DISCOVERING INFORMATION SYSTEMS

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Kindly note that this edition was last substantially edited in 2001 and so some of the material contained herein is dated and/or applicable to South Africa only.

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DEDICATIONS

To my parents, Roger and Monique
for showing me *how* to live

And to my own family
Eva, Anneke, Jonathan and Sylvia
For showing me *why* to live

JPVB

To my wife Stella
For being such a wonderful person

ME

To my students of the past, present and future

JN

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Foreword

Why Study Information Systems?

Why did you enrol for this course in information systems? It is probably a mix of pragmatism and idealism. For many of you, this course is *not* an elective, so you *have* to endure and pass it in order to obtain your degree. On the other hand, many of you *chose* to study this degree, and perhaps even selected information systems as a major. This choice was probably inspired by practical considerations such as the desire to have at least a reasonable fighting chance on the job market a couple of years from now, and the hope of earning the typical above average salary which graduates with an "IS" course (or better even: IS major) on their academic record tend to earn. But hopefully, you also have some *interest in* and positive expectations about this course. You may already have quite a bit of exposure to computers, be it from hacking away on the Internet or playing Doom. And you have definitely already encountered information systems in many different areas of your lives: they may have been responsible for the late publication of your test results, your (in-)ability to withdraw money from the ATM, or they enabled you to get great marks for your school projects.

Unfortunately, we cannot promise that this course will make you better Doom or PacMan players. (We are not very good Doom players ourselves.) But we *do* hope to keep at least some of the fun and excitement in the course. Let us give you some motivation for giving this course an extra effort.

- **Money**. IS graduates are amongst the best paid of all graduates. In fact, to our annoyance, many of our graduates walk into a job with a higher starting salary than we, their lecturers, earn after many years!
- **Importance**. University graduates must expect to work in an environment where information systems play an important, if not critical, role in their day-to-day activities. The ability to use personal productivity tools, and a working knowledge of the fundamental concepts underlying today's, and more importantly, tomorrow's information systems, are no longer "nice to have" skills from a career perspective: they have become essential minimum requirements.
- **Change and dynamism**. Unlike many other academic disciplines, the pace and rate of change in our field is extremely fast. You will already be familiar with the rate at which the computer and communication technologies are changing, perhaps best illustrated by how quickly personal computers become out-dated. But many of our (academic) theories, views and commercial practices also have to be revised on an almost annual basis. As a young science, we constantly have to re-examine our body of knowledge. This continuing renewal may scare off the casual-type persons, but it should excite people like you: dynamic, energetic and thriving on change.
- **Fun and challenge**. In our most humble opinion, there is more fun and challenge to be had in IS than in all other disciplines combined. (Hmm, maybe we *do* sound a tiny bit biased here!) In building up your skills in the literacy component, you will be challenged to discover new tricks and short-cuts all the time. You may have to push yourself to the limit to cope with the amount of power and capabilities presented to

you by the software. But also in the more conceptual sections, we hope that this will be the *one* course where you will have to use some critical thinking skills and, above all, accept that there is no one correct solution to each question. In fact, we often do not yet know what the right question to ask is.

If you delve a little deeper in the *curricula vitae* of the academic staff in the department, you will notice that many of your lecturers have *non-IS* backgrounds: accounting, engineering, management, or even the liberal arts. What made them change was (typically) not boredom with their original fields of endeavour but the excitement, change and dynamism that comes with information systems. We hope that you will discover this for yourself and share some of our excitement!

The Importance of Information Systems

Since many of you may have had limited exposure to the way large organisations work, the following facts may be of interest:

- Globally, the annual capital *(fixed) investment* in information technology (computers, telecommunications) currently exceeds the investment in all other productive capital assets (buildings, equipment, machinery, tractors etc.) combined.
- In the *developed countries*, more than half of the labour force can be classified as *knowledge workers* i.e. it spends most of its time processing information.
- The amount of *new knowledge* is said to double every five years i.e. in the next five years we will create as much new knowledge as was created in mankind's entire previous history. (The *quality* of this new knowledge is of course an entirely different issue!)
- Each *month* the equivalent processing power of one of the early personal computers (half a million microchip transistors) is being produced for *each* human on the entire planet.
- The information systems of many large organisations would be able to store and process the curriculum vitae of *every single human being* that lives and ever lived on the Earth, assuming that this information was available in electronic format.
- Four years after graduating from UCT, Mark Shuttleworth sold his IT business for a billion rands – sufficient to generate an hourly income of about R30 000!

Information Systems and Related Disciplines

IS, which is normally considered one of the *commercial sciences* along with management and accounting, has its "cousins" in the other major groups of scientific disciplines.

- **Computer Science**, typically part of the natural and exact sciences such as (applied) mathematics, is concerned with the scientific basis of software and hardware technologies which underlie information systems: computers and communications. Sample research areas include computer architectures, programming languages, efficient algorithms, artificial intelligence, computability, etc. These, together with innovative electronic engineers and material scientists, are often responsible for fundamental advances in the technology and are usually five to ten years ahead of the commercial application of these technologies. However, they tend to pay far less attention to the organisational and human context in which computers are used e.g. market viability, cost, project management, system effectiveness, organisational change management. Computer science also has little to say about non-computerised information systems, though this also applies to many information systems curricula and research agendas.

- **Information Science** has grown out of library science, typically considered part of the liberal arts discipline. It is far more philosophical in approach than computer science and information systems. Many of its findings apply equally well to computer and non-computer based systems alike. The main emphasis is on the storage and retrieval in large databases (libraries) of information. This includes issues such as classification, indexing, abstracting.

If the above gives you the impression that there is little overlap between the fields, we have to state that the converse is in fact true. There are many overlapping fields of research and undergraduate curricula often cover similar topics. (This sometimes results in some demarcation or "turf" disputes, despite the fact that "some of our best friends are computer and information scientists!") On the other hand, each discipline has its own perspective on even the most common topics of interest. IS has a very strong organisational bias, usually taking the commercial business enterprise as the implicitly assumed context of our studies. This is reflected in research into project management, procurement issues, audit and control principles, management issues, IS professionals' profiles and the like.

Rather than looking at undergraduate syllabi, a good feel for the differences in scope and emphasis between the disciplines can be obtained by browsing some of the prominent scientific journals of each discipline.

Contents of This Book

This text consists of thirteen chapters, which have been grouped into four sections:

- **What is Information Systems?** These three chapters describe the role of information systems in modern organisations, and explain the underlying concepts of "information" and "systems" in some detail.
- **IS Technologies**. These four chapters provide an overview of the basic technologies that are found in all computer-based information systems: computer hardware, software, communications systems and databases.
- **IS Applications**. These three chapters examine in some detail how information systems are used to support and enhance business processes, at all levels of the organisation and in linking organisations with their customers and suppliers. We also consider some wider societal concerns such as ethics.
- **IS Management**. An information system does not simply appear out of nowhere; it needs to be planned, developed and maintained using well tested management

principles. Issues ranging from software and hardware acquisition to disaster recovery are discussed in these three chapters.

You should not see this text in isolation from the practical worksheets, case studies, videos and group work that will be provided in the lectures. The intention of these additional materials is to enhance the educational process through participatory learning units: as you know, you learn best when *doing*.

It is also our conviction that university students need to be introduced from the first year to academic pluralism: too often undergraduate students are given the impression that there is one single correct approach or, even worse, that most problems have one and only one correct solution. You may therefore be asked to locate and discuss additional readings related to concepts covered in this book, which will expose you to alternative views on the course material.

Section I: What is "Information Systems"?

Welcome to our world: the world of *information systems* (IS). It is an exciting world where the borders change daily, the landscapes vary dramatically, the limits go far beyond the skies and many places have hardly been explored. In fact, most of our world is still uncharted territory. Fun is to be found around almost every little corner, often just across the road from those other big corners where frustration is lying aplenty.

You may have chosen IS as your major, or have had it imposed on you by your curriculum; you may be looking forward to the challenges it will present, or regard it as a hurdle to be overcome. Either way, it's important to begin with an understanding of what you can expect from the subject, and what the subject will expect from you.

IS is not simply about computers - it's about how businesses can make the best use of computer technology to provide the information needed to achieve their goals. In the same way as your own needs and priorities are unique to you, each organisation has different goals and requirements, and the successful implementation of IS requires a through understanding of the business issues involved, as well as the different technologies that are available. Most of the time there is no single "correct answer", and you will need to draw on your own knowledge and judgement when planning or using an information system. The purpose of this introductory course is to provide you with a basic knowledge of the different elements of information systems: the building blocks that can be combined in a variety of different ways to suit particular business needs.

Perhaps the best way to illustrate the importance of IS, is to consider the impact that it has on your own life. Try to imagine what your daily life would be like without information systems: you might be able to survive without your student fee account, but can you also imagine no television, no cellphone, no fax, the end of mass air travel as we know it, the collapse of the banking system ...? Most of our lives would be affected dramatically. Now stop to consider the times that you have been irritated or frustrated by the inefficiency of a large organisation (Home Affairs? University registration?), and you will see that technology alone is not the solution to business problems – computers are simply one element of a complete system intended to support the flow of information within a business environment.

This first section of this textbook briefly examines the different roles played by IS in organisations, and explains the basic concepts of a system and of information, which underlie all information systems.

1. The Role of IS in Business

Businesses make use of information systems so that accurate and up-to-date information will be available when it is required. Since it is not always possible to predict what information will be needed at some future date, most organisations use computers to record and store the details of all their business transactions. When a query arises, or a standard business report must be produced, this raw data can be retrieved and manipulated to produce the required information.

An employee may want to know how much leave he has due, a customer may enquire whether an item is in stock, financial statements must be produced for shareholders. Because the methods and calculations used in processing the employee payroll are very different from those used for managing stock control or for preparing a balance sheet, you will usually find that a number of different application programs are used within a single business. These application programs, plus the computer equipment that they run on, and the data that they use, must together meet the information requirements of the organisation, and their integration must be carefully planned to ensure that all aspects of the business are supported as efficiently as possible.

1.1 Classification of Information Systems

Within any single organisation, executives at different levels in the management hierarchy have very different information requirements, and different types of information systems have evolved to meet their needs. A common approach to examining the types of information systems used within organisations, is to categorise IS applications by the roles they play at various levels in the organisational structure – this is known as the **vertical** approach. In this case the organisation is viewed as a management pyramid with four levels:

- At the lowest level, non-management staff attend to routine daily business transactions such as selling goods and issuing receipts for payment.
- Operational management are responsible for monitoring the transactions that are occurring, and dealing with any problems that may arise.
- Tactical management decide on budgets, set targets, identify trends and develop short term plans for the business.
- At the top of the pyramid, strategic management is responsible for defining the long term goals of the company, and how it intends to position itself within its particular industry.

These levels of management correspond approximately to four different types of information systems (see Figure 1-1).

1.1.1 Transaction Processing Systems

At the lowest level of the organisational hierarchy we find the **transaction processing systems** (TPS) that support the day-to-day activities of the business. These applications are normally the first to be computerised and are characterised by large numbers of transactions updating the corporate database. These systems are mainly used by clerical staff performing such regular business activities as invoicing and issuing of stock, following well defined business procedures. The users of transaction processing systems tend to work at the lowest level of detail as they process or query one transaction at a time, using computer systems to capture the raw data which reflects the business processes of the organisation. For example, the itemised till slip from a supermarket is produced by the TPS, and details of each individual item sold will be recorded in the store's database.

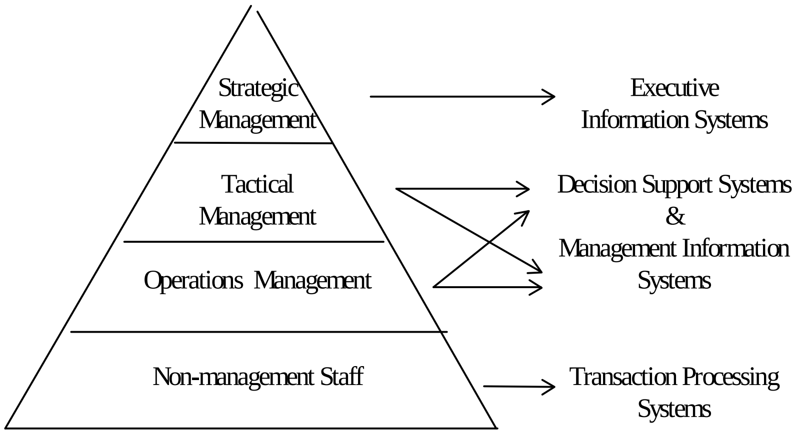


Figure 1-1: Levels of management and types of support systems

1.1.2 Management Information Systems

The next level in the organisational hierarchy is occupied by low level managers and supervisors. This level contains computer systems that are intended to assist operational management in monitoring and controlling the transaction processing activities that occur at clerical level. **Management information systems** (MIS) use the data collected by the TPS to provide supervisors with the necessary control reports. For example, in a debtors system, the individual responsible for collection of unpaid accounts could extract a listing from the computer of customers whose accounts have been outstanding for more than three months. At this level, output reports generally contain summarised totals of the TPS data, produced either on a cyclical basis (weekly or monthly) or on request. Additional reports include control listings, where totals are balanced between processing runs to ensure that data has not been lost or fraudulently manipulated, or exception reports, where the computer selects and reports only on unusual transactions that need to be reviewed by management. The main focus of MIS is to avoid wading through huge volumes of detailed data, instead using control totals and exceptions to identify problems.

1.1.3 Decision Support Systems

Tactical management occupies the next level in the organisational hierarchy. These managers are responsible for ensuring that plans and targets set by senior management are achieved. They tend to focus not on the progress of individual transactions but on the bigger picture – for example the relative sales performance of different sales areas in the organisation. To achieve this they need to receive regular reports from the MIS with summary totals and comparison between prior months and years, or planned activity levels. Where summary figures are of concern, these managers may request more detailed reports from the operations personnel.

However there is also a new requirement for information from this level of management. In many cases problems arise and additional ‘ad hoc’ reports are needed. Perhaps the sales figures for the Cape Town region are below the annual year-to-date forecast and management needs to investigate where the problem lies. Analysis of the monthly sales information in the database may reveal the answer. For example it could be poor sales performance by a retail outlet or salesman, loss of a major customer or lack of demand for a particular product. Often problems arise that require management to look at data in the database from a new or different perspective. This particular information requirement may not have been identified when the computer application was developed and therefore no standard report is available to management.

In the past the IS department received regular requests for selected information to be extracted from the database for presentation to management. Many organisations have recognised the importance of this type of information need, and have implemented sophisticated user driven **decision support systems** (DSS) which allow managers to generate their own reports and enquiries. When information is required to support management decision making, the user is able to interact directly with the computer via a graphical user interface to request the relevant data, select and apply the appropriate decision model and generate the output report in the format required.

1.1.4 Executive Information Systems

The highest level in the organisational structure is that of strategic management, and once again its information requirements are unique. These managers are charged with the task of setting the strategy for the organisation. They require an information system that will enable them to identify problems, opportunities and trends that may enhance or threaten their organisation’s competitive position.

In the early days of commercial computing, top management spent much of its time wading through reports relating to the performance of strategic areas of the business. In order to reduce the time taken in finding and integrating a few critical numbers from many different reports, the concept of the **executive information system** (EIS) was developed. Top executives identify particular indicators that best measure business performance in critical areas of the business. Data relating to these indicators, as well as information about competing companies and the overall business environment, is collected, analysed and presented (usually in a graphical format). If a problem is identified by top management, then the EIS provides the facility to drill down to a lower level of detail in the database to obtain a better understanding of the problem and its causes.

The following table (Figure 1-2) summarises the major differences between the four levels of organisational support systems based on their major inputs, processing characteristics and outputs:

Management Level	Applications Support	Inputs	Processing	Outputs
Clerical	Transaction Processing System	Detailed transactions	Transaction updates	Detailed reports Operational documentation
Operational Control	Management Information System	Operational data	Selection Summarisation Reconciliation	Summary and Exception reports
Tactical	Decision Support System	Operational data & Decision models	Simulation Analysis	Ad hoc reports
Strategic	Executive Information System	Internal and External data	Summarisation Drill down	Critical Success Indices

Figure 1-2: Characteristics of each level of management support

1.2 Office Automation Systems (OAS)

Other types of information systems are not specific to any one level in the organisation but provide important support for a broad range of users. Many standard computer applications, such as word processing, spreadsheeting, data management, and presentation graphics are used across all management levels of the organisation. Apart from their individual capabilities, many of these programs are able to exchange information, so that for example a word processing document may include a graph developed using a spreadsheet program, which is dynamically updated when the data in the spreadsheet is changed.

Word processing software is used to create and maintain electronic documents. Because word processors create virtual (electronic) documents as opposed to physical ones, any errors or alterations can be made to the document before it is printed. This simple concept has empowered all the one and two fingered typists of the world and made the professional typist an endangered species. More than 90% of all white collar workers in the USA now use a word processor to perform their jobs; however, as personal computers and word processing packages become more powerful, so users continually need to update their skills to get to grips with the next generation of software.

Spreadsheets are to numbers what the word processor is to text. They allow for easy preparation of financial statements, cash flows, budgets and other problems requiring quantitative analysis. The beauty of the electronic spreadsheet is that it mirrors the way we performed the task manually, except that users enter data via a keyboard and view it on a computer screen rather than writing on to paper. This similarity ensures users understand and become proficient in the use of spreadsheet packages in a very short period of time. Because of their ability to use formulas and functions to recalculate answers when values are changed, spreadsheets are excellent tools for performing "*what if*" analysis. Today's spreadsheet packages also offer a variety of statistical and business analysis tools, together with the ability to generate business charts directly from the spreadsheet data.

Data management software is used to create and maintain records about items such as customers, stock or employees, which are vital to the operation of any business. The main advantage of automation when applied to organisational record-keeping, is the power of the computer to select, sequence, summarise and report on data once it has been captured. In addition, data management software incorporates error-checking features, which could ensure for example that only valid account numbers may be entered in a transaction, and sophisticated backup and retrieval methods. Traditionally, data management has been regarded as the most difficult of the office automation applications, and is used mainly by those with specialised skills. There are, however, a number of simple data management facilities in most word processing and spreadsheet packages, such as the ability of word processing programs to perform mail merges in which a standard letter is merged with personal information from a database.

Presentation graphics software provides an easy means of generating high quality presentation materials based on colour overheads, slides or large screen displays. The latest versions include advanced slide show facilities together with animation and sound clips. This has become a popular tool for marketing, executive reporting, training and seminars.

1.3 Groupware

Most office automation applications are designed for standalone users although the data and information can be shared through the use of networks and e-mail. However, much of the work performed in business today is cooperative with individuals working together in groups to achieve common goals. **Groupware** is the term given to software developed to support the collaborative activities of work groups, with typical requirements being information sharing, electronic meetings, scheduling and e-mail.

Groups are often informal and could include members of a project team, employees within a department, or individuals with a common interest. Normally an individual is included in a number of groups, each with a specific focus. For example a lecturer in the accounting department would probably be included in the staff group (university wide), accounting department group, lecturers group (university wide), accounting lecturers group, Accounting II group (which he co-ordinates), accounting research group (international) and so on. Mail and discussions can be focused by means of a particular group name which addresses all its members. As long as the groups are kept up to date as members change careers and interests, addressing 2,500 co-workers can be as easy as addressing a single individual.

