation	*Integrated circuit (IC)* grouping an entire electronic circuit of several transistors and other components onto the same semi-conductor chip/silicon wafer (invented in 1958)	US$25,000
Fourth generation	*Large Scale IC (LSCI) Microprocessor* grouping all processing functions onto a single chip (invented in 1971)	US$2,500 at first US$250 now
Fifth generation	Very Large Scale Integrated Circuits (VLSIC)	

A further trend, for example within microprocessors, has been the emergence of global standards. Intel is a US company that produces the CPUs for many microcomputers throughout the world. It has developed a series of generations of microprocessor CPUs, with each generation being faster (because of faster clock speeds) and more powerful than the previous generation. When purchasing microcomputers, you often need to understand the latest generations available.

Table 2: Generations of Intel Microprocessors

Intel Microprocessor Generation Name	Date of First Use	Clock Speed Range (MHz)
4004	1971	0.108 (108 kilohertz)
8080	1974	2
8086	1978	4.47
286	1982	8-28
386	1985	16-33
486	1989	20-133
Pentium	1993	66-200
Pentium Pro	1995	150+
Pentium II	1997	266+
Pentium III	1999	450+
Pentium 4	2000	1500 (1.5 Gigahertz)
Itanium	2001	1500+

To give a further idea of change, the 8086 chip contained 29,000 transistors. Pentium 4 chips contain about 42 million transistors.

Storage Technology

Storage technologies are normally classified as primary and secondary. While the primary storage refers to the computer memory, other technologies that are used for keeping a permanent record of data, information and instruction after (and before) the computer is used are commonly known as secondary storage technologies.

i. Storage Technologies in Common Use

Primary Storage

- *Memory*: retains or stores electronic representation of programs or data inside the computer. Broadly speaking, there are two types of memory chips, which are used for different purposes: Read Only Memory (ROM) and Random Access Memory (RAM).

  - *RAM (random access memory)* on which you can store (write) and retrieve (read) data and instructions, and which loses all data when the computer's power is turned off. All other storage hardware retains its data even when the power is off. RAM is used for holding data or instructions temporarily just prior to, or just after, processing by the CPU and forms the main workspace of a computer. Normally, a computer's memory capacity refers to the RAM size and is one of the factors that affect the speed of the computer

  - *ROM (read-only memory)* holds permanent data or instructions built into the chip at the factory, and may be read (retrieve data or instructions) from but not written to - that is, you cannot change the instructions on them. ROM, as its name suggests, cannot store any additional data, but it retains its existing data even when the power is off. ROM is typically used for performing specific tasks such as helping start up the computer when it is switched on.

Secondary Storage

- *Hard Disk*: a set of rotating inflexible disks covered in magnetisable material, and typically built into the computer. Disks are faster than tape because each surface has a floating electro-magnetic reading/writing 'head' that can move very quickly to any location on the disk. Disk is slower (though cheaper per byte stored) than computer memory and is used for permanent storage of files and software programs.
- *Floppy Disk*: a single rotating flexible disk covered in magnetisable material, held inside a plastic case (often blue or black). It can be put in and out of the *disk drive* that is held within the computer box. The disk drive houses the motor that turns the floppy disk and the reading/writing head. The most commonly-used format of floppy disk is the $3^{1}/_{2}$-inch size. Floppy disks hold much less data than a hard disk but have the advantage that they can easily be moved from one computer to another.
- *CD-ROM*: compact disk read-only memory. An optical disk similar to those used for music, from which data is written and read by a laser beam. Data is stored by burning away (0) or leaving (1) tiny reflective spots on the CD. CDs can hold large amounts of data (equivalent to 200,000 typed pages) but, like other ROM, can only be used to read pre-recorded data rather than for storage of additional data. They are mainly used for distributing large files such as software programs, books or audio and video data.
- *DVD-ROM*: digital versatile disk read-only memory. Like CDs, these are optical disks, but they have a capacity at least seven times greater.
- *Magnetic Tape*: plastic tape covered in magnetisable material. In simple terms, all magnetic media (i.e. both tape and disks) store data by magnetising (1) or demagnetising (0) tiny areas on the brown iron oxide surface. To access an item of data on tape, you have to wind the tape all the way through to the relevant spot. Tapes are therefore relatively slow but can hold large amounts of data quite cheaply and are therefore used mainly for archiving or 'backing up' large files.