Apart from the obvious e-mail communication, there are a number of other group activities supported by current software.

Where individuals are encouraged to maintain an **electronic calendar** detailing their appointments and availability, groupware can search through the calendars to find times when all members of a group are available (for example when a staff meeting needs to be scheduled) and makes the required entry in each individual's diary.

The use of **compound documents** makes it easier to circulate files among the members of a group and keep track of changes that are made. Many office products allow some integration of files from a number of different systems, so that part of a spreadsheet for example can be embedded in a word processing document. However some groupware products (such as Lotus Notes) go further and create a database for each communication where any combination of documents can be combined for distribution around the group. Another useful feature of groupware documents is the ability to control group editing and update, by allowing colleagues to attach comments to the document without altering the original text. In addition, in cases where criticism is required and even encouraged, the system can also allow for the group input to be anonymous.

Project management software provides graphical tools to help manage projects by sequencing tasks, allocating and scheduling resources and reporting on project progress. Files can be checked in and out by members of the project team, changes are tracked using version control, and project managers can use "what if" queries to assess the impact of changes in the use of resources or time.

Electronic meeting software is designed to support interaction between members of a distributed group, without the cost and time wasted through travelling to a physical destination. Here groups can log into an electronic meeting from their offices or in special purpose electronic meeting rooms. While the meeting can be conducted by typed communications between the recipients, voice and even video communication can also be included. Apart from providing the means of communication, groupware can also store the output of such sessions in electronic format to assist with documentation and analysis of the group input. In the past, video-conferencing facilities were expensive but today multimedia upgrades can be installed on local machines at low cost. The one bottleneck to this groupware functionality is the quality of communications between the participants as video communication requires relatively large volumes of data to be exchanged.

Electronic mail, commonly referred to as e-mail, can be defined as the electronic exchange of messages between users. Where a user has the required software and links to the internet (for mail dispatched to remote locations), he or she can enter a message into the computer and transmit it to the recipient's Internet address. The message is then transferred across the network and stored on the network server in the recipient's mailbox from where it can be retrieved. E-mail facilities allow users the ability to print out messages, forward them to third parties and store mail in appropriate folders for future reference. In addition e-mail has a number of advantages over the traditional "snail mail" system. Mail can travel to anyone connected to the Internet in a very short time. It is simple to set up mail groups so that a number of individuals can communicate about common issues. Files can be attached to e-mail transmissions, so any material in electronic form can be communicated across the internet.

E-mail is also useful for inter-office communication. Often colleagues are busy or unavailable when you need to pass on information or discuss a problem. Leaving an e-mail message in the appropriate mailbox will achieve the required communication without the irritation and stress of attempting to make verbal or face to face contact. Nevertheless, e-mail communications do have their limitations. For those who type slowly, entering a long communication can be an arduous task. In addition e-mail is not as confidential as most users would like, since organisations may monitor and even open their employees personal e-mail documents.

1.4 South African Perspective

Automation of data capture and business processes can lead to improved management information, employee empowerment and customer satisfaction.

- By redesigning their processes for extracting customer data and printing TV licence statements, the SABC has cut their statement production time from 15 to 7 days, resulting in reduced costs and faster revenue collection.
- Spur Steak Ranches recently commissioned a new Human Resource system that will allow staff to check their leave balances and apply for leave on-line.
- And ABSA Bank will soon be building a new call centre in Auckland Park, which will use sophisticated IT to enable advisors to deal with multiple queries from the same customer, and allow supervisors to design duty rosters based on trends in service demands.

However, a word of warning comes from Arthur Goldstuck, commenting on the South African Government’s plan to adopt an IT system that will provide a single gateway to all state information and services, including a toll-free information centre operating in all 11 official languages (Intelligence magazine, November 2002). Goldstuck points out that existing services are inadequate at most government outlets, such as Home Affairs, the Labour Department and the Welfare Department. Investing in technology is not likely to make a significant improvement to customer service, unless at the same time the attitudes of staff can also be changed. “If an organisation’s workers regard the people they serve as annoyances, they will keep treating them as annoyances, regardless of the systems that are put in place.” His conclusion: if you want to use technology to streamline a process, first make sure that the process works.

1.5 Beyond the Basics

All too often, information systems are developed in order to automate existing business processes. But what happens if those existing processes are inefficient? Increased processing speed may simply increase the rate at which problems occur. This is where the concept of **business process reengineering (BPR)** enters the picture. BPR involves the fundamental redesign of an organisation’s business activities, in order to achieve dramatic improvements in quality, cost and speed. This is a major undertaking, which must be carefully managed to avoid employee resistance, since it often involves restructuring of the entire organisation. However, the benefits of BPR can be enormous. For example, IBM Credit Corporation reduced the turnaround time for approving credit orders from seven days to four hours by reengineering the credit approval process so that it could be handled by a single employee using a decision support system instead of forwarding the credit application through four different departments.

Trivial fact: T J Watson, the founder of IBM, was once asked how many computers he expected to sell worldwide, and his answer was 5. There are now over 34 million desktop computers sold worldwide every year!

1.6 Exercises

1.6.1 Organisational Information Systems

Consider the example of a large supermarket chain such as Pick 'n Pay.

- Identify a typical activity that would be recorded using the Transaction Processing System. How often would such an activity occur, and what member of staff would be responsible for recording it ?

- Operational management is responsible for monitoring routine daily activities. Suggest a regular weekly report that might be produced by the MIS, which includes information based on the activity you have just identified. Can you think of a situation in which this activity might be included in an exception report, in order to draw attention to a potential problem ?

- Tactical management are responsible for forward planning, based on a combination of MIS reporting and forecasting with the aid of a DSS. What sort of decision about future business operations might incorporate information about the activity you originally defined ?

- Strategic management make use of external as well as internal data in developing long term business strategies. What examples of external data might be relevant to the strategic planning of a supermarket chain ?

1.6.2 Using Corporate Information

Make a list of all the different organisations that are likely to have recorded your personal details (UCT, sports club, cellphone company, hospital, school, church etc).

- In what ways could this information have been useful in monitoring the (past) activities of the organisation?

- In what ways could this information be used for future planning?

2. Transforming Data into Information

In everyday speech, we do not always draw a clear distinction between the terms “data” and “information”, but the difference between the two is vital to the understanding of what IS is all about. Data is a collection of raw facts, each one of them insignificant when viewed in isolation. The purpose of an information system is to process that collection of raw facts in some way, so as to produce information that is useful to somebody.

For example, if the telephone directory contained a random assortment of names, addresses and telephone numbers, in no particular order, and with no logical association between names and phone numbers, it would be of no use to anybody. The facts (data) might all be present, but the information value of such a directory would be worthless. By associating each phone number with the name of the corresponding subscriber, and by sorting the list in alphabetical order of surname, information is produced. This helps to illustrate the inherent complexity of any information system – first you need to define what purpose it is going to serve (i.e. what information you want to produce), then you need to identify what data will be required in order to generate that information, work out how the data will be captured, how it will be stored, how it should be processed to get the desired result, and how the resulting information should be communicated to the person needing it.

Viewed in this way, we can see that data and information have very different characteristics.

2.1 Data

Since facts are *about something,* data *refers to* some outside object, event or concept. Data does not necessarily have to refer to a *physical* object: it can be about concepts (I think therefore I am a thinker; my bank balance is R4321.01 in debit), relationships between objects (I live in Oubordvolwater), etc. but it does pertain to an objective real world “out there” which the information system seeks to describe or model. Often the data model is an incomplete model since we are usually just interested in certain aspects of the real world. Alternatively, a complete model may consume too many resources or not be practical.

It follows logically that facts or data have a ***truth-value.*** They are *true* if they reflect the state of the outside world accurately. Of course, they can also be *false,* as is the case in the last two statements. Sometimes, it may not be possible to check the truth-value; in this case, the truth-value of the data element may be ambiguous.

Also, data has to be *represented* somehow. This representation can take one of many forms, all of which boil down to some particular structuring (pattern) of matter or energy. You have one example in front of you: this sentence consists of shapes made up of black ink particles on a white sheet of paper! (It can also be dark grey on light grey, depending on the print and paper quality.) We will discuss the representation issue in more detail later.

The fact that data is represented in a matter or energy form leads to another characteristic of data: it is *encoded* using a specific symbolism and the data can be understood only if one knows how to *decode* it. The symbolism can be a certain language and its written alphabet, a digital (numerical) representation of sound frequency (compact discs), the colour and shape of flags (ship-to-ship visual signalling) or any other agreed code. Often many different options exist depending on need: an English message could be spoken or "signed" in sign language, written using the "normal" alphabet or in shorthand, in Braille, in Morse code, in bar code etc.

A final characteristic of data is that it can often be *structured* quite easily into a standard format and grouped into large sets of similar data items, especially in organisational contexts: address lists, customer records, inventory details, personnel records.

2.1.1 Representing Data

Data can exist only if it is encoded using some form of structured matter or energy. The actual physical encapsulation (in matter or energy form) of the data is its ***storage medium***. The following are just some examples of how data can be represented.

- Ink particles on a piece of paper or other material (book, packaging, T-shirt logo, graffiti)
- Polystyrene lettering or logos on a promotional in-store display board
- Needle pins on a city map (indicating e.g. locations of recent robberies)
- Magnetic polarisation of suitable materials (music tapes, floppy diskettes)
- Light pulses through air or glass fibre (flashing lighthouse, laser light in optical fibre)
- Electronic pulses through copper, etc.

The way that data is represented within a computer system, is dictated by the fact that the basic electronic circuit inside a computer can usually manage only two different states: ON or OFF, i.e. either electricity is flowing or it is not; or, depending on which circuit we are discussing, it either holds an electrical charge or it does not. This is why computers are called binary: they can work only with two values ("bi" means two as in bicycle: two wheels). The ON and OFF state can represent, depending on convention, a "Yes" or a "No"; a "True" or a "False"; a "0" or a "1". Or, in fact, anything else that could be coded using only two discrete values: positive/negative (numbers), white/black (printing), open/closed (switch), in/out of stock, registered or not, pass/fail etc. In this sense it can be said that computers can count only... one ... two!

Anything that can be encoded using only a single one of these simplistic "On/Off" electronic circuits is said to consist of **one *bit* of information**. The word *bit* is allegedly derived by contracting the term "binary digit" because computer scientists usually represent these two states by means of the two digits 0 and 1.

A bit is the smallest unit of information, everything less than a bit is nothing! Unfortunately, most data is far more complex than "Yes/No". But, amazingly, even the most complex information can be represented using these simplistic binary circuits.

2.1.1.1 How Computers Store Numbers

We are all familiar with the decimal numbering system, based on the number 10. In this system, the available digits are 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9, i.e. for every number position, there are 10 possible options. Numbers consisting of multiple digits are computed based on powers of 10. For example, consider the number 4075. The value of this number is computed in the following way (from right to left):

5x1 + 7x10 + 0x100 + 4x1000 = 4075

Since computers are inherently based on the idea that their components are either on or off, this is usually represented in terms of binary numbers, where all digits are either 1 or 0. This means that for every number position there are only two options, 0 or 1. Numbers consisting of multiple digits are computed based on powers of 2 (since there are only two possible options for each position). For example, consider the number 11001. The value of this binary number in decimal terms would be computed in the following way (from right to left):

1x1 + 0x2 + 0x4 + 1x8 + 1x16 = 25

In decimal numbers, each "column" is 10 times the column to its right, so from right to left we have units, 10s, 100s, 1000s, etc. With binary numbers, each column is 2 times the column to its right (because a column can hold only two possible values, 0 or 1), so instead we have units, 2s, 4s, 8s, 16s, 32s, etc.

Thus to translate a decimal number into binary format, so that it can be stored and processed by a computer, we need to determine how many 32s, 16s, 8s, 4s, 2s and 1s the decimal number contains, and indicate the presence or absence of each of these by using a 1 or 0 in the correct column position. For example, the decimal number 43 consists of a 32, no 16, an 8, no 4, a 2 and a 1 (32+8+2+1=43), and would be represented in binary as 101011. In practice, numbers are usually represented in groups of at least 8 bits; and more commonly, 32 bits are used to allow for the storage of extremely large numbers.

2.1.1.2 How Computers Store Text

Much of the data in which people are interested does not consist of numbers but rather of text e.g. names, addresses, descriptions and sentences such as "The Bulls have won the match!" Any piece of text is composed of a collection of *alphanumeric* symbols: letters, punctuation marks and spaces. Our roman alphabet letters (both upper and lower case), the digits 0 to 9, the punctuation symbols as well as a number of "special symbols" which are commonly used in text such as the $ or the %, together add up to about 100 different *characters*. Since we already have a way of storing numbers in binary form, it is a simple matter to just assign a number to each of the characters we wish to represent. There are indeed a number of international standards for this: EBCDIC and ASCII are the two most common ones. Text is therefore commonly represented in a computer using bit sequences, which represent the numbers of the various characters which make up the text, according to some standard list of character codes. Although 7 bits would be sufficient to store up to 256 different binary codes, for technical reasons it turns out that it is easier to use groups of 8 rather than 7 bits; so text is usually stored in computers by encoding each character of the message in "clumps" of 8 bits. These sets of 8 bits are called ***bytes.*** Our "The Bulls have won the match!" sentence therefore would be represented by a sequence of 29 bytes.

Two notes to round off this section:

- As computers are being used in many countries that do not use Roman characters, the standard set or list of characters is being enlarged to include many more characters. This means that more bits are required to code each character (e.g. 2 or 4 bytes or 16/32 bits in Unicode). Do you understand why?
- Some of you may by now have realised that there is another method of storing numbers. Since a number can be written out in decimal form (as in "12876"), it is possible to encode each digit separately and store the number as a sequence of "text" characters. E.g. instead of calculating the binary equivalent of the number, you could store the it as a sequence of five characters, "1", followed by a "2", "8", "7" and "6". This method is not quite as efficient as the first method since it requires more space. (As an exercise, you should check how many bits or bytes would be needed to represent 12876 using its equivalent binary number and using text representation.) Also, computers are much better at doing number arithmetic in their native binary number representation.

32	65 A	97 a
33 !	66 B	98 b
34 "	67 C	99 c
35 #	68 D	100 d
36 $	69 E	101 e
37 %	70 F	102 f
38 &	71 G	103 g
39 '	72 H	104 h
...	...	...

Table 2.1. Decimal equivalents of some ASCII codes

2.1.1.3 How Computers Store Sound

The same principle applies here as with storing text: we need to find some way of translating sound into a sequence of numbers. This process is called ***digitisation***. It has been discovered that voices, music and any other sound signals are completely defined by the shape of their sound waves: their frequency. (We ignore the loudness or amplitude here for simplicity.) To make an almost perfect recording of any sound signal, all one needs to do is to check or *sample* the sound signal many thousands of times a second and record the frequency of the signal at each interval. This frequency can be represented as a number, typically below 20 000 (Hertz). One second of sound can therefore be represented as a long (say many thousands) sequence of numbers, each number corresponding to the frequency of the sound at each fractional part of a second (a *real* split-second!). If this seems like a lot of data for a short time of music, you're right! As you may have guessed, this is the way music or sound is recorded on compact disc, digital audio tape or sent between digital cellular telephones.

This discussion should explain why there is a trade-off between the amount of data and the quality. You can increase the accuracy of the sound by using larger numbers to represent the frequencies (a popular choice is between 8 or 16 bits). And you can increase the sampling rate (how many times per second the frequency gets "checked" or converted into a number, or in how many parts you split the second). Doing so will increase the fidelity of your data i.e. the quality of your digital recording. But: you also increase the total number of bits you require!

It should also be said that there are many alternative ways of representing sound in digital format, often vastly more efficient but typically less universal. For instance, the different notes of sheet music can easily be converted directly to numbers, without having to convert them first into frequencies. This is the principle behind MIDI-based music. This method would require less than one-thousandth of the number of bits generated by a sampling method!

2.1.1.4 How Computers Store Graphics

How can a computer store a picture of, say a mountain? Again, we need to find a way of converting the picture into a set of numbers. This is done in a manner very analogous to digitising music. Basically a picture is divided into many tiny squares or dots ("*raster-ised*"). If you look closely, you can still make out these dots on a television tube, newspaper photograph print or the printout of a low-quality computer dot-matrix printer. Each dot represents a tiny fraction of the overall picture and is therefore called a *picture element* or ***pixel***, which is then converted into a number. For a black-and-white picture this number will indicate how light or dark the pixel is, using a *grey-scale* of say 0 to 100, with 0 representing very white and 100 very black. (A real grey-scale will again use a "funny" number based on a round power of two – usually 256, which equals 2x2x2x2x2x2x2x2 and takes exactly one byte!) Colours can also be coded although not quite as straightforwardly. Colour coding is based on the fact that all colours are basically a combination of three primary colours. Three numbers representing the percentage of each primary colour to be used will uniquely reflect any colour of the dot. As with sound, the more accurate the numbers (more bits!) for each colour and the finer the raster grid, the higher the quality of your picture but also the more data is required. A good quality picture could easily require many millions of numbers to encode.

2.1.1.5 Animation and Movies

To record animation or "moving pictures", we make again use of the "time slicing" technique. Anyone who knows some of the technicalities of film movies or television is aware that the human eye can easily be fooled into seeing movement if shown a series of still pictures in quick succession. A film is indeed nothing but a series of photos taken at intervals of about a thirtieth of a second, which are shown rapidly one after the other. This is also the way cartoon movies are made: several tens of slightly different drawings have to be made for each second of movement. So digitising movies involves nothing but storing many, many successive pictures, often together with one or more sound tracks! Needless to say, this involves huge quantities of numbers.

2.1.1.6 Limits to Computer-based Data Processing

From the previous discussion, you have hopefully developed a more general idea of how data gets stored on computers. We experience the real world as continuous: time and space can be divided into as small a piece as we want. Digitisation involves slicing and cutting a big chunk of information about an object into very small elements and somehow catching the essence of each of these elements in a number. Usually there is more than one way to do this and often incompatible competing "standards" exist.

The question naturally arises: *can all data be digitised?* This is still an unresolved question. The following are just some of the limits to our current computer technologies.

- Digitisation of sensual data such as smell or taste is currently at a very primitive stage, although some success has already been achieved.

- Another problem area is accuracy: digitisation of real world objects is always an imperfect approximation of reality; sometimes we encounter limits to the precision that can be obtained. For many purposes, e.g. converting currencies or calculating taxes, this limit is of theoretical concern only. But for other purposes, such as weather prediction, fluid dynamics modelling etc., these are very real concerns.

Only time will tell whether these limits are only temporary shortcomings of the technology or reflect *real* limits of digital information processing.

2.1.2 Measuring Data

Once you have a basic understanding of how data is stored, it is relatively straightforward to tackle the question of how data can be measured. The simplest measure of data is its quantity or *size*: how *much* data is there? If we take our previous sample of text: "The Bulls have won the match!", then it is fairly easily to work out that it contains 29 characters (spaces and punctuation included). Thus, if each character requires 8 bits (which is one byte) to encode, then our sentence is 29 bytes long.

Just to get some feel for data quantities, some examples follow to indicate *typical byte* sizes.

- **One page of typewritten text**. A typical page contains around three thousand characters (about 50 lines of text of 12 words of 5 letters each), so it would be about 3000 bytes. How far is Cape Town from Simon's Town? You're likely to reply using *kilo*metres (40) rather than metres (40000). So whenever we refer to many thousands of bytes, we will also use the abbreviation *kilobytes* (or *KB* for short). A typed page with text holds a couple of kilobytes of information.

- **A paperback novel**. A typical novel consists of a few hundred of pages, say two hundred and fifty. Two hundred and fifty times three kilobytes is close to one million bytes. Most novels are between one half and two million bytes. Again, we try to avoid large numbers and one million bytes, or one thousand kilobytes, is called a *megabyte* (usually abbreviated to MB).

- **Two hours (a double CD) of high-fidelity music**. This calculation is a bit technical and it is really the end-result in which we are interested. But for those of you who *are* interested, here goes. Frequencies are encoded as two-byte (or 16-bit) numbers and the frequency is sampled about 40000 times each second. There are two stereo channels so for each second of music we need 2 x 40000 x 2 = 160 000 bytes or 160 KB. Two hours of music is 2 x 3600 seconds i.e. 7200 seconds x 160 KB per second = 1152000 KB = 1152 MB. One thousand megabytes is called a *gigabyte* (*GB* for short).

- **Photographic data sent back from a space exploration vessel**. On its mission, a planetary explorer could send back to earth medium resolution colour pictures of 10 megabytes each, at a rate of about 100 per day. Each day mission control receives therefore 100 x 10 megabytes = 1000 MB = 1 gigabyte. If the space voyage lasts three years (a typical trip to the outer planets) we have about 1000 days' worth of data i.e. 1000 gigabytes. You've guessed it: 1000 gigabytes also has a special name, a *terabyte.* A full-motion video would (uncompressed) also contain about a terabyte of (uncompressed) data!

From the above, you can see that digitising visual and audio signals requires a lot more data than text. A picture is worth a lot more than a thousand words, in fact it is more like a million words! And actions speak much, much louder than words if a short movie scene requires the equivalent of many billions of text words to store digitally.

Trivial fact: The film Toy Story took over 800 000 hours of work on 300 computers to produce. Each minute of animation took about two days to create.

2.2 Information

When we compare data with information, the first obvious difference is that information must be seen in a *context* in which it makes sense. This context usually relates to an action or a decision to be taken. In the case of a credit manager, information about outstanding accounts might be needed to decide whether to pursue a tighter credit policy. A telephone directory provides useful information when you need to contact a friend. Sometimes a decision might be made that no action needs to be taken as a result of information being provided; after checking the results for the first class test, your lecturer may decide that additional revision exercises are not needed! To put it into other words: there must be a *useful purpose* before data becomes information. In an organisation, we will try to collect only the data that satisfies the informational needs of the system's users, since superfluous data costs time and money to collect and store.

The second characteristic is that there must be a *process* by which *data* gets transformed into *information,* as illustrated in figure 2-2. This process can be as simple as looking up and locating a single data element in a data set (e.g. one number in a telephone directory), counting or totalling data elements (accounts) or it can involve more advanced statistical processing and charting.

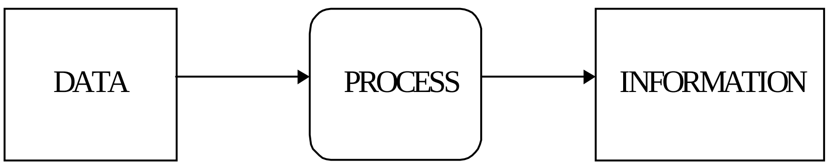


Figure 2-2: Transforming data into information

2.2.1 Qualities of Information

We live in a time where we are bombarded from all sides with information: the age of *information overload.* (Just ask any student!) It is becoming a vital survival skill to assess the quality of information. What distinguishes "good" from "bad" information? The following are just some of the *characteristics* or *attributes* of information. But note that these attributes are not always of equal importance - depending on the particular type of decision that needs to be made and the degree of risk attached to it, some attributes may be more critical than others.

- **Accuracy**. How accurate is the information or how much error does it contain? We do not always require perfect accuracy. Where a bank statement or invoice should be 100% accurate (although it may be rounded to the nearest cent or rand), "Errors & Omissions" of many millions of rands in the South African export statistics could be acceptable. If you want to drive a big lorry across a small bridge you need to know its weight to the nearest ton whereas if you wish to purchase diamonds you want a weight measurement which is significantly more accurate! If I, as production manager of a sweet factory, need to know how much stock of sugar we have available for the production of a particular sweet, I may not be satisfied with the answer "a lot" or "plenty".
- **Reliability**. How dependable is the information? This is closely related to but not the same as accuracy. It is related to *how* the information was obtained, e.g. the quality of the source of the information. Take the example of the sweet factory. I ask the inventory manager how many tons of white sugar are remaining. She informs me "36200 kilograms" but obtained this figure by looking at the size of the pile of sugar and making a rough estimate or, even worse, checked the *brown* sugar instead. Despite the apparent accuracy, 36200 kg is not a very reliable figure.
- **Completeness**. Does it contain all the important facts? In the above sugar example, she could give the exact weight but fail to communicate that she is expecting another 200 tons of sugar to arrive later that day, or that they are about to use most of the sugar for the production of another type of sweet.
- **Verifiability**. Can the correctness of the information be checked? Is it possible to obtain another estimate for instance by using another source or another method? In the sweet factory, one might be able to use a computer-based inventory system to verify the answer given by the manager. On the other hand, if large quantities of sugar move in and out the warehouse all the time, it may be impossible to verify the figure.
- **Relevance**. How pertinent is the information to the question or decision? The course fees, the academic standard (pass rates!) and job opportunities are all factors which may have led you to choose to study Information Systems at UCT but some would have been more relevant than others. The Rand/Dollar exchange rate is more relevant to South African exporters than it is to Brazilian farmers.
- **Timeliness**. How up-to-date is the information? There is little use in having a computer program predict the next day's weather with perfect accuracy if it takes 48 hours to produce the forecast!

- **Simplicity**. How complex or detailed is the information? To indicate the outstanding performance of students on the IS1 course, I could give standard deviations and other probability distribution characteristics of student marks over the last 10 years, full result lists or simply the pass rate of last year's students. A mere pass rate would probably be too simplistic while a complete list of results is too detailed. Best would be to give a bar chart showing the distribution of symbols.
- **Cost**. How much did it cost to produce the information? One should always compare the cost of producing the information with the value gained from it. There is no need to write a five-page report with many tables and charts to answer a simple question or indicate that performance is in line with expectations or budget.

2.2.2 Measuring Information

As you have already seen, it is not difficult to measure the size or quantity of data. The measurement of information is more complex. Consider the two statements "Bulls win" and "The Bulls team has shown its superiority by winning the match"; their information content is very similar, yet the second sentence contains almost eight times as much data as the first. Also, the amount of data in a message may change depending on the method used to encode it. A sentence coded in Morse code has about only about a quarter of the data of the same sentence in Unicode. But Unicode can also cope with Vietnamese text whereas Morse code cannot even distinguish between capitals and lower case Roman alphabet.

This has prompted communication theorists to look at another way of measuring information, which involves reducing it to the smallest expression that can still communicate the required content. For instance, the Bulls can either win or not, so the shortest way to send a message expressing the result of the match would be through a (previously agreed upon) binary code e.g. 1 = Win, 0 = No win. So the information content of "The Bulls have won the match!" can be reduced to one single bit.

Of course, we might require more detailed information about the result of the match, especially about the "no win" option. A perhaps more appropriate coding scheme would be 0= Bulls lose; 1= draw; 2= Bulls win; 3= match has been postponed. In this case we would have an information content of two bits. See whether you can work out a scheme for coding these four options using only two bits (i.e. in binary format).

An alternative concept for measuring information is based on its "surprise value", which calculates the number of options you have before you receive the information and measures how the information reduces these possibilities. *Information reduces uncertainty*. Drawing a playing card at random from a full deck has 52 possibilities, so the surprise value or information content of which card has been drawn is 1 in 52 or (slightly less than) 6 bits since 6 bits can encode 64 different options.

2.3 Knowledge and Wisdom

The concepts of data and information, which have been discussed in some detail, are actually the two lowest levels of a hierarchy (see Figure 2-3).

Knowledge is a much broader concept than information because knowledge consists of many pieces of related information, and has a structure or organisation whereby each piece of information is linked to others. In addition to a large number of data facts, knowledge often includes rules to validate new information, algorithms by which to obtain or derive information, frameworks that indicate what types of information are relevant in which context, information about the information and its structure (*meta-information*) etc. If information is data in the context of a question, then knowledge is what enables you to ask the right questions. Knowledge consists of knowing which action alternatives are available and what information is required before one can decide on a specific course of action.

A related concept is *expertise,* which consists of more detailed and validated (proven) knowledge in a selected area e.g. a car mechanic is supposed to have a lot of specific knowledge about the functioning of a motor car and its engine. Expertise has the connotation of being specific to a more restricted (often quite technical) domain, but also deeper or more detailed than knowledge.

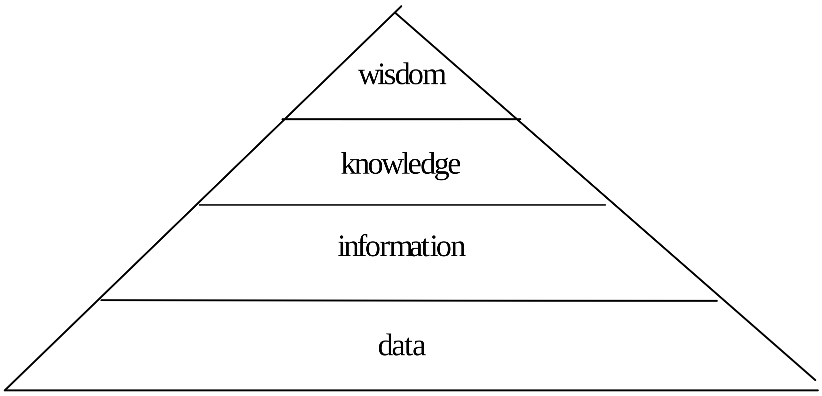


Figure 2-3: The hierarchy from data to wisdom

Finally, **wisdom** adds yet another dimension by combining knowledge with experience, critical reflection and judgement, such as when assessing the moral and ethical implications of a decision. The issue of representing higher levels of information e.g. knowledge, reasoning, expertise, experience, etc. is also still very much the subject of current research. No computer has (yet?) been able to generate original wisdom. But then, so have few humans!

2.4 Producing Business Information

The various characteristics of data and information that have been presented in this chapter, are directly relevant when developing systems that are intended to produce business information. In deciding what information is needed, it is important to consider how it will help to reduce uncertainty (surprise value) and how concisely it can be communicated (size). Not all of the attributes of information are equally important in every situation: in one case, early access to information may be more valuable than extreme accuracy, while in another case accuracy may be sufficiently vital to justify a time delay. If you are choosing a movie to watch this evening, you do not need to know all the details of the plot; if you are thinking of investing in a film production, a lot more information will be needed, even if it takes longer to acquire. A knowledgeable business manager will ensure that appropriate information is being provided to meet specific business requirements.

Careful analysis is needed to identify the data that will be used to produce this information. How well can its truth value be established? If you are not sure whether your facts are correct, then any business decision based on those facts is likely to be of dubious value – illustrated by the acronym GIGO (garbage in, garbage out). Sensible decisions need to be made about the types of data that will be stored, and the size implications: consider the difference between storing the sound of a spoken message, or its text equivalent.

Finally, all levels of the organisational structure must be catered for. Data accumulated through the TPS must be sufficient to generate the various types of MIS reports, to allow for forecasting using the DSS, and to explain trends over time which could influence strategic planning. As we commented earlier, there is more to an information system than simply buying a computer!

2.5 South African Perspective

The rapid growth of Nando's fast-food franchise created a need to manage its operations more effectively, particularly because until recently information from separate stores was only supplied to strategic management on a monthly basis. Information technology has now been used to collect operational data which provides managers with instant access to information about sales (at daily or even hourly level), profit margins, turnover, service problems and sales trends. Ten strategic Key Performance Indicators were identified that allow strategic management to monitor problem areas at individual store level and improve customer service while minimising operational costs. Errol Epstein, the MIS director at Nando's, comments that as a result of their new information system "we have an holistic view of our business and can manage our stores efficiently, cut down on wastage, and build our brand strategically".

2.6 Beyond the Basics

Knowledge is more complex than either data or information, and is more difficult to define and to store. **Knowledge management** systems attempt to capture organisational knowledge, including undocumented personal knowledge based on experience, so that it can be shared and applied effectively throughout the organisation. This requires the identification of valuable knowledge and where it is located, the extraction and encoding of the knowledge, storage, maintenance and retrieval processes for the knowledge base, and delivery of knowledge to recipients when needed. For example, BP has captured knowledge related to drilling malfunctions based on the practical experience of its technicians around the world, which can be used to provide solutions for problems that may occur in the future.

Grant Brewer of Ernst & Young believes that knowledge sharing should be a part of every organisation's information strategy (Intelligence magazine, November 2002). "Your information strategy should be to ensure that employees have ready access to current information. You then have to tackle the more difficult task of getting your employees to share their expertise, which most often comes in the form of experience rather than structured learning. The intellectual capital of your employees is possibly the most valuable asset in your organisation."

2.7 Exercises

2.7.1 Data encoding

A simple way to make a code is to think of a word or phrase and write it down, followed by the rest of the letters of the alphabet that you didn't use in the phrase, and then replace the original letters of your message with the code letters in corresponding positions. The reason you use a specific word or a phrase before the other letters is because that makes it easy for you and your correspondent to remember the key without having to write the code down, and risk having it discovered by the enemy. (If a letter is used more than once in your word or phrase, just leave it out after the first time you use it.)

- Try using your first name as the key for encoding the message "Data must be decoded to be understood".

2.7.2 Binary numbers

- What is the decimal equivalent of each of the following? 10011, 01110, 10101
- Write each of the following numbers in binary format: 13, 22, 9

2.7.3 Data vs Information

At the end of the year, assuming that your student fees have been paid, your exam results will be posted to your home address. The statement you receive will show your name and student number, your degree, and your final result for each course. It will also inform you whether you have been awarded any supplementary or deferred exams, and whether you have met the readmission requirements for your degree.

- In order to generate this document, what data would have been captured and when?
- What processing of the original raw data would have taken place?

2.7.4 Information attributes

Refer back to question 1.6.2 at the end of the previous chapter, in which you identified organisations that have recorded your personal details. How accurate is that data at the present date (i.e. have you changed address, phone number etc)? In what ways might incorrect data affect the usefulness of reports or cause inefficiency of business processes?

3. How Systems Function

An information system is, as its name implies, a special type of *system*. In this chapter we will introduce you to the basic systems concepts, and briefly explore some of the systems theories that are directly applicable to organisations. Along the way, we hope that you will master the practice of looking at your environment through "systems-coloured glasses" and applying these new principles to the world around you.

3.1 What is a System?

As a university student, you form part of the educational system, regardless of what subjects you are studying or how well you perform. Your body in turn is a highly complex biochemical system, as is the annoying mosquito buzzing around in your room or the more restful plant standing next to your window. You, as an individual, also form part of your family (social) system. The electrical light illuminating your room forms part of the electrical (energy) system, which, like the plumbing or air-conditioning system, is part of your house or hostel, which can also be seen as a (physical) system. The pen you are holding in your hand is a small, self-contained system, as is the whole earth ("*Gaia*"), which is in turn a sub-system of our solar system. Once you start looking for systems, they seem to crop up everywhere. But what, exactly, is a system? What have all of the above systems, despite their apparent diversity, in common?

3.1.1 Definition of a System

Since a system is a subjective concept, there is no unanimously accepted definition of a system. In order to study this phenomenon more closely, we will adopt the following definition:

- A **system** is an organised assembly of **components** with special relationships between the components.
- The system does something, i.e. it exhibits a type of **behaviour** unique to the system or has a specific objective or **purpose**.
- Each component contributes specifically towards the behaviour of the system and is affected by being in the system. If a component is removed, it will change the system behaviour.
- Someone has identified the system as being of special interest.

Not just any random collection of parts or elements constitutes a system. For example, a pile of rocks is *not* a system, just like a random collection of words does not make up a meaningful sentence. There needs to be a definite (perceived) structure that has some form of order, pattern and purpose. Sometimes the structure may be very tenuous, apparent only to few observers. At other times observers may agree on the fact that a given structure constitutes a system but there may be disagreement about what exactly is part of the system and what not i.e. its exact boundaries. An **information system** is a system that gathers and transforms data in order to produce information for its end-users. If it is to function successfully, then its developers and its users must agree on the purpose of the system, its components and the relationships between them.

Another essential element of the definition involves the subjective aspect: a system is not an objective "thing" out there that exists on its own but it is something attributed to a set of interrelated components by an observer.

3.1.2 The Systems View and Systems Thinking

The definition of a system is, however, somewhat of an academic exercise. The real essence of systems theory is being able to look at the world from a different perspective. The **systems view** involves adopting the reference framework and the terminology of systems theory, trying to apply various analogies with other systems and checking which of the systems laws and theories hold for the system of interest. **Systems thinking** is just a whole new way of thinking about the world in which you live. Being able to adopt this approach is quite an eye-opener for many, a pleasant and novel experience in fact, and much more important than merely being able to explain all the various concepts that will be introduced in this chapter.

Why is this systems view so important? Can we not just learn about the technology of information systems and dispense with more philosophical matters? The problem with the purely technical approach is that it often fails to take into account the inter-relation of problems and proposed solutions, which is incorporated in the systems view. The study of information systems is about solving an organisation's problems with respect to its information needs. Installing a computer is often a quick fix but may turn out to be a very sub-optimal solution, not taking into account many of the human and organisational factors. Some authors go even further and claim that most of today's complex problems, such as crime, drugs, poverty, war, suicides, breakdown of family structures, unbridled materialism, global warming and more, are a result of the short term and technicist vision of society's decision makers who fail to adopt a holistic systems view when addressing problems.

3.2 Elements of a System

3.2.1 Environment and Boundary

As soon as we identify a system, we define a **boundary**: what is inside the boundary belongs to the system, everything outside the boundary is not part of the system. However, most systems do not exist in isolation. Systems, or their components, inter-act with the world outside their boundary. The part of the outside world with which the system interacts is called the system's **environment**. What about the boundary itself: do you think that it belongs to the system itself, or is it part of the environment?

3.2.2 Inputs, Transformation Process and Outputs

The interactions of a system with its environment can take the form of inputs or outputs**.** **Inputs** take the form of material objects, energy and/or information flowing from the environment into the system. **Outputs** are released or sent from the system back into its environment. This output can either be useful (to some outside system) or waste. Within the system, the inputs usually undergo some kind of **transformation process** so that the outputs are different from the inputs. Often, inputs and outputs undergo further specific transformations *at* the system boundary; the system components responsible for these transformations are called the **interfaces**.