ii. Other Storage Technologies

- *WORM*: write once, read many optical disk. A special type of compact disk and disk drive that can write data onto a blank CD once, and then read it off many times.
- *Erasable Optical Disk*: a special type of compact disk and disk drive that allows data to be written, read and erased just as with a conventional floppy disk (except much more costly and with a far higher storage capacity). Because they generally use a combination of magnetic and optical material, these are often known as *magneto-optical disks*. *CD-RW* (compact disk rewriteable) is one example.
- *Smart Card*: combined memory and processor on a credit card-sized device. Can be used to hold personal details (e.g. education records) or ‘electronic money’.

iii. Other Relevant Definitions

- *Storage Capacity*. is measured in terms of the bytes the storage technology stores. While most computers have RAM size measured in megabytes, storage technologies with Gigabytes capacities are common. For example a typical floppy disk can store around 1.44 MB; in other words 1,440,000 bytes of data but in most personal computers the hard disk capacity is measured in gigabytes.
- *File*: when you do some work on a computer and store that work on a disk, the result is called a 'file'. Notice that this a rather different and more general definition than that given earlier for files connected with a database.

- *Filename*: every file stored on your disk needs to have a name (preferably one as meaningful as possible rather then FRED1, FRED2 and so forth). The computer program you are using may well add something to the end of the name (the *filename extension*), for example .DOC or .TXT for a text document.
- *Directories and Sub-directories*: a filing cabinet used for storing documents is divided into drawers, and each drawer is divided into folders. This allows you to quickly locate any document you want without having to look through every document you own. In the same way, a hard disk used for storing electronic files is divided into 'directories', and each directory is divided into 'sub-directories'. For example, your hard disk might have one directory for word processed documents, another for spreadsheet files, another for database files, and so on. The word processing directory might have one sub-directory for project report documents, one for external correspondence, one for internal correspondence, and so on.

iv. Storage Technology Trends

Storage technology is becoming cheaper, quicker, smaller, and higher capacity. The trend is towards massive capacities using optical media. In addition, because of the increase in the volume of data that organizations maintain, businesses are building a new form of infrastructure called *Storage Area Networks* (SANs) that connect different storage technologies and enable users to access and share data across globally distributed businesses and applications. Moreover to serve the storage needs of businesses a new form of service providers known as *Storage Service Providers (SSP)* are mushrooming. Organizations rent storage space from SSPs and pay for the service pretty much the same as they rent physical warehouse for stocking inventory.

Output Technology

i. Output Technologies in Common Use

- *Monitor*: a device that produces an image in much the same way as a television. The image on the monitor is made up from thousands of tiny dots, known as *pixels* (short for 'picture elements'). The more of these dots there are, the higher the quality of image or *resolution* produced by the monitor. The monitor is sometimes referred to as the *screen*, particularly on portable computers where the screen is flat. Flat screens use a different display technology, generally based on liquid crystals like those used in calculators or digital watches.
- *Printer*: a device that produces a paper-based output of text or images. There are a number of ways printers can be classified,
  - ***Impact vs non-impact printer-*** a classification based on the method used to place the image on the paper or form the character on paper. In ***impact printing*** the image is transferred onto paper by some type of mechanical print heads striking paper in the manner used by typewriters. Printers in this category include, dot-matrix, and line printers. ***Non-impact printers***, on the other hand, use a variety of non-mechanical printing manners such as ink jets ('spitting' a tiny piece of ink through a nozzle onto the paper) or low-power laser or electrostatic techniques (as in a photocopier) to form characters on a paper. Printers in this category include, ink-jet and laser printers.

  - Printers can also be classified into three on the basis of their mode of printing: ***character printers, line printers and page printers***. Character printers produce printed

output by consecutively printing each character at a time to produce a line of information. Line printers, as their name implies, print a complete line at a time. Page printers (also called laser printers) use laser and electro-photographic technologies to assemble and print a page at a time.

As you move from dot-matrix to ink-jet to laser then, in very general terms, the printing becomes: faster, higher quality, and more expensive.

- *Speakers*: produce sound (audio) output. Speakers generally require a *sound card* (a special circuit board that creates sound) to be inserted into the computer for them to function.

ii. Other Output Technologies

- *Speech Synthesis*: produces an output of computer-generated speech.
- *Plotters:* output devices for producing (drawing rather than printing) graphs and graphical diagrams. Many of them have several pens so that multi-coloured output can be produced by using a different coloured ink for each pen.

iii. Other Relevant Definitions

- *Dot Pitch*: a measure of how close together the dots on a monitor screen are: the smaller the dot pitch, the higher the image quality.
- *Dpi*: dots per inch. A measure of how many ink dots the printer uses to create the image on paper: the more dpi, the higher the image quality.
- *Printer Speed*: measured in terms of the number of character or line or page a a printer prints per minute.
- *Card*: a small circuit board of components performing some specialised function that can be inserted into a slot on the main circuit board (the *motherboard*) housed within the computer.

iv. Output Technology Trends

It is getting easier and quicker to produce output using new technologies, which are increasingly producing higher quality and colour outputs. There is also a trend towards *multimedia* outputs. Multimedia means the ability to produce output in a variety of media including text, sound (including speech), graphics and video. A multimedia computer is one that has a DVD- or CD-ROM, sound card, speakers, video card and good quality monitor in addition to other hardware. This is now the norm for office computers.

Transmission Technology

It is possible to identify two types of transmission technologies. The first is that used for the passing of data and signal among the different components of a computer such as from input device to the processor and then to out put devices and the second is the transmission of information among different computers and geographically dispersed users.

i. Transmission Technologies in Common Use

- *Bus*: hardware paths that transmit data inside the computer from one component to another, e.g. from the memory to the processor.
- *Wire*: copper wire that transmits data. Comes in two forms: *twisted pair* (like a traditional telephone wire) and *coaxial cable* (like a television aerial wire).
- *Optical Fibre*: a cable made up of thousands of strands of transparent glass fibres, each the size of a human hair. These fibres transmit data in the form of pulses of light from a laser rather than as an electric signal, as in wire. Optical fibres are generally more costly than wires but can transmit greater amounts of data.
- *Microwave*: transmission of data as high frequency radio waves directly between earth-based microwave dishes. Microwaves travel in a straight line, limiting the distance between microwave dishes to around 30 miles (because the Earth's curve gets in the way).
- *Satellite*: transmission of data using microwaves from one earth site to another via an orbiting satellite. Because satellites are high above the Earth, they can transmit across vast distances. They are the most costly form of transmission technology but, as costs fall, they are becoming more competitive with microwave even for short distance transmission.

ii. Other Transmission Technologies

- *Packet Radio*: the use of ordinary radio waves to transmit *packets* (small blocks of digital data). These systems are cheap and suitable for covering large distances when relatively small amounts of data need to be transmitted.
- *Cellular Transmission*: the use of the cellular/mobile phone network for data transmission. These systems provide an easy form of mobile transmission in areas where a cell phone network already exists.
- *Infrared Transmission*: the use of infrared light to transmit data. This method is used within offices for portable devices, e.g. to transmit data from a portable computer to a printer.

iii. Other Relevant Definitions

- *Bps*: bits per second. A measure of the speed at which data is transmitted. There is a set of internationally agreed *CCITT* (Consultative Committee for International Telephone and Telegraph) standards for bps rates. Standard V32, for instance, means transmission at 9,600 bps, and standard V34Plus means transmission at 33,600 bps.
- *Bandwidth*: a measure of the data-carrying capacity of a transmission channel.
- *Signal*: the way in which data is transmitted along the communication channels. There are two forms of signal:
  - *Analogue Signal*: a continuous wave, like that of the human voice.
  - *Digital Signal*: a series of on-off pulses corresponding to the 1s and 0s of digital data. Radio and telephone channels have traditionally only been able to carry analogue and not digital data. However, this is changing with more and more transmission channels able to carry digital data: computer buses, most new phone lines and new mobile telephony, optical fibres and packet radio all fall into this category.

iv. Transmission Technology Trends

Transmission technologies are becoming smaller, cheaper and faster, with greater data-carrying capacity. They are also allowing less interference or loss of signal ('attenuation').

There is increasing use of 'wireless' technologies, and there is increasingly globalised connectivity being provided.