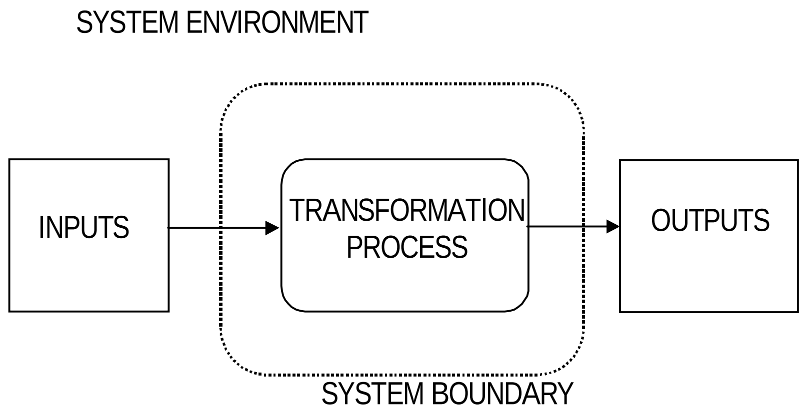


Figure 3-1: The basic elements of a system

Some systems perform very simple energy or matter transformations. Other, more complex systems, such as our human mind, perform quite intricate and sometimes even incomprehensible transformation processes (as evidenced by some student examination answers!) A motor car, for instance, turns petrol and oxygen into motion, heat and a variety of waste gases (exhaust fumes). It also takes its occupants from one physical location to a hopefully different location.

Information systems Error! Bookmark not defined. accept data as input, via an interface such as a computer keyboard or barcode scanner. Transformations may be trivial (counting or adding a set of numbers, copying a set of data), slightly more complex (e.g. drawing a map from co-ordinate data) or extremely complex (making a medical diagnosis based on symptoms and signs, deciding whether to launch a new product range, translating a poem). The information outputs of the system will finally be presented to end users, via an interface such as a computer screen or a printer.

3.2.3 Components and Subsystems

A system consists of various **components** which, taken together, make up the system. The interaction between the system components is responsible for processing the inputs into outputs. Although components can also interact directly with elements from the environment i.e. across the system boundary, most of their interactions will be with other components within the same system.

Often, components themselves can be viewed as smaller systems on their own: they are **sub-systems** of the system under consideration. The motor car mentioned above, for instance, has an electrical sub-system and an air-conditioning sub-system.

In the case of an **information system**, the basic components that interact are

- the hardware or physical equipment used to process and store data
- the software and procedures used to transform and extract information

- the data that represents the activities of the business
- the network that permits the sharing of resources between computers
- the people who develop, maintain and use the system.

Each of these components will be discussed in more detail in later sections of this book. At the same time, don't lose sight of the fact that the information system in turn is merely one component of the organisation, and must interact with other departments and business activities.

To understand the workings of a system, it is often useful not to take into account all the details of each of the subsystems. The level of detail with which you study a given system is called the **granularity**. If you want only to drive a car, you may be satisfied with a fairly coarse granularity i.e. you need to know about such things like the ignition and petrol tank but not about the condenser or the differential. However, if you are a car fanatic or repair mechanic (or if the car does not want to start), you need a much more detailed understanding of the subsystems within the car i.e. you need to study the system at a much finer granularity.

The coarsest possible description of a system is called the **black box** view of the system: you just describe the inputs and outputs but make no attempt at understanding what actually goes on *inside* the system. When first analysing or discussing a system, it often makes sense to view its subsystems as black boxes. The telephone communication system is, for most of us, very much like a black box: we dial a number and, if all is well, we hear a familiar voice in our handset. Luckily, we do not need to know how the various telephonic exchanges managed to establish our connection or how our voice signal got transmitted. Our scientific pocket calculator is another example: when we want to calculate the cosine of a certain angle, we enter a number, press on the *cosine* function and it displays a result without us being aware of how in fact it arrived at this result. If a black box hides *all* internal system details, what do you think is meant by a **white box**? A **grey box**?

Trivial fact: The biggest machine in the world is the telephone system. The vast network of cables and satellites links together over a billion different telephones, fax machines and modems that connect a third of our world.

3.2.4 Objectives, Control and Feedback Loops

Systems have a **function**, **goal** or **purpose**. This goal can be internalised e.g. the desired room temperature for a central heating thermostat device or the profit motive in a commercial business enterprise. This purpose can also be imposed from the outside e.g. when we use a motor car to drive from our home to the shop. In order for the system to achieve its goal(s), it needs to be able to modify its behaviour. **Control** is the mechanism whereby special **control signals** or, when coming from outside the system, **control inputs**, modify the processes and activities which occur within the system.

The **controller** is the component or (sub-)system which exercises the control and can be part of or outside the system under consideration. The controller observes the behaviour of the system, typically by looking at certain system outputs and compares them to the desired state or objective. In the case of a deviation, the controller would adjust certain (input) controls to modify the system's processes. This 'round trip' of using output signals and using them to modify input signals is called a **feedback loop**, and the whole process is one of **feedback control**. There is always a slight delay before the output can be "interpreted", the consequent control changes are effected and the system behaviour is adjusted. This delay is called the (time) **lag.** Lags can vary from the milliseconds it takes an ABS car braking system to release the brakes of a locked wheel to the many years it may take to vote an unpopular government out of office in a country's democratic political governance system. In the case of a business, output from the MIS will be used to provide feedback regarding routine business transactions, so that managers can monitor operational activities and introduce changes if necessary.

System feedback can be **positive** or **negative**. If the system behaviour needs to be altered (reversed) in order for its output to move closer to the desired state, then we have a ***negative feedback loop***. Two examples are the way a singer adjusts the tone of her voice so that it is in harmony with the orchestral instruments or the correction that we apply to the steering wheel if the car moves slightly out of its lane. However, if the feedback loop reinforces the current behaviour of the system, then we speak of ***positive feedback***, such as when a student achieves good marks after studying hard for a test. Consider a small boy throwing a tantrum: his mother could discipline him by sending him to his bedroom, or could pacify him by giving him a sweet. Which of these would be positive and negative feedback, and why?

The study of how systems can be controlled, with a particular focus on automatic or self-controlling systems, is called **cybernetics**. Although it initially arose from engineering, it is now considered to be a sub-discipline of general systems theory.

3.3 Systems Concepts

When analysing systems and their interaction with the environment, a number of useful concepts should be borne in mind.

3.3.1 Open vs Closed Systems

Any system that interacts with its environment is called an **open system.** There is in reality no such thing as a **closed system,** which would have no inputs or outputs and therefore, in a sense, no environment. Nevertheless, some systems are mainly self-sufficient whilst other, more open systems have a much greater degree of interaction with their environment. It is important to cater for this interaction with the environment when planning any system – there would be no point in starting a business that manufactures top quality goods, if you have no way of delivering them to your potential customers, or if you do not have access to the raw materials that you need!

3.3.2 Dynamic vs Static Systems

A **dynamic system** is a system that has at least one (and usually many) activity or process; as opposed to a **static system**, which has no activity, whatsoever. Again, there are very few completely static systems and we typically use these concepts in a relative sense: we refer to one system as being more dynamic than another, more static system. The more dynamic a system, the more flexibility must be built into the inter-relationship of components, allowing them to function in different ways as activities change – especially important in a modern business environment.

3.3.3 Continuous vs Discrete Systems

A **continuous system** is a system where inputs (and outputs) can be varied by extremely small amounts or quantities. **Discrete systems** are systems where the inputs or outputs can take on only certain discrete or distinct values. A traffic light (*robot*) is a discrete traffic signalling system because its three lights (green, amber or red) are either on or off. It remains discrete, even if we extend the number of signals e.g. some lights can be switched on simultaneously (as in England where a simultaneous amber and red light indicate an imminent change to green) or allow for flashing lights (to indicate malfunction or during night-time operation). A mercury-based thermometer, like many physical systems, is a continuous system as the level of mercury rises or falls gradually along with imperceptible fluctuations in the environment's temperature. Many electronic systems are a combination of both e.g. a digital thermometer has a sensor that records temperature as a continuous input but displays a temperature reading which has been rounded to the nearest degree.

Discrete systems have clearly identifiable **states.** The traffic light is either green or not when you cross the intersection; there is little use in arguing with the traffic officer that it was still a little bit green! A continuous input or output is often converted or approximated to a nearly continuous but actually discrete measure, such as when we measure a temperature to the nearest tenth of a degree or time the finish of an athlete to the nearest hundredth of a second. This enables us to model the real, physical world with electronic equipment such as computers, which can work only with finite precision (i.e. discrete) numbers. A good example of how well this conversion process can work is the Compact Audio Disc recording system which samples the music many thousands of times a second and converts the frequency of the sound signal at each time point into an integer number between 1 and 60000.

3.3.4 Structure and Hierarchy

The interactions between the various sub-systems and components of a system display some pattern or regularity. In this sense the observer can identify certain relationships, which contribute to the overall behaviour of the system. The entire set of relationships is referred to as the **structure** of the system. In a purely physical system, the physical location of the components and the connections between them will account for most of the structure e.g. the way the various parts of a car are joined together would account for its structure. In systems that involve informational and conceptual components, the structure will be much less tangible and involve some level of abstraction e.g. when you try to identify the social structure of an extended family unit.

Often, components of a system can be regarded as smaller systems in their own right. These are called **sub-systems** of the system under consideration and the latter probably constitutes most of their environment. These smaller sub-systems are thus embedded within the system, which in turn may be a sub-system of yet another, larger system: the **supra-system**. This nesting of systems within systems within systems is referred to as a **system hierarchy**. A common example is the physical universe (the ultimate physical supra-system), which is made up of galaxies (our Milky Way is one), which in turn consist of solar systems (e.g. ours with the familiar sun at the centre), which contain planets (including the planet Earth with its moon). Our planet Earth consists of a biosphere which contains all living things, including human society, which is in turn made up of social sub-systems or cultures, made up of humans (biological systems), made up of cells, in turn consisting of complex molecules etc. all the way down to the basic building blocks of matter (currently quarks). Another example is a large multinational organisation (one system, whose super-system is the international political economy) which may consist of various national companies, who in turn have regional branches or establishments, which may consist of various departments or project groups etc.

3.3.5 Holism and Emergent Properties

The chemical behaviour of one molecule of water (H_2O) is very different from the behaviour of large amounts of them when they make up an ocean. The inorganic chemist will have little to share with the wave surfer, art photographer or scuba diver about the properties of water. We are also familiar with the fact that the actions of a large mob or crowd may be very different from the behaviour of any individuals making up the mob. And of course the psychological and emotional behaviour of an individual can not be understood from the perspective of (or reduced to) his biological make-up i.e. his cell structure.

The perspective from which claims that many aspects of a system can be understood only in terms of its entirety, and not necessarily be reduced to the characteristics of its components, is called **holism** (the opposite of *reductionism*)**.** This is often expressed in the popular saying that a system is *more than the sum of its parts.* Holism also implies that it is important to be aware of the inter-relation between the various components of a system: *everything is related to everything.* When a person is ill, traditional medicine will look at the symptoms of the patient, diagnose the illness and prescribe some medication which will cure the patient by relying on some type of biochemical reaction within the body of the patient. The holistic approach will look at the lifestyle of the person, her emotional well-being and any psychological factors which may have contributed to the illness, i.e. a much wider perspective is taken, and illnesses are viewed in the context of the individual as a social, psychological *and* biological system.

The holistic systems view implies that a system has certain properties, qualities or attributes which cannot be reduced to or understood from its components alone. These properties are called the **emergent properties** of a system. Examples of emergent properties are the corporate culture of an organisation, the consciousness of a living individual, the feel of a car, the atmosphere or vibe of a pub, the cultural identity of a social group.

3.3.6 Entropy

An important measure of a system is the amount of order (in the case of matter or information) or potential energy it contains. The measure for disorder or energy degradation is **entropy**: the higher the level of disorder, the higher the entropy level. All systems change over time and, unless a system can draw on resources from the environment, it will tend to become more disorderly or lose energy (“run down”) i.e. entropy increases. This is one of the systems fundamental laws; it is a generalisation of the *second law of thermodynamics*, which states that the energy in the universe degrades irreversibly as time passes.

The concept of entropy is a fairly difficult one to understand conceptually. Though it is possible to define it more rigorously (i.e. mathematically!) the following examples illustrate the essence of the concept. A hot plate of food or an ice-cold drink placed on the table will tend to take on the ambient room temperature. A spring-driven clock or watch will slowly unwind and stop. A house or garden that is not maintained will slowly become more and more disorderly. Music or video signals on a magnetic tape will slowly fade away until, after many decades, nothing but noise remains. As a log fire keeps radiating heat and light energy, it slowly cools down until nothing but ashes remain. In every one of these examples, the input of energy serves to restore the system temporarily to a lower level of entropy (although this usually implies an increase in the overall entropy of the supra-system).

3.4 South African Perspective

Careful analysis of an intended system (its inputs, outputs, interfaces, processes etc) can prove invaluable in identifying unforeseen problems at the planning stages. Apparently this did not happen in the case of the renovation and expansion of the facilities served by the upper cable station on Table Mountain – no process was included to dispose of the increased volume of sewage that resulted, until a major problem had become apparent!

Until the end of 2001, a mixture of partially treated sewage from lavatories and waste water from the restaurant's sinks and dishwashers was allowed to seep down the mountain, killing vegetation and causing an outcry among environmentalists. Since then, effluent has been stored in a tank on the summit and is removed by cable car, but with the expansion of facilities and increasing numbers of visitors, the cableway company is concerned that this is not a sustainable solution.

3.5 Beyond the Basics

A number of system rules, which have been developed based on general systems theory, are particularly relevant to business. Examples of these are:

- Law of requisite variety: Control can be obtained only if the variety of the controller is at least as great as the variety of the situation to be controlled. In other words, every possible situation should provide feedback, which can be acted upon if required; this can be applied to controllers ranging from smoke detectors to computer error messages.
- Law of requisite hierarchy: The weaker and more uncertain the regulatory capability, the more hierarchy is needed in the organisation of regulation and control to get the same result – where systems (or people) are not self-regulating, then strong management supervision becomes essential.
- Sub-optimisation: If each subsystem, regarded separately, is made to operate with maximum efficiency, the system as a whole will not operate with utmost efficiency. In practice, the goal of the entire organisation must be the first priority, even if this is achieved at the expense of some projects or departments.

- 80/20 principle: In any large, complex system, eighty per cent of the output will be produced by only twenty per cent of the system. This applies to people, equipment, products, etc, and it is worth trying to identify the most productive 20% to make sure that it continues to function effectively.
- Redundancy of resources principle: Maintenance of stability under conditions of disturbance requires redundancy of critical resources. So make sure that you have spare parts for critical equipment, and staff who are able to fill in if a key employee is off sick!
- The environment-modification principle: To survive, systems have to choose between two main strategies. One is to adapt to the environment, the other is to change it. And after all, changing the (customer) environment is what marketing is all about.

3.6 Exercises

3.6.1 Systems concepts

Consider the following two systems:

1. *McDonalds hamburger franchise in Rondebosch*
2. *A large hospital, e.g. Groote Schuur*

- Give examples for *each* system of the system goal or purpose, 2 inputs, 2 components, 2 processes, 2 outputs, one sub-system, one supra-system and an external feedback mechanism.
- How would you measure whether the ***entropy*** of each system increases or decreases?

3.6.2 Systems Thinking

“Systems thinking” refers to trying to solve problems by looking at their wider context, and examining the root causes, interactions, feedback mechanisms, etc.

- Think of an example of a problem that cannot be solved effectively by addressing only its apparent symptoms, and explain why this is the case.

3.6.3 The Systems View

Make a list of at least 10 different systems that you are a part of in everyday life.

CASE STUDY: GREENFINGERS GARDEN SERVICES

Greenfingers Garden Services was established in Cape Town in 1990, starting as a small suburban garden maintenance service (mowing lawns, weeding flowerbeds, etc), employed by a limited number of clients on an annual contract basis. Over the last decade the business has expanded considerably, and it now has three branches (in the Southern Suburbs, Northern Suburbs, and Camps Bay area) which offer consulting and landscaping services, one-off "spring cleans" as well as regular garden maintenance. The company has both residential and corporate clients, and ascribes its success to the efficient and personal service that it has always provided.

The main Southern Suburbs branch is run by the owner, Alice Cooper, and is responsible for overall management of the business, including all the accounting and general administration functions, marketing, consulting, and stock. Each branch manages its own supplies of gardening equipment and schedules its labour force (permanent and casual staff) to ensure that jobs are completed on time.

In more detail, the business operates as follows:

- The **marketing** function, headed by Steve Carlton, includes newspaper, yellow pages and radio advertising, colour brochures which can be left with prospective clients, and regular phone calls to existing clients to check that they are happy with the service they have received. Garden service foremen are also supposed to suggest additional services to clients, such as pruning, replanting or fertilizing, but in many cases the householder is not home at the time of the garden service. Steve relies on information received from the various branches to let him know when they have spare capacity, in which case flyers are distributed in letter boxes within a restricted area, offering special deals on garden cleanups or new contracts for a limited time. Steve deals with all responses and queries, provides quotations, draws up contracts, and then passes on new client information to the accounts department.
- The **accounts** department receives new client information from Steve Carlton, and receives a daily listing from each branch of jobs completed for invoicing. In addition, they order equipment and supplies for all branches, schedule vehicle maintenance, attend to creditor payments and client receipts, and maintain the payroll for permanent and casual staff.
- Alice Cooper oversees the business **administration** herself, and does her best to keep costs down by having equipment repaired rather than replaced, and by ensuring that the permanent staff is kept as small as possible by utilising casual labour. However, this increases the complexity of management, since she needs to know a week ahead of time how many casuals will be required, so as to ensure that she will not be short-staffed. Also, while equipment is being repaired, it is often necessary to reschedule jobs or try to shift lawnmowers etc between branches, involving a number of telephone calls.
- The garden **equipment** itself (mowers, trimmers, sprayers, clippers, spades & forks, etc) is kept in store at each branch, and issued to each team at the start of the day. At

the end of the day it is checked back in, and any problems or breakages are reported to central administration at the main branch. Central admin checks whether or not the item is still under guarantee, and arranges for any necessary repairs to be undertaken. Each branch also has a number of light delivery vehicles for transporting work teams and equipment to the clients' premises.

- Greenfingers does not directly employ any **landscaping** consultants, but maintains a short list of landscapers and other garden specialists who can be called on when required. When a landscaping job is undertaken, the consultant is paid a commission based on the value of the job, but Greenfingers make use of their own labour and source the plants themselves. They have arrangements with a wholesale nursery for the provision of shrubs etc at a discount price. Heavy machinery for earthmoving or tree removal is hired when needed.
- The actual **work teams** who carry out the garden maintenance jobs, are managed by their specific branches. Based on the orders received via marketing, and the regular scheduled contract jobs, the admin department informs each branch on Mondays of their jobs for the following week. The branch manager must then check that labour and equipment will be available, and inform central admin of any potential problems so that they can be resolved in good time. Each work team has a foreman and at least one gardener who are on the permanent staff, and additional casual workers are hired by the day. Once the work teams have left for the client properties each morning, the branch manager compiles a list of the previous day's completed jobs, the staff employed, and any damaged equipment, for submission to central admin.

With the growth of the business, its administration is turning into a nightmare, and Alice finds that her evenings and weekends are being spent collating information, working out schedules, and trying to overcome problems by sharing equipment and even staff between branches. More and more clients are complaining that special instructions given to Steve Carlton are not being carried out by their work team, or that discounts that were promised have been omitted from the invoice. Alice is also aware that opportunities are being missed for the provision of extra services such as spraying and pruning, which are highly profitable since the work team is already on site and no additional time or cost is needed for transport.

(a) Construct a labelled diagram that will show the flow of information between central administration, marketing, accounts, each of the branches, the work teams, and the consultants.

(b) Explain how the automation of this information flow could improve the running of Greenfingers Garden Services.