Telematics Technology

- *Telematics*: the linking ('convergence') of computer and telecommunications technology.

i. Telematics Technologies in Common Use

- *Computer Network*: two or more computers linked together so that data can pass between them. There are two principle types of network:
  - *Local Area Network (LAN)*: a network covering computers in a single building. These are sometimes based around a *PBX*: private branch exchange. This is a computerised telephone switching system for the organisation that handles both voice and digital data.
  - *Wide Area Network (WAN)*: a network covering computers in more than one building, typically in different cities or countries. There are thousands of different wide area networks around the world. Many of these are linked to each other through the 'network of networks' known as the *Internet*. Whereas LANs normally use connections bought and operated by the user organisation, WANs rely more connections provided by telecommunications companies. These connections may be either the *switched lines* available to the general public, or *dedicated lines* leased for sole use of the user organisation.
- *Network Node*: any device connected to a network, such as a computer, printer, etc.
- *Modem*: MOdulator DEModulator. As already described, computers use digital data whereas traditional telephone lines cannot, because they were built to carry the continuous wave form, analogue signals of the human voice. To transmit computer data over traditional phone lines, you therefore require a modem. This is an electronic box or circuit board card that sits between the digital signals that a computer can understand and the analogue signals that the telephone lines can carry. Where traditional telephone lines are supplanted by transmission systems that can cope with digital signals, modems are no longer required.
- *Network Interface Card (NIC)*: a circuit board card that is installed in the computer to make the physical connection between a computer and a network that can accept digital signals. The card has a socket at the back to which you link up the network cable.
- *Fax*: combined scanner and printer that converts text and images on paper into digital form, transmits the data to another fax, which reconverts the digital data back to text and images on paper. Fax thus combines input, output and transmission technology. It is increasingly used in the form of a *fax card* inserted into a computer, for which the start and finish are a digital rather than paper-based document.
- *Interconnection devices*: there are many devices that connect network components. They include *hubs* that connect nodes to a LAN; *bridges* that interconnect LAN segments; and *routers* that determine the optimum network route for data traffic.

ii. Telematics Technology Trends

There is increasing convergence of computers and telecommunications through increasing connection of computers to ever-larger telecommunications networks (and through increasing use of computers to run networks). At the beginning of the 1990s, the majority of computers

in the world were 'stand-alone'. Today, the majority of computers in the world are networked. There is also an emergence of global standards defining how data is passed around networks.

Computer Classifications

Traditionally, on the basis of size, processing speed and cost, computers were classified into four: *Super, Mainframe, Mini ad Micro*

- **Supercomputers** are very sophisticated and powerful computers that can perform very complex computations extremely rapidly.
- **Mainframes** (also known as legacy systems) are largest category of computers typically serving the needs of organizations with large-scale data processing activities but whose use has declined since the 1980s.
- **Minicomputers** (sometimes called midranges) typically serve the needs of dozens or hundreds of users. One might be sufficient for an organisational department. First used in the 1970s.
- **Microcomputer:** a small computer that would fit onto a desktop. When first used, one microcomputer served the needs of one person. They are therefore also known as *personal computers (PCs)*. However, as microcomputers have become ever more powerful, they have become able to support the work of several individuals, leading to the apparently contradictory existence of 'multi-user personal computers'. First used in the 1980s.

Other computer sizes include

- *Workstation*: a powerful PC with a high-resolution monitor for use by a specialist professional, such as a designer, engineer or scientist. It is seen as lying between the midrange and microcomputer categories.
- *Portable Computer*: a PC that can be carried around, sometimes known as a *laptop* if it can fit on your lap, or a *notebook computer* if it is the size of an A4 notebook. Smaller still are *palmtop computers*. Handheld computers that use pen input and can recognise handwriting are called *personal digital assistants (PDAs)*.

Nowadays the distinction between microcomputers, minicomputers and mainframe is becoming increasingly blurred, as microcomputers become available with the power, which mainframe computers had only a few years ago, and the price for the same amount of computing power drops all the time. The situation is further complicated by the rapid spread of networks, which link computers, and enable microcomputers to be used as terminals linked to mainframes. Nevertheless, one can roughly say that, moving down these categories, the computers progressively become cheaper, smaller, easier to use, needful of a less specialised environment (such as air-conditioning) but also less powerful.

6. SOFTWARE

Computers are directed to perform each operation by a set of instructions, which define the operation to be performed, and the data or device needed to carry it out. The various types of sequence of instructions, which are actually put into the computer to perform a given task are collectively known as **software** (program)

Software is intangible: we can only see the hardware on which it is carried. To use an analogy, our brain (a physical organ of the body) represents hardware but our ideas (which can be communicated but never seen or touched) represent software.

It is worth reinforcing the point that hardware is nothing without software. All the supposedly 'hardware' items detailed in the section above require software to make them work. Some are highly software-intensive, such as speech synthesis in which the hardware elements are relatively simple. In the early years of computing, software took a back seat to hardware. Now software is recognised as being a more important component of IT than hardware as, for example, the global prominence of US company Microsoft attests.

There are three broad types of software, each of which is discussed below:

- *System Software*: which controls the basic internal operations of the computer system.
- *System Development Software*: the programming languages that are used to build other software.
- *Application Software*: which does useful work by carrying out a particular task or application. This can be divided into:
  - *General purpose application software* (often called *office automation (OA)* applications) which can be used in any part of an organisation.
  - *Application-specific software,* which is used by specific organisational users for specific purposes.

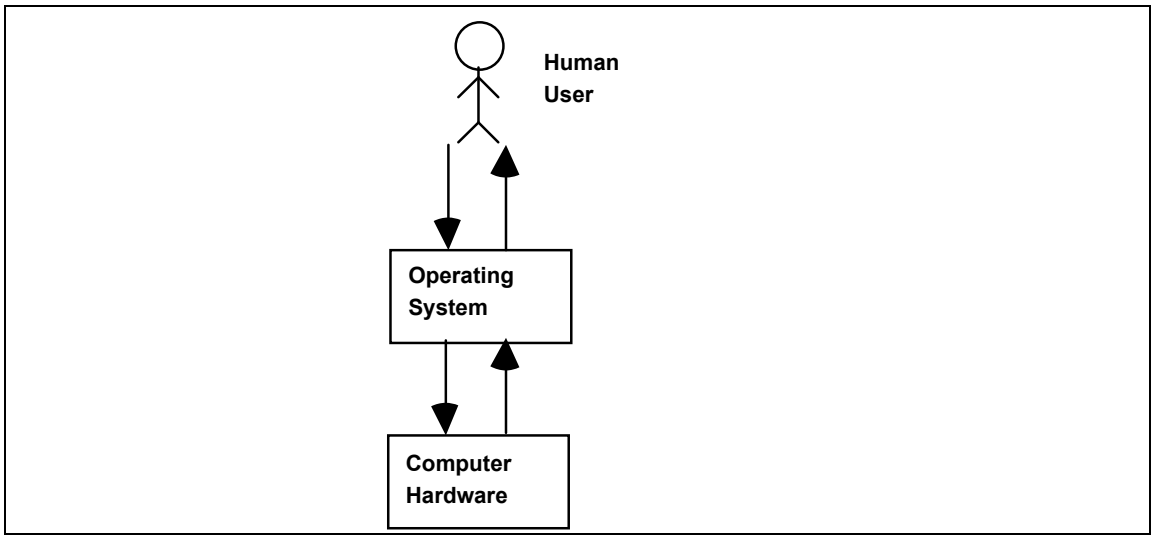
System Software

i. System Software in Common Use

- *Operating System (OS) Software*: controls the basic operations of the computer. This includes:
  - managing the *interface* between computer and user (that is the connecting link between the computer and the human);
  - controlling input, output and storage; and
  - managing files in the memory and on disk.
  - error reporting: detect and report any system or command errors