(c) At a Transaction Processing level, what data would need to be captured in order to provide the input for an automated information system?

(d) Provide a comprehensive list of useful reports that could be produced by a Management Information System, and specify who each would be used by.

(e) What feedback mechanisms could be put in place to monitor and control business activities?

Section II: IS Technologies

An **information system** is a system that gathers and transforms data in order to produce information for its end-users. Typical technologies that are incorporated in this process are hardware, software, data and networks. (The fifth important component of an information system, people, is not classified as a technology!)

These same components are found in small, informal information systems such as the one you use to keep track of the contact details of your friends and family. You may have phone numbers stored in an address book, on your cell phone, and on the cover of your exam pad (hardware); you have particular rules about whose numbers you are going to keep and how you store them (software); the collection of numbers that you already have forms your database; and when you update a number in your address book from the back of the exam pad, you are transferring data between resources. But for the purposes of this book, we will focus on the components of larger, computerised information systems, operating within the environment of a commercial organisation.

Hardware

The most easily visible component of an information system is the *hardware*. One can typically distinguish between the media used to store the information and the capital equipment used to read, write and store the media. In *manual* information systems, paper is perhaps the major information medium, although microfilm, microfiche and audio/video tape are also still popular. Some of the capital equipment associated with manual systems are pens, typewriters, photocopiers, filing cabinets and shelves, binders, staplers, shredders, microfilm readers, recorders. Many of these manual technologies are still a significant component of c*omputerised* information systems but the latter also use various optical and magnetic disc media which can be read using only sophisticated computer input and output devices such as scanners, printers, monitors and projectors. Other hardware includes the computer itself, storage devices such as hard drives and a whole "alphabet zoo" of network or communication devices and cabling.

Software and Procedures

Software consists of the methods used to record, transform and extract information. The term is used mainly in the context of computer-based systems where it refers to the computer programs containing detailed instructions that govern their data processing. Although computer hardware used to receive most attention in the past, software has since become far more important than hardware, both in terms of monetary investment and management attention.

Generally considered part of the information systems software are the documentation, instructions and training that are needed to use the software.

The various *organisational procedures* for humans also form part of an information system's software, though this is extending the concept of software to the realm of people, not just computers. This would include the paper forms, procedures and guidelines for handling incoming telephone calls, dealing with mail, processing orders and purchases, internal communication, meetings, decision criteria etc. For conceptual purposes, it should make no difference whether a certain procedure is executed by people or by computers.

Data

Although a computer stores program software and data in the same way, from a system's viewpoint data is a very important and separate subsystem. Only recently have organisations (and individuals) started to realise that their databases represent huge investments, which potentially contain significant value.

Corporate data should have its own guardians such as database administrators who control access, integrity, format and security. Careful analysis of organisational data requirements is needed to be able to produce useful management information to support both current and future decision-making. In addition, the data storage mechanisms that are implemented are likely to influence the ease with which current and historical data can be retrieved and processed.

Networks

The *networking and communications infrastructure* has recently been considered to be a separate component of information systems, although in some cases this distinction can be regarded as a matter of personal opinion. There are definitely a number of specific decision and management issues associated with the network infrastructure. On the other hand, the network infrastructure also consists of hardware and software components, most of which share attributes with the mainstream information systems hardware and software mentioned above.

Organisations have realised that *stand-alone* computers present many problems: fragmentation of data, lack of control, insufficient integration and limited opportunity for teamwork. One of the major trends over the last decade was the move not only to have a personal computer on the desk of virtually every knowledge worker, but to have that computer linked to the other computers in the organisation.

Although these different technologies will be described separately in the chapters that follow, it is important to remember that they all need to work together in order to achieve the goals of any particular organisation. Compatibility of the various system components is vital, since the outputs of one technology may well provide the inputs for another. And above all, the purpose of an information system is to provide useful information to **people** (the non-technical component of the system), so the selection of technologies to be used should be based on the need to meet human requirements.

4. Hardware

Hardware is the most visible part of any information system: the equipment such as computers, scanners and printers that is used to capture data, transform it and present it to the user as output. Although we will focus mainly on the personal computer (PC) and the peripheral devices that are commonly used with it, the same principles apply to the complete range of computers:

- Supercomputers, a term used to denote the fastest computing engines available at any given time, which are used for running exceptionally demanding scientific applications.
- Mainframe computers, which provide high-capacity processing and data storage facilities to hundreds or even thousands of users operating from (dumb) terminals.
- Servers, which have large data storage capacities enabling users to share files and application software, although processing will typically occur on the user's own machine.
- Workstations, which provide high-level performance for individual users in computationally intensive fields such as engineering.
- Personal computers (including laptop/notebook computers) have a connected monitor, keyboard and CPU, and have developed into a convenient and flexible business tool capable of operating independently or as part of an organisational network.
- Mobile devices such as personal digital assistants or the latest generation of cellular telephones, offer maximum portability plus wireless connection to the internet, although they do not offer the full functionality of a PC.

And we are already moving into the age of wearable computers for medical or security applications, embedded computers in appliances ranging from motor cars to washing machines, and the smart card which will provide identification, banking facilities, medical records and more!

4.1 Input devices

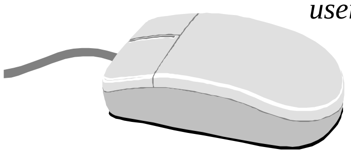
Data may enter an information system in a variety of different ways, and the input device that is most appropriate will usually depend on the type of data being entered into the system, how frequently this is done, and who is responsible for the activity. For example, it would be more efficient to scan a page of typed text into an information system rather than retyping it, but if this happens very seldom, and if typing staff are readily available, then the cost of the scanner might not be justified. However, all of the input devices described in this chapter have at least one thing in common: the ability to translate non-digital data types such as text, sound or graphics into digital (i.e. binary) format for processing by a computer.

4.1.1 The keyboard

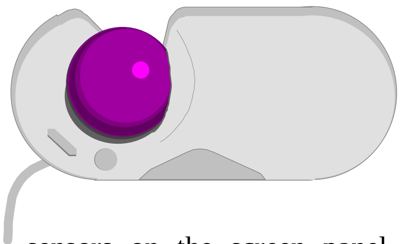
A lot of input still happens by means of a keyboard. Usually, the information that is entered by means of a keyboard is displayed on the monitor. The layout of most keyboards is similar

to that of the original typewriter on which it was modelled. Ironically, this “QWERTY” keyboard layout was originally designed to slow the operator down, so that the keys of the typewriter would not get stuck against each other. This layout now works counter-productively since a computer can process keyboard input many times faster than even the fastest typist can manage. A number of attempts have been made to design alternative layouts by rearranging the keys (the Dvorak keyboard) or by reducing the number of keys. None of these alternative designs has really caught on. Special keyboards have also been designed for countries that use a non-Roman alphabet, and also for disabled people.

4.1.2 Pointing devices

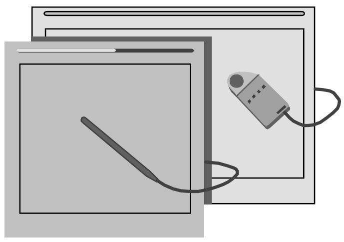


The now ubiquitous electronic *mouse* is an essential input device for use with any *graphical user interface*. It consists of a plastic moulded housing, designed to fit snugly in the palm of the hand, with a small ball at its bottom. Moving the mouse across a flat surface will translate the movements into a rolling action of the ball. This is translated into electronic signals that direct the corresponding movement of a cursor on the computer monitor. Buttons on the mouse can then be used to select icons or menu items, or the cursor can be used to trace drawings on the screen.



The less popular *trackball* operates exactly like an “upside-down” mouse except that the ball is much larger and, instead of the mouse being moved over a surface, the user manipulates the ball directly. Since the trackball can be built into the side of the keyboard, it obviates the need for a free surface area and is therefore handy in situations where desktop surface area is at a premium or not available. Originally popular in educational laboratory settings and for laptop computers, trackballs are now mainly confined to exhibition displays and other public terminals.

Touch-screens are computer monitors that incorporate sensors on the screen panel itself or its sides. The user can indicate or select an area or location on the screen by pressing a finger onto the monitor. *Light and touch pens* work on a similar principle, except that a stylus is used, allowing for much finer control. Touch pens are more commonly used with handheld computers such as personal organisers or digital assistants. They have a pen-based interface whereby a stylus (a pen without ink) is used on the small touch-sensitive screen of the handheld computer, mainly by means of ticking off pre-defined options, although the fancier models support data entry either by means of a stylised alphabet, which resembles a type of shorthand, or some other more sophisticated handwriting recognition interface.



Digitiser tablets also use a pressure sensitive area with a stylus. This can be used to trace drawings. A similar conceptual approach is used for the *touch pad* that can be found on the majority of new notebook computers, replacing the more awkward joystick or trackball. The user controls the cursor by moving a finger across a fairly small rectangular touch-sensitive area below the keyboard, usually about 5 cm by 7 cm.

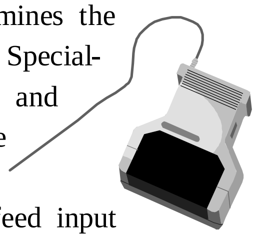
A large number of *game interfaces* have been developed to provide a more realistic and natural interface in various gaming situations and simulations: the joy stick, steering wheel, foot pedal and other gaming devices. They all perform functions similar to the mouse in that they allow the user to control a cursor or simulate generally real-time motion control. Contact your nearest game arcade for details.

Although the *data glove* also fits under the previous category, it is technically a lot more complex. It looks like a hand glove but contains a large number of sensors and has a data cable attached; though the latter is being replaced by means of infrared cordless data transmission. Not only does the data glove allow for full three-dimensional movement but it also senses the position of individual fingers, translating this into a grip. The glove is currently used in virtual reality simulators where the user moves around in an artificially rendered environment projected onto tiny LCD screens fitted into vision goggles. The computer generates various imaginary objects, which the user can "pick up" and manipulate by means of the glove. Advanced models even allow for tactile feedback by means of small pressure pockets built into the glove.

4.1.3 Optical scanners and readers

There are a number of different optical scanner technologies on the market.

§ *Optical Scanners* use light-emitting devices to illuminate the printing on paper. Depending on how much light is reflected, a light-sensor determines the position and darkness (or colour) of the markings on the paper. Special-purpose optical scanners are in use by postal services to read and interpret hand-written postal codes. General-purpose scanners are used with personal computers to scan in images or text. These vary from handheld devices (see picture) to flatbed scanners which feed input documents one sheet at a time. A common use of optical scanners is the scanning of black-and-white or colour images and pictures. When scanning text, it is necessary to load additional *optical character recognition (OCR)* software that converts the scanned raster-image of the text into the equivalent character symbols, so that they can be edited using word processing software.



§ *Barcode scanners* detect sequences of vertical lines of different widths, the ubiquitous barcode as found also on the back of this book. These scanners have become very popular with retailers due to the fact that all pre-packaged products are now required to have a product bar code on their packaging, following the standard laid down by the South African Article Numbering Association (SAANA). Libraries and video shops now also commonly use bar code scanners. They are more generally used for tracking and routing large numbers of physical items such as for asset inventory purposes in many larger organisations, postal items by the postal services and courier services, or for luggage handling by airlines.

§ *Optical mark readers* are capable of reading dark marks on specially designed forms. The red multiple choice answer sheets in use at many educational and testing institutions are a good example.

4.1.4 Other input devices

A *magnetic card reader* reads the magnetised stripe on the back of plastic credit-card size cards. These cards need to be pre-recorded following certain standards. Although the cards can hold only a tiny amount of information, they are very popular for access (door) control and financial transactions (ATMs and point-of-sale terminals).

Magnetic ink character recognition (MICR) uses a special ink (containing magnetisable elements) and a distinct font type. It is used mainly in the banking sector for the processing of cheques.

Touch-tone devices can use a voice telephone to contact computer-based switchboards or enter information directly into remote computers. Many corporate telephone help-lines rely on the customer pressing the touch-tone telephone buttons to route his/her call to the correct operator by selecting through a menu of possible options. South African banks also enable their clients to perform a number of banking transactions via telephone.

Digital cameras allow you to make pictures of physical objects directly in a digital, i.e. computer-readable, format. Relatively low-cost digital still picture cameras are now available that capture images directly on electronic disk or RAM media instead of the traditional film. Apart from being very compact, most of these digital cameras can also interface directly with personal computers and are thus becoming a popular tool to capture pictures for e-mailing or loading on the world-wide Web.

Biometric devices are used to verify personal identity based on fingerprints, iris or retinal scanning, hand geometry, facial characteristics etc. A scanning device is used to capture key measurements and compare them against a database of previously stored information. This type of authentication is becoming increasingly important in the control of physical access.

Finally, *voice input devices* are coming of age. Voice-recognition has recently made a strong entry into the market with the availability of low-cost systems that work surprisingly well with today's personal computers. These systems allow for voice control of most standard applications (including the operating system). With voice control, the computer recognises a very limited number (50 or less) of frequently used, programmable system commands ("save", "exit", "print"…) from a variety of users. In fact, these systems are not only used for the interface of computer programs; they are also slowly making an appearance in consumer appliances, novelty items and even motor cars!

Much more difficult to achieve than voice control, is true *voice dictation* used to dictate e.g. a letter to your word processor. The difficulty is that the computer must not only distinguish between many tens of thousands of possible words, but it must also recognise the almost unnoticeable breaks in between words, different accents and intonations. Therefore, voice dictation typically requires a user to train the voice recognition software by reading standard texts aloud. Nevertheless, for personal purposes and slow typists, voice recognition is rapidly becoming a viable alternative to the keyboard.

4.2 Central Processing Unit (CPU)

Once data has been entered into a computer, it is acted on by the CPU, which is the real brain of the computer. The CPU takes specific program instructions (usually one at a time), applies them to the input data and transforms the input into output.

4.2.1 Components of the CPU.

The CPU has two major components.

- The *Arithmetic and Logic Unit (ALU)* executes the actual instructions. It knows how to add or multiply numbers, compare data, or convert data into different internal formats.
- The *Control Unit* does the "housekeeping" i.e. ensures that the instructions are processed on time, in the proper sequence, and operate on the correct data.

Figure 4-1 gives a detailed representation of a computer system.

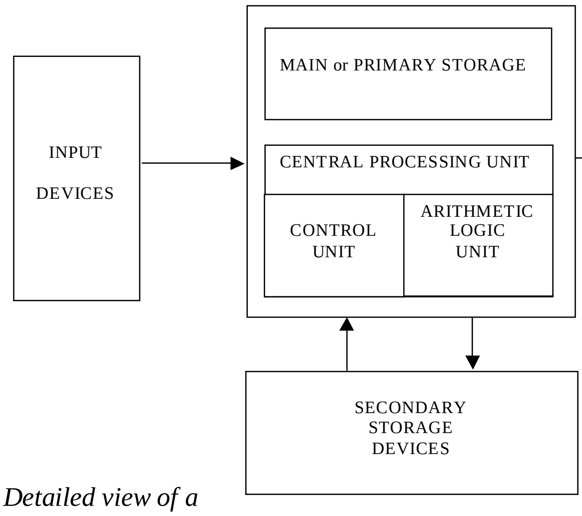


Figure 4-1: Detailed view of a computer system.

4.2.2 Types of CPUs

The CPU is an electronic device based on microchip technology, hence it is also often called the *microprocessor*. It is truly the showcase and culmination of the state-of-the-art in the electronics industry: a tiny silicon-based chip occupying less than 1 square cm contains several millions of transistor elements, measuring less than a thousandth of a millimetre across. They operate at speeds way beyond our comprehension: a typical CPU can multiply more 7-digit numbers in one second than a human could do in ten lifetimes, but uses less energy than a light bulb!

Think of the motor car industry: there are different manufacturers or makes of cars (Volkswagen, Toyota, etc.), each with different models (Golf, Jetta, …), which come out in different versions (City Golf, Sports model, coupé, etc.). In addition, there exist *custom-made* special-purpose cars. It is the same in the computer chip business. There are many different types of CPUs on the market. The best-known manufacturer is Intel, which produces the microprocessors for the IBM-compatible personal computer (*PC*). Some of its competitors produce clones or imitations (e.g. AMD), others manufacturers produce different types of microprocessors or concentrate on small volumes of highly specialised or very fast microprocessors. Intel has produced a large number of CPU types: the earliest model used in the Personal Computer was the 8088, followed by the 8086, the 80286, the 386, 486 and the line of Pentium processors.

4.2.3 Speed of processing

How does one measure the speed of, say a Porsche 911? One could measure the time that it takes to drive a given distance e.g. the 900 km from Cape Town to Bloemfontein takes 4½ hours (ignoring speed limits and traffic jams). Alternatively, one can indicate how far it can be driven in one standard time unit e.g. the car moves at a cruising speed of 200 km/hour.

In the same way, one can measure the speed of the CPU by checking the time it takes to process one single instruction. As indicated above, the typical CPU is very fast and an instruction can be done in about two billionths of a second. To deal with these small fractions of time, scientists have devised smaller units: a *milli*second (a thousandth of a second), a *micro*second (a millionth), a *nano*second (a billionth) and a *pico*second (a trillionth).

However, instead of indicating the time it takes to execute a single instruction, the processing speed is usually indicated by how many instructions (or computations) a CPU can execute in a second. This is exactly the inverse of the previous measure; e.g. if the average instruction takes two billionths of a second (2 nanoseconds) then the CPU can execute 500 million instructions per second (or one divided by 2 billionths). The CPU is then said to operate at 500 *MIPS* or 500 *million of instructions per second.* In the world of personal computers, one commonly refers to the rate at which the CPU can process the simplest instruction (i.e. the clock rate). The CPU is then rated at 500 *MHz* (megahertz) where mega indicates million and Hertz means “times or cycles per second”. For powerful computers, such as workstations, mainframes and supercomputers, a more complex instruction is used as the basis for speed measurements, namely the so-called floating-point operation. Their speed is therefore measured in *megaflops* (*million of floating-point operations per second*) or, in the case of very fast computers, *teraflops* (billions of flops).

In practice, the speed of a processor is dictated by four different elements: the “clock speed”, which indicates how many simple instructions can be executed per second; the word length, which is the number of bits that can be processed by the CPU at any one time (64 for a Pentium IV chip); the bus width, which determines the number of bits that can be moved simultaneously in or out of the CPU; and then the physical design of the chip, in terms of the layout of its individual transistors. The latest Pentium processor has a clock speed of about 4 GHz and contains well over 100 million transistors. Compare this with the clock speed of 5 MHz achieved by the 8088 processor with 29 000 transistors!

Moore’s Law (see Figure 4-2) states that processing power doubles for the same cost approximately every 18 months.