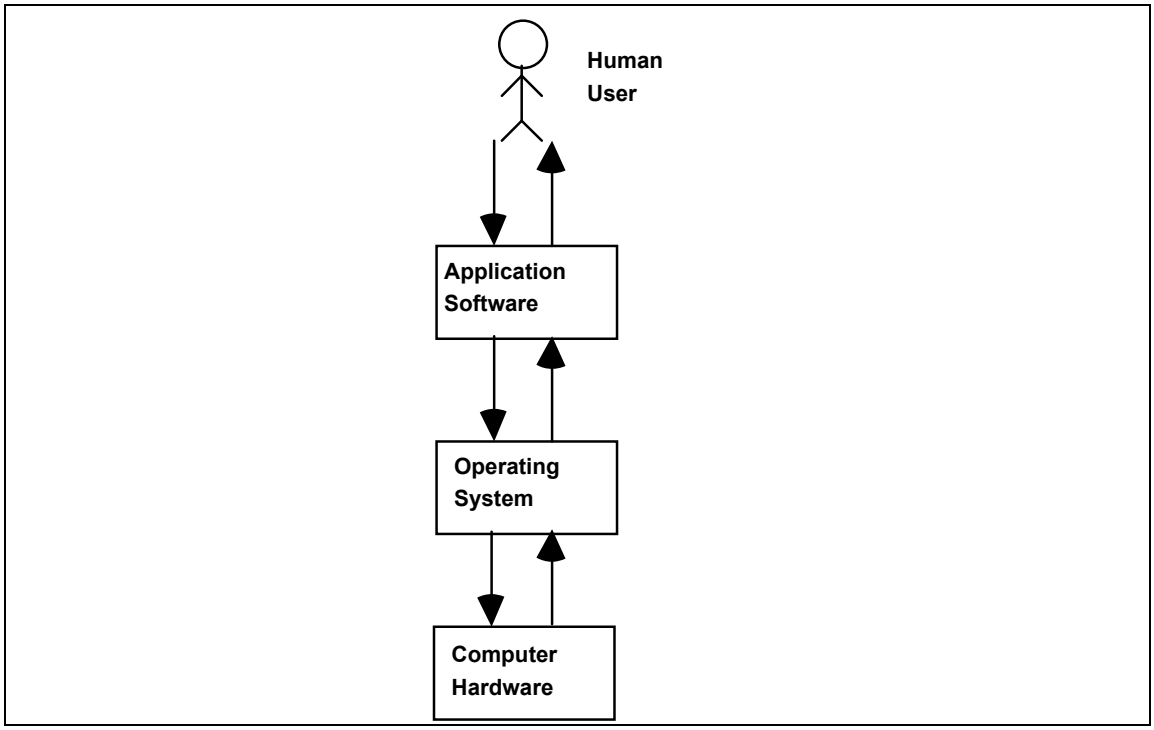
We can therefore think of the operating system as sitting between the human user and the computer hardware, as indicated in Figure 4.

Figure 3: Role of the Operating System



When application software is being used on the computer, the operating system assists it. In these cases, we can think of the OS as sitting between the application software and the computer hardware, as indicated in Figure 5.

Figure 4: Role of the Operating System with Application Software



ii. Other System Software Technologies

- *Utility Programs*: perform specialist system management tasks such as detecting and removing computer viruses, reporting on the performance of the computer system, or scanning a disk for damaged or unused areas.
- *Communications System Software*: controls the sharing of resources and communication of data between computers on a network. The main component is the *network operating system* (NOS). Some ordinary operating systems now have a NOS embedded within them.

iii. Other Relevant Definitions

- *Single user operating system software:* allow only one user to utilize the resources of a single-user computer system. A typical example is DOS (Disk Operating System).
- *Multitasking*: the ability of operating systems to run more than one task at the same time. For example, they allow you to enter data into a database at the same time as printing a document from your word processing package. This makes it easy to move data from one application to another, e.g. to take a graph created by your spreadsheet and put it into a report document being created by your word processor.
- *User-friendliness*: a measure of how easy any software program is to learn and to use
- *Graphical User Interface (GUI)*: traditionally, operating systems were used by typing in commands from the keyboard. Modern operating systems provide a GUI that is operated using a mouse. GUIs are sometimes referred to as *WIMP interfaces* because they consist of

Windows, Icons, Menus and Pointers. The significance of this technology in the adoption of new information systems can often be lost, but GUIs have spearheaded use of IT in many areas because they reduce the skill and time barriers so significantly.