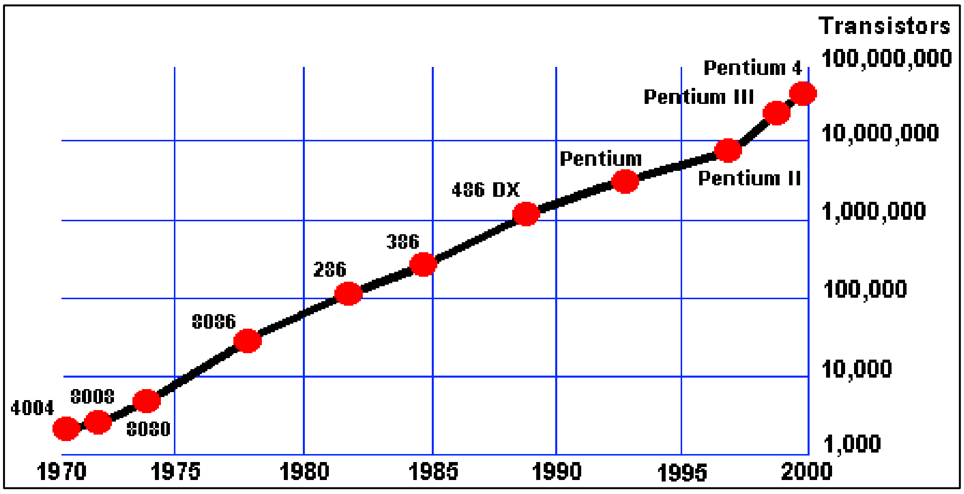


Figure 4-2. Illustration of Moore's Law

4.2.4 Von Neumann versus Parallel CPU Architecture

The traditional model of the computer has one single CPU to process all the data. This is called the Von Neumann architecture because he engineered this approach to computers in the days when computers were still a dream.

Except for entry-level personal computers, most computers now have two, four, or up to sixteen CPUs sharing the main processing load, plus various support processors to handle maths processing, communications, disk I/O, graphics or signal processing. In fact many CPU chips now contain multiple "cores" each representing an individual CPU.

Some super-computers that have been designed for massive parallel processing, have up to 64,000 CPUs. These computers are typically used only for specialised applications such as weather forecasting or fluid modelling. Today's supercomputers are mostly clusters (tight networks) of many thousands of individual computers.

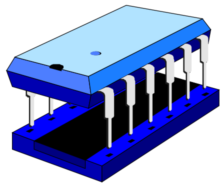
4.2.5 Possible Future CPU Technologies

Perhaps the major future competitor of the microchip-based microprocessor is *optical computing*. Although the technology for developing electronic microchips suggests that CPUs will continue to increase in power and speed for at least the next decade or so, the physical limits of the technology are already in sight. Switching from electronic to light pulses offers a number of potential advantages: light (which consists of photons) can travel faster, on narrower paths and does not disperse heat. In theory, one can even process different signals (each with a different light frequency) simultaneously using the same channel. Although the benefits of optical processing technology have already been proven in the areas of data storage (CD-Rom, CD-R) and communication (fibre optics), the more complex all-optical switches required for computing are still under development in the research laboratories.

A very experimental alternative to optical and electronic technologies is the *organic computer*. Research indicates that, for certain applications, it is possible to let a complex organic molecule act as a primitive information processor. Since even a tiny container filled with the appropriate solutions contains many trillions of these molecules, one obtains in effect a hugely parallel computer. Although this type of computer can attack combinatorial problems way beyond the scope of traditional architectures, the main problem is that the programming of the bio-computer relies entirely on the bio-chemical properties of the molecules.

Another exciting but currently still very theoretical development is the possible use of quantum properties as the basis for a new type of computer architecture. Since quantum states can exist in juxtaposition, a register of qubits (a bit value in quantum state) takes on all the possible values simultaneously until it is measured. This could be exploited to speed up extremely parallel algorithms and would affect such areas as encryption, searching and error-correction. To date, experimental computers with a few qubits have been built but the empirical validation of the actual usefulness of quantum computing still remains an open question.

4.3 Main Memory



The function of main memory (also referred to as primary memory, main storage or internal storage) is to provide temporary storage for instructions and data during the execution of a program. Main memory is usually known as RAM, which stands for Random Access Memory. Although microchip-based memory is virtually the only technology used by today's computers, there exist many different types of memory chips.

4.3.1 Random Access Memory (RAM)

RAM consists of standard circuit-inscribed silicon microchips that contain many millions of tiny transistors. Very much like the CPU chips, their technology follows to the so-called *law of Moore*, which states that they double in capacity or power (for the same price) every 18 months. A RAM chip easily holds hundreds of Megabytes (million characters). They are frequently pre-soldered in sets on tiny memory circuit boards called *SIMMS* (*Single In-line Memory Modules*) or *DIMMS (Dual …)* which slot directly onto the *motherboard*: the main circuit board that holds the CPU and other essential electronic elements. The biggest disadvantage of RAM is that its contents are lost whenever the power is switched off.

There are many special types of RAM and new acronyms such as EDO RAM, VRAM etc. are being created almost on a monthly basis. Two important types of RAM are:

§ ***Cache memory*** is ultra-fast memory that operates at the speed of the CPU. Access to normal RAM is usually slower than the actual operating speed of the CPU. To avoid slowing the CPU down, computers usually incorporate some more expensive, faster *cache RAM* that sits in between the CPU and RAM. This cache holds the data and programs that are needed immediately by the CPU. Although today's CPUs already incorporate an amount of cache on the circuit itself, this on-chip cache is usually supplemented by an additional, larger, cache on the motherboard.

§ ***Flash RAM or flash memory*** consists of special RAM chips on a separate circuit board within a tiny casing. It fits into custom ports on many notebooks, hand-held computers and digital cameras. Unlike normal RAM, flash memory is non-volatile i.e. it holds it contents even without external power, so it is also useful as a secondary storage device.

4.3.2 Read-Only Memory (ROM)

A small but essential element of any computer, ROM also consists of electronic memory microchips but, unlike RAM, it does not lose its contents when the power is switched off. Its function is also very different from that of RAM. Since it is difficult or impossible to change the contents of ROM, it is typically used to hold program instructions that are unlikely to change during the lifetime of the computer. The main application of ROM is to store the so-called *boot program*: the instructions that the computer must follow just after it has been switched on to perform a self-diagnosis and then tell it how load the operating system from secondary storage. ROM chips are also found in many devices which contain programs that are unlikely to change over a significant period of time, such as telephone switch boards, video recorders or pocket calculators. Just like RAM, ROM comes in a number of different forms:

§ ***PROM*** *(Programmable Read-Only Memory)* is initially empty and can be custom-programmed *once only* using special equipment. Loading or programming the contents of ROM is called burning the chip since it is the electronic equivalent of blowing tiny transistor fuses within the chip. Once programmed, ordinary PROMs cannot be modified afterwards.

§ ***EPROM*** (*Erasable Programmable Read-Only Memory*) is like PROM but, by using special equipment such as an ultra-violet light gun, the memory contents can be erased so that the EPROM can be re-programmed.

§ ***EEPROM*** (*Electrically Erasable Programmable Read-Only Memory*) is similar to EPROM but it can be re-programmed using special electronic pulses rather than ultra-violet light so no special equipment is required.

4.4 Secondary Storage Devices

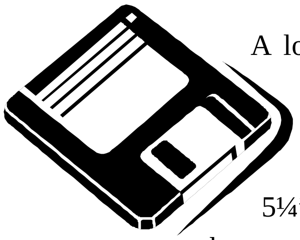
Since the main memory of a computer has a limited capacity, it is necessary to retain data in secondary storage between different processing cycles. This is the medium used to store the program instructions as well as the data required for future processing. Most secondary storage devices in use today are based on magnetic or optical technologies.

4.4.1 Disk drives

The disk drive is the most popular secondary storage device, and is found in both mainframe and microcomputer environments. The central mechanism of the disk drive is a flat disk, coated with a magnetisable substance. As this disk rotates, information can be read from or written to it by means of a head. The head is fixed on an arm and can move across the radius of the disk. Each position of the arm corresponds to a “track” on the disk, which can be visualised as one concentric circle of magnetic data. The data on a track is read sequentially as the disk spins underneath the head. There are quite a few different types of disk drives.

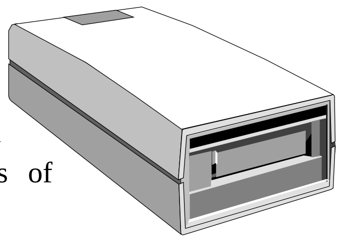
In *Winchester hard drives*, the disk, access arm and read/write heads are combined in one single sealed module. This unit is not normally removable, though there are some models available where the unit as a whole can be swapped in and out of a specially designed drive bay. Since the drives are not handled physically, they are less likely to be contaminated by dust and therefore much more reliable. Mass production and technology advances have brought dramatic improvements in the storage capacity with Terabyte hard drives being state of the art at the end of 2006. Current disk storage costs as little R1 per gigabyte.

Large organisations such as banks, telcos and life insurance companies, require huge amounts of storage space, often in the order of many terabytes (one terabyte is one million megabytes or a trillion characters). This was typically provided by a roomful of large, high-capacity hard drive units. Currently, they are being replaced increasingly by *redundant arrays of independent disks (RAIDs*). A RAID consists of an independently powered cabinet that contains a number (10 to 100) of microcomputer Winchester-type drives but functions as one single secondary storage unit. The advantage of the RAID is its high-speed access and relatively low cost. In addition, a RAID provides extra data security by means of its fault-tolerant design whereby critical data is mirrored (stored twice on different drives) thus providing physical data redundancy. Should a mirrored drive fail, the other drive steps in automatically as a backup.



A low-cost, low-capacity version of the hard disk was popularised by the microcomputer. The *diskette* consists of a flexible, magnetic surface coated mylar disk inside a thin, non-removable, plastic sleeve. The early versions of the diskette were fairly large (8” or 5¼”) and had a flexible sleeve, hence the name floppy diskette. These have rapidly been replaced by a diskette version in a sturdier sleeve, the stiffy disk, that despite its smaller size (3 ½”) can hold more data. Although the popular IBM format only holds 1,44 megabytes, a number of manufacturers have developed diskette drives that can store from 100 to 250 megabytes per stiffy. An alternative development is the *removable disk cartridge*, which is similar in structure to an internal hard drive but provides portability, making it useful for backup purposes.

4.4.2 Magnetic tape

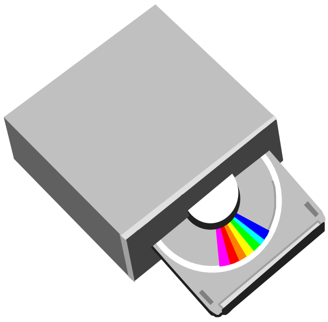


While disk and optical storage have overtaken magnetic tape as the most popular method of storing data in a computer, tape is still used occasionally – in particular for keeping archive copies of important files.

The main drawback of magnetic tape is that it is not very efficient for accessing data in any way other than strictly sequential order. As an illustration, compare a CD player (which can skip to any track almost instantly) with a music tape recorder (which has to wind the tape all the way through if one wants to listen to a song near the end). In computer terms, the ability to access any record, track, or even part within a song directly is called the *direct access* method. In the case of the tape recorder one may have to wind laboriously through the tape until one reaches the song required – this is referred to as the *sequential access* method.

The high-density diskette and recordable optical disk have all but eroded the marginal cost advantage that tape storage enjoyed. This technology is therefore disappearing fast.

4.4.3 Optical disk storage



Optical disks, on the other hand, are rapidly becoming the storage medium of choice for the mass distribution of data/programs and the backup of data. Similar to disk storage, information is stored and read from a circular disk. However, instead of a magnetic read head, a tiny laser beam is used to detect microscopic pits burnt onto a plastic disk coated with reflective material. The pits determine whether most of the laser light is reflected back or scattered, thus making for a binary “on” or “off”. In contrast to hard disks, data is not stored in concentric cylinders but in one long continuous spiral track.

Trivial fact: The spiral track used to store data on a CD is over six kilometres long.

A popular optical disk format is the 12-cm *CD-ROM*. The widespread use of music compact discs has made the technology very pervasive and cheap. Production costs for a CD-ROM are less than R1, even for relatively small production volumes. The drive reader units themselves have also dropped in price and are now hardly more than the cost of a diskette drive. A standard CD-ROM can store 650 megabytes of data and the data can be transferred at many megabytes per second, though accessing non-sequential data takes much longer.

The CD-ROM is a read-only medium. Data cannot be recorded onto the disk. The low cost and relatively large capacity makes the CD-ROM ideally suited to the distribution of software. They are also ideal for the low-cost distribution of large quantities of information such as product catalogues, reference materials, conference proceedings, databases, etc. It is indispensable for the storage of multimedia where traditional textual information is supplemented with sound, music, voice, pictures, animation, and even video clips.

The limitation of the read-only format lead to the development of low-cost recordable optical disks. The *compact disk recordable (CD-R)* is a *write-once*, *read-many (WORM)* technology. The CD-R drive unit takes a blank optical disk and burns data onto it using a higher-powered laser. This disk can then be read and distributed as an ordinary CD-ROM, with the advantage that the data is non-volatile i.e. permanent. The rapid drop in the cost of drive units and blank recording media (less than R2 per CD-R) is making this a very competitive technology for data backup and small-scale data distribution.

Although the 650 megabytes initially seemed almost limitless, many multimedia and video applications now require more storage. A new format, the *Digital Video Data (DVD)* standard increased the capacity of the CD-ROM by providing high-density, double-sided and double-layered CDs. By combining the increased storage capacity with sophisticated data compression algorithms, a DVD disc can easily store 10 times as much as a CD, sufficient for a full-length high-quality digital motion picture with many simultaneous sound tracks.

Even the DVD is not sufficient storage capacity and currently two optical technologies have been developed to increase storage capacity even further. The basic specification of both HD-DVD and Blu-Ray provide for more than 25 GB of storage on a disc although multi-layer Blu-Ray discs with capacities of more than 200 GB have already been developed.

A promising research area involves the use of *holographic disk storage* whereby data is stored in a three-dimensional manner. Though in its infancy, early prototypes promise a many-fold increase in storage capacity and it could become the answer to the ever increase storage requirements of the next decade

Device	**Access Speed**	**Capacity**	**Cost**
RAM	< 2 nanosec	256 MB (chip)	<R1/MB
Tape	serial only	500 MB-4 GB	<10c/MB
Diskette (3 ½”)	300 ms	1,44 MB	R1/MB
PC hard disk	10 ms	40-750 GB	<2c/MB
M/F hard disk	25 ms	100+ GB	R2/MB
CD-ROM	< 100 ms	660 MB	<0.1c/MB
CD-R	< 100 ms	660 MB	<0.2c/MB
DVD	< 100 ms	8 GB	<0.1c/MB
HD-DVD	< 100 ms	30 GB	?
Blu-Ray	< 100 ms	25 GB-200GB	?

Figure 4-3: Comparison of secondary storage devices

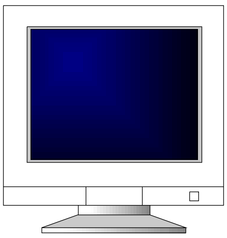
4.5 Output Devices

The final stage of information processing involves the use of output devices to transform computer-readable data back into an information format that can be processed by humans. As with input devices, when deciding on an output device you need to consider what sort of information is to be displayed, and who is intended to receive it.

One distinction that can be drawn between output devices is that of hardcopy versus softcopy devices. Hardcopy devices (printers) produce a tangible and permanent output whereas softcopy devices (display screens) present a temporary, fleeting image.

4.5.1 Display screens

The desk-based *computer screen* is the most popular output device. The standard *monitor* works on the same principle as the normal TV tube: a “ray” gun fires electrically charged particles onto a specially coated tube (hence the name *Cathode-Ray Tube* or *CRT*). Where the particles hit the coating, the “coating” is being “excited” and emits light. A strong magnetic field guides the particle stream to form the text or graphics on your familiar monitor.



CRTs vary substantially in size and resolution. Screen size is usually measured in inches diagonally across from corner to corner and varies from as little as 12 or 14 inches for standard PCs, to as much as 40+ inches for large demonstration and video-conferencing screens. The screen resolution depends on a number of technical factors.

A technology that has received much impetus from the fast-growing laptop and notebook market is the *liquid crystal display (LCD).* LCDs have matured quickly, increasing in resolution, contrast, and colour quality. Their main advantages are lower energy requirements and their thin, flat size. Although alternative technologies are already being explored in research laboratories, they currently dominate the "flat display" market.

Organic light-emitting diodes (OLED) can generate brighter and faster images than LED technology, and require thinner screens, but they have less stable colour characteristics, making them more suitable for cellular telephone displays than for computers.

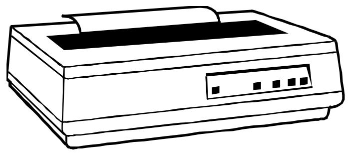
Another screen-related technology is the *video projection unit*. Originally developed for the projection of video films, the current trend towards more portable LCD-based lightweight projectors is fuelled by the needs of computer-driven public presentations. Today's units fit easily into a small suitcase and project a computer presentation in very much the same way a slide projector shows a slide presentation. They are rapidly replacing the flat transparent LCD panels that needed to be placed on top of an overhead projection unit. Though the LCD panels are more compact, weigh less and are much cheaper, their image is generally of much poorer quality and less bright.

4.5.2 Printers and plotters

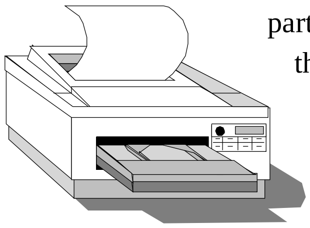
Printers are the most popular output device for producing permanent, paper-based computer output. Although they are all *hardcopy* devices, a distinction can be made between impact and non-impact printers. With impact printers, a hammer or needle physically hits an inked ribbon to leave an ink impression of the desired shape on the paper. The advantage of the impact printer is that it can produce more than one simultaneous copy by using carbon or chemically-coated paper. Non-impact printers, on the other hand, have far fewer mechanically moving parts and are therefore much quieter and tend to be more reliable.

The following are the main types of printers currently in use.

§ *Dot-matrix printers* used to be the familiar low-cost printers connected to many personal computers. The print head consists of a vertical row of needles each of which is individually controlled by a magnet. As the print head moves horizontally across the paper, the individual needles strike the paper (and ribbon in between) as directed by the control mechanism to produce text characters or graphics. A close inspection of a dot-matrix printout will reveal the constituent dots that make up the text. Although it is one of the cheapest printer options, its print quality is generally much lower that that of laser and ink-jet printers. However, today's models are quick and give a much better quality by increasing the number of needles.



§ *Laser printers* are quickly growing in market share. They work on the same principle as the photocopier. A laser beam, toggled on and off very quickly, illuminates selected areas on a photo-sensitive drum, where the light is converted into electrical charge. As the drum rotates into a "bed" of carbon particles ("*toner*") with the opposite charge, these particles will adhere to the drum. The blank paper is then pressed against the drum so that the



particles "rub off" onto the paper sheet. The sheet then passes through a high-temperature area so that the carbon particles are permanently fused onto the paper. Current high-end laser printers can cope with extremely large printing volumes, as is required e.g. by banks to print their millions of monthly account statements. The laser technology continues to develop in tandem with photocopier technology. Laser printers can now handle colour printing, double-sided printing or combine with mail equipment to perforate, fold, address and seal automatically into envelopes. At the lower end of the scale are the low-cost "personal" laser printers, which give a very good printing quality at a relatively modest cost.

§ *Thermal printers* use heat to print. The older thermal printers used *heat-sensitive* paper, similar to the special fax paper. A slight heat or pressure will leave a darker area. This produced very cheap but low-quality output. Currently, thermal-printing technology is used mainly for high-quality colour printing. These new thermal printers use coloured *wax* sticks and melt the wax onto the paper. Although they are slower than competing colour laser and inkjet technologies, they give a much more vibrant, colour-saturated image.

§ *Inkjet printers* are probably the most popular low-cost printing technology. Liquid ink is squirted onto the paper in the form of tiny droplets. These printers are about the same price as dot-matrix printers, albeit more expensive in terms of consumables. Their quality is close to that of the laser printers. Their great advantage is that the printers can easily be adapted to use coloured ink, thus making popular colour printers.

§ *Plotters* are mainly used for engineering and architectural drawings. A plotter consists of one (or several – in the case of colour plotters) pen(s) affixed to an arm. As the arm moves across the sheet of paper, the pen draws lines onto the paper. It is ideal for line drawings such as plans, especially in cases where the paper size exceeds that which can be accommodated by the other types of printers.

§ *Chain and line printers* are still popular in mainframe environments for the quick production of large volumes of internal printing. The line printer consists of a horizontal, rotating "drum" with 132 cylinders, each containing a full character set. As the 132-column wide paper moves up past the drum, a line at a time, each one of the 132 hammers on the other side of the paper strikes at the exact moment that the corresponding cylinder "shows" the correct character. The hammer hits the drum (and ink ribbon) and leaves an imprint of the character on the paper. The chain printer works on the same principle, but uses a horizontally rotating chain with engraved characters, instead of a drum. As anyone with some working experience in a large organisation knows, the print quality of these "computer printouts" is not very high.

Figure 4-4 compares the various output devices in terms of a number of characteristics.

Device	Technology	Quality	Speed	Dupli-cates?	Graph ics?	Fonts?	Colour?
CRT	softcopy	High	Very fast	NA	yes	yes	yes
LCD	softcopy	Fair	Very fast	NA	yes	yes	yes
Plotter	hardcopy	Fair	Slow	no	yes	yes	yes
Chain/ line printer	hardcopy	Low	Very Fast	yes	no	no	no
Laser printer	hardcopy	High	Fast/ fair	no	yes	yes	yes
Dot-Matrix printer	hardcopy	Fair	Fast/ fair	yes	yes	yes	some
Inkjet printer	hardcopy	Good	Fair	no	yes	yes	yes

Figure 4-4: Comparison of output devices

4.5.3 Audio-output devices

A type of output that is becoming increasingly popular is audio output. There are many different types of audio output.

§ *Sound output* is required by most multimedia applications and sophisticated games. The sound card in many of today's personal computers synthesises sound by drawing from a library of stored sounds, essentially using the same process as found in music keyboards. More advanced multimedia workstations are equipped for full stereo multi-channel surround sound and easily surpass many a modern hi-fi system in cabling and speaker complexity.

§ *MIDI in/output*. Modern day music production would be impossible without a vast array of electronic instruments and keyboards. These are typically controlled by a personal computer by means of Musical Instrument Digital Interface (MIDI), a common standard for linking, controlling and processing electronic music.

§ *Speech synthesis* is the production of speech-like output using an artificial voice. Although the lack of intonation still makes the voice sound artificial, the technology is reasonably mature and can be found anywhere from talking clocks and luxury cars to automated responses for telephonic directory enquiries.

4.5.4 Other Output Devices

Many other, extremely specialised input and output devices have been developed. Process control, for example, is a very specialised field but extremely important for automated factories (car manufacturing, canneries), continuous process environments (nuclear plants, refineries) or hazardous places (microbiological research laboratories, space exploration). For these applications, the computer relies on a multitude of sensors for its inputs: temperatures, speed, pressure, flow rates, weight, position, … These sensor inputs are then processed by the computers, which in turn control directly robot arms and other mechanical devices such as cutters, welding equipment, valves, switches, mixers etc.

4.6 South African Perspective

A number of car manufacturers have introduced new model vehicles that optionally includes a vehicle safety system that could reduce road deaths and injuries by foreseeing an unavoidable collision and activating passenger restraint and protection systems before it happens. "Pre-crash safety" has three elements:

- A sensor uses millimetre-wave radar to detect vehicles and obstacles on the road ahead.
- An electronic control unit (ECU) determines whether a collision is imminent based on the position, speed and course of the object. If it is...
- The seat belts retract to pull the passengers back into their seats and emergency brake assistance pressure is built, ready for the driver to hit the pedal.

Until now, vehicle safety devices have only been able to activate after a collision.

The car's radar, Toyota says, works even in rain and snow and is constantly scanning ahead. Newly developed computer software can quickly determine whether a collision is imminent based on the expected course of the host vehicle as well as the position, speed and expected course of preceding or oncoming vehicles. This could be the solution we need for South Africa’s unacceptably high road death rate - all we need is for every South African driver to be able to afford the new Toyota!

4.7 Beyond the Basics

Commercial development is set to begin on the next generation of memory: the samarium cube. This technology will allow the storage of up to one terabyte (1000 gigabytes) of data in a cubic centimetre of glass. When an extremely short pulse of laser light is applied to a piece of glass containing the rare earth element samarium, a dot around 400 nanometers in diameter becomes luminous, allowing the glass to be used as an optical memory. These luminous dots can be spaced 100 nanometers apart, and up to 2000 layers of dots can be stored and read within a cubic centimetre of glass, producing a three-dimensional storage medium. The pulse of light used to irradiate the cube lasts for only 1000-trillionth of a second (a femtosecond), because a longer pulse of light will create heat that can cause the glass to crack.

4.8 Exercises

4.8.1 PC specifications

A friend of yours wants to buy a **personal computer** for her small, home-based service business. She wants to use industry-standard software to create brochures, do accounts and financial calculations and maintain a database of customers, suppliers, products and orders. She copied down the specifications for a computer that she saw advertised on TV at a competitive price, but she is not sure whether she would really need all the components, and she doesn't understand all the technical "buzzwords". As a knowledgeable friend, she has asked you

- to explain in non-technical terms her questions about the various components;
- to identify any obviously incorrect specifications that she might have copied down wrongly from the advertisement, and briefly explain why they are wrong.

The following is her specifications sheet:

Specification	*Question*	*Correct?*
1.7 GHz Pentium-IV	What does "1.7 GHz" mean?	
4 MB RAM	What is RAM used for?	
500 GB Hard Disk	What sort of things would be stored on the hard disk?	
X50 CD-ROM	Would I use this to make backups? If not, what would I use it for?	
32 MB SVGA Graphics card	What does this do?	
Stiffy drive	Why do I need one if I have a CD-ROM?	
102 keyboard	Should I get any other input devices as well?	
14" monitor	Is this likely to be a modern flat screen like you get on laptops, or the old fashioned sort of monitor?	
Colour inkjet printer	Why not get a dot-matrix printer?	

4.8.2 Input / Output devices

A standard Automatic Teller Machine ("ATM") has a large number of input and output devices. List as many of its I/O devices as you can (you may include *sensors* as well).

5. Software

The computer owes most of its success to its versatility. By loading a different set of instructions, the same computer becomes a word processor, a games machine or a scientific number-cruncher. The set of instructions that tells the computer what to do is called the computer *software* or *program)*.

The real purpose of a computer is to perform information-processing tasks for the user. Thus the user will need to have *application software* such as an accounting package, word processor, graphics design software, a game or a Web browser. Applications do not grow on trees – they are complex products that have to be designed and coded very carefully. Although it is possible in principle for users to develop their own application software, most end-users leave this task to professional software designers. These software developers require the use of a variety of *development tools*. Finally, since that all applications perform certain common tasks such as printing, reading or saving data from disk, handling input devices, etc, one single master program called the *operating system* has been developed to relieve each individual program developer of these common tasks.

Regardless of the type of software being used, or the purpose that it is being used for, it will have to provide some means for a human being to interact with it: to enter data or program instructions, to request that a file be saved or printed, or simply to view the information that has been produced. This function is performed by the *user interface*.

5.1 The User Interface

The user interface relates to the presentation and formatting of information on the user's screen, as well as the various methods available to the user of selecting data and initiating actions. It controls the way the user and computer system interact, for example by means of error messages or help functions.

Although application programmers are free to develop their own interface independently of the operating system, most applications inherit or make use of the user interface functions provided by the operating system. We will therefore illustrate the various generations of user interfaces by means of examples of operating systems.

5.1.1 Command-based interface.

Figure 5-1 shows an example of a command-based interface. It demonstrates how the user checks for the existence of a file before copying it onto her diskette, using Microsoft DOS (MS-DOS). When using a command-based interface, the user has to remember (or look) up a variety of commands and their various options or parameters, making it difficult for novice users to operate. Other examples of command-based operating systems are UNIX (popular on mini-computers, but even more cryptic than MS-DOS) and most mainframe operating systems such as MVS or BS2000.


```
C:\TODO>dir *.jpg /w

 Volume in drive C is UCT
 Volume Serial Number is 3D63-14D1
 Directory of C:\TODO

PAHEL1.JPG      PAHEL2.JPG      PAHEL3.JPG
PIC_003.JPG     PIC_001.JPG     PIC_004.JPG
PAHEL7.JPG      PAHEL8.JPG      VAN1.JPG
        13 file(s)        638,161 bytes
         0 dir(s)     708,476,928 bytes free

C:\TODO>copy van1.jpg a:

Not ready reading drive A
Abort, Retry, Fail?r
```

Figure 5-1: A sample MS-DOS session.

5.1.2 Menu-driven Interface

A menu-driven user interface allows the user to select from a *menu*, a predefined list of available options or selections. This is already an improvement on the command-driven interface, since the user no longer has to rely on memory to remember the available options or commands. Many applications running under command-driven operating systems are menu-driven. "Power-users" (very experienced or knowledgeable users) often prefer the command-driven interface to a graphical alternative, because it allows a greater degree of customisation and may be quicker. A menu-driven interface is also appropriate when you wish to limit the functions that are available to users.

Figure 5-2 below shows an example of the Novell Netware SYSCON utility. Novell Netware is a popular networking operating system.

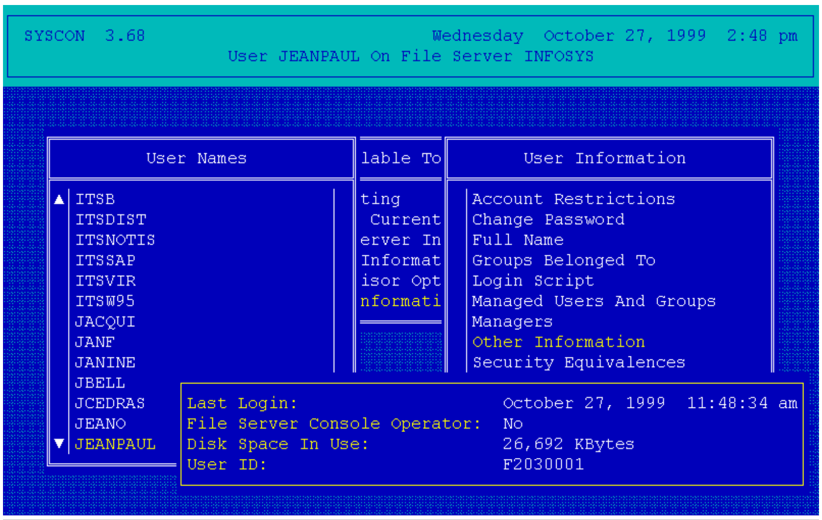


Figure 5-2: A menu-based interface (Novell)

5.1.3 Graphical User Interface

The graphical user interface (GUI) is currently the most popular interface on PCs. It requires a high-resolution graphics monitor. The metaphor used in many GUIs is that of a "desktop" on which various tools and documents are laid out. Active applications will have their own *window*, which can be re-sized at will, often overlaying windows of other applications. (Hence the name of the dominant GUI operating system, *Microsoft Windows*.) A window typically contains a document (or at least as much it as will fit in the space) and a number of tool and menu-bars. Options and commands on toolbars, as well as non-active applications or documents on the desktop, are indicated by means of *icons* (small graphical symbols or pictures). A GUI requires frequent use of the pointing device, usually a mouse, e.g. to move items across windows, highlight portions of a document, select specific icons or pinpoint destinations.

Figure 5-3 gives an example of a Windows desktop with a few applications open.

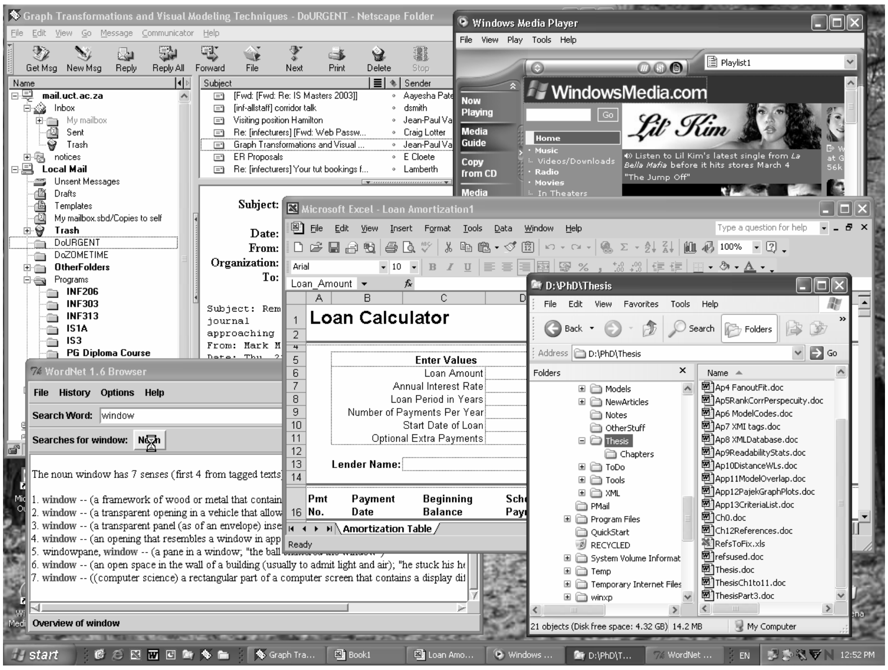


Figure 5-3: A GUI (MS-Windows XP)

5.1.4 Pen-based Interface

Pocket computers, handheld computers and *personal digital assistants (PDAs)* are generally too small to incorporate a keyboard. Instead, many combine the liquid crystal display (LCD), which is the output screen, with a pressure sensitive layer that can be used for input. All user input happens by means of a stylus or any pen-like pointing device. The pressure-sensitive LCD pad is then used in the same way as one would use a writing tablet or clipboard. Most of the interface consists of ticking off menu options, such as lists or timeslots on a diary. However, many devices also employ advanced handwriting recognition software so that users can actually enter words and numbers in their own handwriting.

5.1.5 Natural Language Interface

Voice input and output based on a limited set of stored sounds is readily available across all computer platforms, and is widely used by the visually impaired, and for hands-free data input. However, the ambition of a large number of computer scientists is to provide a completely unrestricted natural language interface to computers. Although voice recognition and voice synthesis are technically quite achievable, the major technical challenge remains to interpret standard English language statements, because this would require actual *understanding* or knowledge processing on behalf of the computer. This active area of research is known as *natural language processing (NLP).* Although it has become relatively standard practice to develop natural language interfaces for restricted subject domains, we are still a long way from providing a natural language interface that can deal with the many ambiguities of general life.

5.2 Application Software

The type of software with which users are in general most familiar, is application software – programs such as word processors or salary packages that do specific jobs to improve business productivity. Because of the big variety in user needs, there is a large multitude of application software available. By comparison, there are only about 5 to 10 popular different operating systems, and probably less than 100 different ones in use world-wide. If one looks at development tools, there are about 20 to 100 fairly popular development platforms available, although there are several thousands in use. But a quick scan of e.g. the web-site of "shareware.com" will reveal tens if not hundreds of thousands of different applications, with several thousands of commercial applications enjoying fairly widespread use. It is therefore impractical to attempt to discuss each of the many different applications that are available. Instead, this section will look at some of the many *classification schemes* used for various types of application software.

5.2.1 Classification by Function

A popular way to classify applications is to distinguish them according to application area.

§ *General purpose, productivity* or *end-user* applications assist a wide variety of users with common information processing tasks such as number crunching, word processing, business graphics, web browsing, electronic mail, scheduling or data management.

§ *Business applications* aim to automate common, generic business functions or processes. They include debtors, creditors, general ledger, inventory management, order entry and sales processing.

§ *Scientific applications* are focussed on the needs of scientists and researchers: astronomy, weather forecasting, *geographical information systems (GIS)*, statistics, simulations, engineering drawings, etc.

§ Finally, there is a large category of *miscellaneous* applications that do not fit neatly in any of the above categories, such as computer-based training software or games.

Trivial fact: Chess champion Gary Kasparov was beaten by a computer, Deep Blue, in 1997.

Deep Blue considered 200 million positions per second in order to evaluate alternative outcomes before making each move.

5.2.2 Vertical vs Horizontal Classification

§ *Vertical* applications target a specific industry or sector with similar business processes. Examples are packages for video store management, medical practice management, pharmacists, retailers, commercial banks etc.

§ *Horizontal* applications are business applications that can be used by virtually any business because of the universality of the business needs, e.g. accounting applications, inventory management or debtors control.

§ *Enterprise-wide systems*, often called *enterprise resource planning (ERP)* systems, aim to fulfil *all* the information system requirements of a business. These systems consists of many different modules, covering all generic business processes, with a great degree of standardisation of interfaces and an integrated, corporate database. Popular ERP vendors are SAP, BAAN and PeopleSoft.

§ *Inter-organisational systems (IOS)* are systems that cross the boundaries of individual organisations. Examples are electronic data interchange (EDI), electronic funds transfer (EFT) or the Internet.

5.2.3 Organisational Level

A popular academic classification of functional business applications looks at the hierarchical level of the organisation in which the software is used. This has already been discussed in Chapter 1.

§ *Transaction Processing Systems (TPS)* perform the business process-related data-processing tasks such as invoicing, statements, inventory, order and sales processing. They assist mainly clerical staff.

§ *Management Information Systems (MIS)* assist the operations and line managers with the control of the business process activities, usually by means of standard, regular reports. Virtually all TPS incorporate a MIS reporting module.

§ *Decision Support* Systems *(DSS)* are more interactive applications that actually assist with the decision making process of middle management (and professionals). Spreadsheets, *geographical information systems* (*GIS*) and expert systems are good examples of DSS.

§ *Executive Information/Support Systems (EIS* or *ESS)* assist top-level executives with their daily information needs for top management control as well as their strategic decision-making.

5.3 System Development Software

Many end-users never come into contact with the software that was used to create their applications (and operating systems). However, a good understanding of the alternative system development software options can help you in comparing different software packages, or in making the decision whether to have an application custom-developed for a particular business need.

5.3.1 Programming languages, source code and compilers

The majority of systems are developed by means of *programming languages*: artificially constructed languages to code the instructions for a computer. These languages have their own vocabulary, grammar (*syntax*), constructs and have often been designed to meet the demands of developing certain types of applications.

Lately, more and more systems are being developed partially or wholly by means of application generators. An *application generator* allows the system developer (or even end-users) to define problems for the computer in terms of inputs, outputs and processing requirements, without having to specify technical implementation issues such as how to store data in memory or on file. In theory, these tools require no programming knowledge; in practice, all but the simplest of applications produced by these generators require a substantial amount of *tweaking*: changes made manually, using a programming language, in order to make the program function properly.