- *Other Interface Modes*: GUIs involve two interface modes – menus, and manipulation of on-screen objects such as icons – which are both easy to learn and use, but relatively slow and inflexible. They are therefore particularly useful for new users. Other interface modes that may be used in systems (and other) software include:
  - *Question prompts*: a question presented by the computer to which the user provides the answer. For example, the question 'Save Changes Before Quitting? Yes/No'. These help to guide users and are quick and easy to learn and use, but they are inflexible.
  - *Forms/dialogue boxes*: a preset layout on screen with blanks that are filled in. For example, a box requesting the name of a file to be saved. These are fairly quick and easy to learn and use. They are inflexible, but deliberately so since they help guide the users through certain processes more than any other mode.
  - *Direct commands*: control of the system by directly typing in a command. For example, pressing the keys 'Ctrl' and 'S' simultaneously to save a file. These take time to learn and can be forgotten. However, they are the quickest mode to use and can be very flexible, so experienced users like them.
  - *Natural language*: a command typed in that is close to human conversation. For example, 'List all files saved last Tuesday'. This takes little time to learn, is easy to use and quite flexible. It can be particularly powerful for new users.

iv. System Software Trends

System software is becoming increasingly easy to use. For example, studies have shown that it takes less than half as long to learn to use a GUI operating system compared with a text-based OS. There has been an emergence of dominant standards: of one or two operating systems that are found on the vast majority of computers. Finally, there has been the (slow) emergence of non-English system interfaces.

System Development Software

i. System Development Software in Common Use

These are the programming languages that allow you to create the instructions that make up a computer program. There are five main types, or generations, of programming language, summarised in Table 4.

Table 3: Programming Language Generations

Name	Widely Used From	Example Languages	Example of Language Instruction
Machine language (1st generation)	1940s	Micro-code	5A 202
Assembler language (2nd)	1950s	ASSEMBLY, PLAN, AUTOCODOR	ADD B
High-level language (3rd)	1960s	COBOL, BASIC, FORTRAN, C	INPUT "ENTER CUSTOMER NAME"; NAME$
Fourth-generation language (4th)	1980s	FOCUS, Natural, Power builder, Access	LIST BY CUSTOMER AVERAGE (INVOICE TOTAL)

Fifth Generation	1990s	PROLOG	

ii. Other System Development Software

- *Web Authoring Tools*: software development tools that help produce documents for the World Wide Web.
- *Computer-Aided Software Engineering (CASE)*: a software environment that aims to automate as much as possible of the process of software development, from initial analysis of problems through to creation of the final software program.

iii. Other Relevant Definitions

- *Object-Oriented Programming Languages*: software development tools that allow easy manipulation of combined data/process items called 'objects'. This aims to make it easier to write and re-write software by storing 'libraries' of reusable, generic objects. Examples are C++, Java
- *Visual Programming Languages*: languages that allow the development of software through use of a GUI rather than by just typing in programming instructions.
- *Approaches to software development*: in all there are four different ways in which software is developed or obtained:
  - *Software package*: buying a ready-made program 'off-the-shelf'.
  - *Customisation*: modifying an existing software package to suit a particular user's needs.
  - *Custom-built*: creating an entirely new piece of software from scratch.
  - *Re-engineering*: modifying an existing custom-built piece of software.

iv. System Development Software Trends

With system development software, there is an increasing ability to rely on statements of what is to be done, leaving the issue of 'how it is to be done' to the language. This can already be seen in the changing instructions listed above in Table 4, and is referred to as the change from *procedural* to *non-procedural languages*. This is allowing increasing end-user development of systems with a change from complex and unnatural to easy and natural programming languages or systems.

The time and effort required for system development is also decreasing because the process of development is becoming increasingly automated, and because there is an increasing ability to reuse software that has already been written. The overall amount of system development within public sector organisations is decreasing because of the commoditisation of software, that is, the increasing use of packages rather than custom-built software.

Finally, there is increasing hardware independence. Whereas machine language and assembler are specific to one particular processor, the higher generation languages can be used across a whole variety of computers.

General Purpose Application Software

i. General Application Software in Common Use

- *Word Processing Software*: supports the creation, storage and manipulation of documents on the computer, including text and images. The single most widely used application of computers.

- *Database Management Software*: supports the storage, organisation and selective retrieval of data. Database management systems (DBMS) are often supplied with a fourth-generation programming language (such as SQL: Structured Query Language) that assists with the production of reports or retrieval queries.
- *Spreadsheet*: supports the manipulation of numerical data, including calculation, analysis and graphical output. Spreadsheets are based on an on-screen matrix of 'cells' into which numerical (or other) data can be typed. They are used particularly for financial and statistical work.
- *Electronic Mail (email) Software*: transmits and receives messages or files between one computer to another. Email requires the computer to be connected to a network.
- *Web Browsing Software:* used for accessing documents and other products and services on the Web and the Internet

ii. Other General Purpose Application Software

- *Desktop Publishing (DTP) Software*: a more powerful and sophisticated version of word processing software. It has recently been somewhat compromised by the increasing power of word processing programs.
- *Graphics Software*: allows the create and manipulation of graphics and drawings. Like DTP, this has been squeezed by the increasing graphical capabilities of word processing and spreadsheet programs. One continuing use is presentation graphics software that can produce slides or overhead projections.
- *Statistical Packages:* Statistical packages are software for data analysis and report writing purposes. Features include: interactive facilities for storage and retrieval of data from various sources, data entry and modification services, elementary and advanced statistics, report writing, graphics, and online tutorial and help facilities. Examples include: SAS, SPSS, Micro Stat, PSTAT, MiniTab, Statistica.
- *Project Management Software*: supports the planning, monitoring and control of projects.

iii. General Purpose Application Software Trends

This software is becoming increasingly easy to use, especially following the introduction of GUIs. It has increasing functionality (i.e. the ability to do more and more things on the computer), and there is increasing integration, particularly of communications software with other software applications. The cost of packages is static or decreasing in real terms. As in other IT areas, there has been the emergence of dominant standards: of one or two packages in each category that are found on the vast majority of computers.

Application-Specific Software

i. Application-Specific Software in Common Use

- *Basic Data System (BDS)*: captures, processes and stores the data that is fundamental to the formal operation of the organisation. The most common form is the *transaction processing system (TPS)* which records the day-to-day, repetitive operational transactions of the organisation, such as those involving the payment or receipt of money.
- *Management Information System (MIS)*: provides reports that assist with the managerial monitoring and control of organisational functions, resources or other responsibilities. For example, software to assist monitoring of expenditure from departmental budgets.
- *Decision Support System (DSS)*: provides analytical modelling capabilities to assist with managerial planning and the making of decisions in ill-structured situations. For example, software to assist the financial appraisal of potential new projects.

ii. Other Application-Specific Software

- *Executive Information System (EIS)*: provides the information and other functions necessary for strategic decision making. For example, software to assist long-term human and financial resource planning.
- *Group Decision Support System (GDSS)*: provides data-gathering, analysis and reporting functions to help a group of people make a decision in an ill-structured situation. For example, software to assist negotiations between management and unions.
- *Expert System (ES)*: encodes human expertise as facts, relationships and rules and applies these to problem solving. For example, software to advise which type of social security payment, if any, an applicant is eligible for. Expert systems are part of a wider group of *decision-prescribing systems* that take decisions themselves or suggest the optimum decision to users. Expert systems are also part of a wider body of computer applications called *artificial intelligence (AI)*. As its name suggests, AI seeks to recreate the process of the human mind using machines and it also includes natural language processing, speech recognition and synthesis, machine translation, computer vision, and robotics.
- *Specialist Support Systems*: these assist the work of particular professional specialists. For example, professional designers may use *computer-aided design (CAD)* packages.
- *Geographic Information System (GIS)*: stores and manipulates data relating to places on the earth's surface. For example, a system that maps the existence and exploitation of natural resources in a country.
- *Functional Information System*: combines the functions of more than one information system to support the specific activities of one functional organisational area at different management levels. For example, an accounting information system might combine a transaction processing system to capture accounting data with a management information system and a decision support system to provide support to different types of management accounting decision. Most MIS and DSS receive their data from a TPS or other basic data system. Indeed, some MIS and DSS are created just by adding a different interface onto an existing basic data system.
- *Cross-Functional Information System*: integrates various different functional information systems. For instance, information systems covering the main functions of the organisation can be linked up with each other and with external information. They may then form the main inputs to an executive information system, which is a type of cross-functional information system.
- *Inter-organizational information systems (IOS)*: these are systems that are used to facilitate business transaction and information interchange among different organizations. An earlier example is Electronic Data Interchange (EDI) but most recent eCommerce and eBusiness systems have this feature

iii. Application-Specific Software Trends:

These software has an increasing capacity to support and/or automate human capabilities. They have seen an increasing addition of user-friendly interfaces, and of communications capabilities. Another trend is the shift from silos of function and organization specific information systems to integrated information systems that integrate not only different units of an organization but also an organization's partners.