A computer application consists of a series of detailed and unambiguous instructions. When the CPU executes a program, these instructions must be in *machine language*: the binary code that can be interpreted directly by the CPU. As will be shown below, it is extremely difficult to write even the simplest application directly in binary code. In addition, each different type of CPU has a different set of programming instructions (also called *operation codes* or *op codes*) which would require you to rewrite your application for each different CPU type. In practice, almost all applications today are written in a higher-level programming language. The list of instructions in a programming language is called the *source code*. A translation program is then used to translate this source code into the *object code* i.e. the low-level machine instructions that can be interpreted by the CPU. There are two basic types of translation programs.

- *Compilers* – programs that translate a high-level language program in its entirety into a new, machine language program. This program is called the *executable* or *compiled* program. To run the program, the compiled program can be loaded directly by the operating system into memory and executed as such by the CPU. The original source code is not needed to run the program; and neither is the compiler. Of course, the source code will be needed by the developer whenever a change or modification needs to be made to the application; in which case the application has to be re-compiled.

- *Interpreters* – programs that convert each of the source program's individual instructions one at a time into equivalent machine language instructions and execute them before translating the next instruction. This is done every time the program is executed. Hence many instructions may have to be translated and executed several times during a single execution of the program. The source program as well as the interpreter must always be available whenever the program needs to be executed.

As can be inferred, it is usually much more efficient to compile than to interpret a program. A compiled program also guards the intellectual property of the developer better, since the users do not have access to the source code. Most commercial software is being distributed in compiled format. The advantages of interpreters are their interactivity (especially useful while developing and debugging the application) as well as the smaller size of the program code. An example of an interpreted language is old-style BASIC although application macros, spreadsheets and JAVA virtual machines share many characteristics of interpreters. In practice, hybrid models have been developed that combine the benefits of both compiler and interpreter.

With this basic terminology out of the way, let us look at the various types of programming languages.

5.3.2 First generation: machine language

The lowest level in which programs can be written is *machine language (ML)*. This is the binary code that can be interpreted directly by the CPU. Obviously, this machine language is dependent on the type and "model" of CPU the computer is using; since each CPU has a different *instruction set*. The *instruction set*, also called the *operand set* or *op set*, is the collection of different instructions a specific CPU is able to understand and execute.

The following is a code fragment in machine language from the MS-DOS operating system. (A full listing of just the command interpreter alone would fill this entire book!) Each sequence of 8 bits is equivalent to a single byte.

```
00001110   00101110   11111111   00101110
00001100   00000001   11111011   11101000
01000011   00000000   00011110   00001110
00101110   11111111   00101110   00010000
00000001   11101000   00111001   00000000
00011110   00001110   00101110   11111111
```

Because these sequences of 1s and 0s are extremely difficult to read, programmers usually use *hexadecimal* (or *hex*) notation, which is actually a shorthand for binary notation. Each sequence of 4 bits is "collapsed" into (or represented by) a hexadecimal "digit" from 0 to 9, and A to F as per following table.

Binary Code	Hex Code
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7

Binary Code	Hex Code
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

Thus the machine language instructions above can be represented much more compactly in hexadecimal code groups as follows.

```
0E 2E FF 2E 0C 01 FB E8 43 00 1E 0E
2E FF 2E 10 01 E8 39 00 1E 0E 2E FF
```


Needless to say, this approach to software development is extremely error-prone and time-intensive: a single bit out of sequence would halt the program.

5.3.3 Second generation: assembler language

The development of *assembler languages* represented a big improvement by replacing the binary or hex code with mnemonics that are easier to remember. Also, instead of having to track each memory address, so-called *symbolic* address could be used to give more descriptive names to memory locations. E.g. instead of referring to memory location “E8 39”, one could call it “SALES”.

The following is a sample fragment of assembler language code (with lower-case comments on the right-hand side).

```
LABL  INFLATE   Start of program segment “Inflate”
LOAD  SALES     Retrieve “SALES” value from memory
MULT  2D        Multiply it by the (constant) “2”
IFLT  1000D     Check if result is less than “1000”
JUMP  INFLATE   If so, continue back at “INFLATE”
STOR  BIGSALES  Else, store the result in BIGSALES”
      ...
```

Although this is a great improvement on machine code, it was still very cumbersome. Hence the development of third-generation languages.

5.3.4 Third generation procedural languages

Third-generation (3GL) or *procedural* languages provided a much higher level of abstraction. Although each 3GL instruction still corresponds more or less directly to a chunk of equivalent assembler instructions, a lot of the nitty-gritty detail household work is performed by the compiler. Another advantage of 3GL is that these languages are generally fairly computer-independent. Each computer manufacturer will develop a language interpreter or compiler for his own machine, so that the software developer does not have to worry about what instruction set is supported by any particular CPU.

Many different 3GLs have been developed during the 60s and 70s. Some of the more successful ones were BASIC (“Beginner’s All-Purpose Instruction Code”), COBOL (“COmmon Business Oriented Language”), FORTRAN (“FORmula TRANslation language”), ALGOL (“ALGOrithmic Language”), PASCAL, LOGO, C, PL-1 and many more.

The following mini-program in BASIC will draw a sine curve.

```
SCREEN 2
VIEW (20, 2)-(620, 172), , 1
CONST PI = 3.141592653589#
WINDOW (0, -1.1)-(2 * PI, 1.1)
Style% = &HFF00  ' Use to make dashed line.
DO
   PRINT TAB(20);
   INPUT "Nr of cycles (0 to end): ", Cycles
   CLS
   LINE (2 * PI, 0)-(0, 0), , , Style%
           ' Draw the x (horizontal) axis.
```

```
   IF Cycles > 0 THEN
      ' Start at (0,0) and plot the graph:
      FOR X = 0 TO 2 * PI STEP .01
         Y = SIN(Cycles * X)
      ' Calculate the y coordinate.
         LINE -(X, Y)
      ' Draw a line from last point to new point.
      NEXT X
   END IF
LOOP WHILE Cycles > 0
```

Anyone who has ever written any computer program or been exposed to a 3GL, will be able to understand many of the instructions above, so the 3GL can be considered much more programmer-friendly than the earlier generations. But they are still not friendly or natural enough, definitely not in the eye of non-specialist end-users.

5.3.5 Fourth generation languages and query languages

There is no consensus as to what qualifies a language as a "fourth generation". Some authors argue that any non-procedural language is fourth generation, others reserve the term "fourth generation language" (4GL) for database query languages only.

A *query language* is a high-level language interface provided by database management systems for accessing data stored in the database. As database management systems are getting more sophisticated, the query language is becoming increasingly natural. Here is how one would request a list of the names of all Cape Town customers who bough a Golf costing more than R40000.

- Using a fairly structured query language:

  - TABLE FILE CUSTOMER

  - DISPLAY CUST_NAME WHERE (PROD EQ 'GOLF' AND CUST_CITY EQ 'CAPE TOWN' AND PRICE GT '40000')

- Using a *Query-by-Example* interface:

CUST_ CODE	CUST_ NAME	PROD	PRICE	CUST_CITY
	*	GOLF	>40000	CAPE TOWN

- Using a fairly advanced 4GL natural language interface:

  - SHOW ME ALL THE CAPE TOWN CUSTOMERS THAT BOUGHT A GOLF COSTING MORE THAN 40000 RAND

5.3.6 Object-oriented languages

Procedural programming languages still construct a program as a list of instructions. The computer starts executing instructions at the beginning of the program, processes them more or less sequentially, operating on some data set stored on a file or database outside the program, until the end of the program is reached. Object-oriented (*OO*) languages take a complete different approach.

Initially, OO languages were used to simulate physical, real-world systems as studied by the natural sciences. Lately, it was found that OO languages were a natural choice for the development of graphical user-interfaces, distributed environments and very interactive applications. An early OO language was *Smalltalk* but current popular languages are C++ (for operating systems and end-user applications) and JAVA (for Internet and multiple platform applications).

The first step in developing an object-oriented application is to identify suitable *objects*. These can be physical entities such as an employee or a part; or they could be informational entities such as an invoice or report. These objects then not only become independent "holders" of the data pertaining to them, they also *encapsulate* or contain the *methods*: actions or instructions that can be performed on the data. The different data elements of each object are its *attributes*. Data is sent to/from an object, or an object is requested to execute a certain action by means of a *message* sent to it by another object.

A way to look at an object-oriented application is to view it as a managed "cloud" or collection of objects, each sending each other messages and executing their activated methods, in turn generating more messages to other objects etc. Because the execution of the OO program depends on certain events (e.g. a user clicking on a certain icon, or a "ready" signal from a hardware device) to trigger other events by means of messages, the OO model is often referred to as an *event-driven* model. Objects sit and wait until they are triggered by some outside event – usually a message from another event. An object reacts to the trigger or message by invoking one of its methods, which may update its *state* (internal data attributes) and/or send messages to other objects

This can be illustrated by means of an extremely simplified example of whereby a customer places an order via the Internet on the corporate order system, although nothing would really change if an internal clerk was processing a telephonic order on-line. The Internet software would send an order form (a message) to the order processing object (which is really a large application). The arrival of this form triggers the "process a new order" method. Amongst other things, this method will send a message with the person's details (a customer object has attributes such as name, address and credit limit) to the credit-checking object (this may be a small object containing a tiny verification method, an large in-house application running a check against the customer database or even an on-line system of an external credit bureau). The credit-checking object will reply with a message saying whether credit is approved. Another message will be sent to the "inventory checking object", probably an independent on-line application running on another computer. This object will check (and possibly hold) current available stock and reply with an "in stock" or "out-of-stock" message. In the latter case, it could even contact the information system of a supplier to place a back-order. In the meanwhile, the order processing object will keep track of incoming messages and re-send messages if "time-outs" are experienced. Eventually, the customer will be informed of the order status and, if everything is ok, the order message will be forwarded to the shipping system (object). As you see from this example, the OO paradigm is ideally suited to a real-time, distributed network environment.

5.4 Operating Systems

The PC of a business end-user will quite commonly provide a number of different application programs, but no program development tools. It is also possible (although unlikely) that the PC of a programmer could provide development tools only, and no other commercial applications. But the one thing that all these machines would definitely have is an *operating system (OS)*. The operating system is an essential piece of software that resides on virtually every computer. It allows the computer to run a number of different applications apparently simultaneously, and shares resources such as printers between a number of different users, while at the same time performing those functions that are critical to the correct operating of the computer system, regardless of which application is running.

Different types of computers may require different operating systems. Most mainframe computers have a proprietary operating system, such as IBM's MVS or Siemen's BS2000. At the opposite end of the market, we find that the leading operating system for the IBM-compatible Personal Computers is Microsoft Windows (having all but replaced its predecessor MS-DOS) although Mac-OS and Unix variants such as Linux also have strong followings.

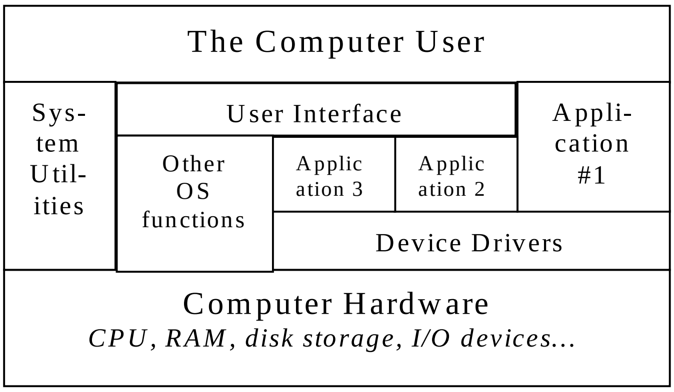


Figure 5-4: Some operating system components

Today's operating systems are true marvels of engineering and rate among the most complex artefacts designed by humans. Their complexity stems from the increasing number of functions that an operating system is required to handle.

5.4.1 Multitasking.

Today's computers handle many applications at the same time: you could be downloading a file from the Internet at the same time as you update a spreadsheet that is embedded within a word-processing document (while at the same time your virus scanner is running in the background). Each application needs to share the CPU, main memory and all peripheral devices. The OS sees to it that all conflicts are resolved and each application gets a fair share of the common resources, often in accordance with a certain priority schedule. An important task, therefore, is that of the proper *scheduling* of different tasks. The OS also ensures that ill-behaving applications do not impact on the integrity of the other applications and their data. (By the way, when a single application program runs multiple tasks simultaneously, this is known as *multithreading*.)

5.4.2 Multi-user management.

Barring the personal computer, computers have more than a single user at any one time – a typical mainframe may have to handle many thousands of simultaneous users. Each of the users may operate a different application (see multitasking) but will not be prepared to wait for other users to finish their tasks. So the OS sees to it that each user gets a fair share of the CPU of the mainframe, by slicing each second in tiny fractions and allocating them to the different users. In addition, each user may have a different profile in terms of access to certain peripheral devices and data. This requires sophisticated security and data management.

5.4.3 Memory management.

Apart from the CPU, primary memory is often the most expensive and scarcest component of a computer system. Efficient memory management is a key component of any OS, especially in multitasking and multi-user environment. The likelihood that there is sufficient memory to load all the data and software for all users simultaneously is extremely small. In practice, a technique of *virtual memory* is used whereby the available amount of main memory is extended by using secondary storage devices, usually the hard disk. During a typical program execution, not all program instructions and data are required at once. The OS will *swap out* all unused software and data segments onto disk, until they are actually required.

5.4.4 Secondary storage management.

All applications require disk storage – if only to store the application software itself. The OS provides the common access routines to the secondary disk storage devices. It will keep track of data and program file names, physical locations and perform common functions such as the copying, erasing or backing up of data. It also makes the differences in physical hardware as transparent as possible: a data file will appear the same to an application whether the data is being loaded from a diskette, a hard disk or an optical CD-ROM.

5.4.5 Peripheral handler.

Apart from managing the memory and secondary storage devices, the OS is usually also responsible for the handling of other peripheral devices. Again, a major objective is to relieve the application from the responsibility of having to cater for a multitude of different possible input and output devices. Thanks to the OS, a program (developer) does not need to cater for the differences between a trackball, mouse or other pointing device. The OS will also ensure that your document will be printed correctly, regardless of whether you have a colour inkjet, a laser or lowly dot-matrix printer attached. Equally, individual programs no longer have to worry about the resolution or capability of your computer monitor. The critical element is again that the applications do not have to worry about the actual *hardware* connected to the computer system. This is usually achieved by means of *device drivers*, small software routines that become part of the operating system and help it to interface correctly with specific hardware devices. The device drivers for popular or standard devices are usually already included in the operating system. More esoteric or very new hardware devices will come with a separate disk containing the proper device drivers. These then have to be installed as part of the operating system at the same time as connecting the hardware.

5.4.6 Communications Management.

Communications software allows a computer to recognise the presence of other machines on a network, and to grant or restrict access to local files. It also manages network traffic, by monitoring communications lines and diagnosing problems, as well as sending and receiving data to and from remote devices. While PC operating systems include some basic networking and communications facilities, **network operating systems** (NOS) such as Novell and Unix provide sophisticated management tools for large networks.

5.4.7 User interface.

Until the late 1980s, operating systems focussed on the efficient management of resources, tasks and secondary storage. The popularity of personal computers meant that a whole class of less-technical end-users entered the world of computing. This pressured the IT industry into developing a user-friendlier graphical user-interface and the user interface is quickly becoming a significant part of microcomputer operating systems. Different types of user interface have already been discussed earlier in this chapter.

5.4.8 System Utilities

As a logical extension of the operating system, additional *system utilities* are often required to assist with the proper and optimal use of the computer. Some system utilities may be provided along with the operating system, while others are marketed by independent third-party vendors.

A number of system utilities focuses on improving the functionality of the operating system (e.g. better hard disk management) while others provide additional functions (e.g. anti-virus or encryption software). More examples of system utilities are editors, additional security utilities, performance monitors, file viewers, data compression software etc.

5.5 South African Perspective

A simultaneous-translation computer that can be accessed via cellphone to interpret business conversations between different languages has been developed by a team of German computer scientists. The Verbmobil uses an innovative speech-analysis process that recognises how intonation can change the meaning of a sentence, and that can correctly interpret hesitation or correction signals such as “um” and “er”. The development of the Verbmobil was based on the principle that computers will not become a universal technology unless the limitations imposed by language differences can be overcome. The prototype version of the Verbmobil can translate Chinese, English, German and Japanese – in a country like South Africa, with 11 official languages and a high rate of illiteracy, let’s hope that that the commercial development of this product is not too far away!

5.6 Beyond the Basics

In January 2003, the heads of ICT departments of the South African government unanimously decided to pursue the deployment of Open Source Software within government. Open Source

Software (OSS) is software that is made available in source code form, at no cost to developers, who can then create further products derived from the software, as well as correcting any bugs discovered in the original source code. Examples of OSS include the Linux operating system, Apache web server, Mozilla browser and StarOffice application suite.

Members of the Government IT Officers Council commented that the use of OSS would encourage technological innovation, and would also make it possible to develop systems that would meet local requirements, by removing the restrictions usually imposed by proprietary software developers.

5.7 Exercises

5.7.1 User interfaces

For each type of user interface described in this chapter, suggest a business context in which its use would be appropriate (briefly describe the business activity, typical user and location).

5.7.2 Types of application software

Use the internet or trade journals to identify examples of the following types of applications. For each example, give the trade name of the product and its distributor, and briefly summarise its main features.

- Three general purpose (productivity) applications NOT distributed by Microsoft
- Three generic business applications
- Three scientific applications
- Three miscellaneous applications

6. Networks & Telecommunications

One of the fastest growing technology areas is that of telecommunications (often referred to as *telecoms*). Organisations have realised that *stand-alone* computers present many problems: fragmentation of data, lack of control, insufficient integration and limited opportunity for teamwork. One of the major trends over the last decade has been the move not only to have a personal computer on the desk of virtually every knowledge worker, but to have that computer linked to the other computers in the organisation.

This chapter deals with the basic telecommunication devices, the types of computer networks and the telecommunications services available in South Africa. We conclude with a discussion of arguably the most interesting development in information systems of the last decade: the Internet.

6.1 Computer Networks

When a numbers of computers are connected together, they form a *computer network.* There are many ways of classifying computer networks.

6.1.1 Networks according to size.

Networks sizes can range from tiny to very large.

§ *Personal Area Network (PAN):* consists of two to five computing devices. This not very common term would apply to the network typically found in the home, and may be based on wireless technology e.g. Bluetooth..

§ *Local Area Network (LAN):* the most common type of network. It consists of from about four up to as many as a couple of hundred of computers linked together with one set of cables, usually within the same building. Most LANs are controlled by a central *file server* that takes care of network communications, security control and the storage of data files. A student computer laboratory typically constitutes one LAN.

§ *Metropolitan Area Network (MAN):* a network infrastructure linking various local businesses within a large city area. This is now almost completely superseded by the Internet.

§ *Wide Area Network (WAN):* the opposite of the LAN. It links computers over large geographical areas. This network usually makes use of the public telecommunications network. The widely dispersed Automatic Teller Machine (*ATM*) network of a commercial bank is typically part of the bank's WAN.

§ *Value-Added Network* (VAN): although not relating to size (but it rhymes with the others!), it refers to the provision of a network infrastructure service to other businesses. The service goes beyond the physical cabling and includes "value-added services" such as limited data and transaction processing or message routing. An example for the banking industry is the provision of an inter-bank *Electronic Funds Transfer (EFT)* and clearing service, linking the computers of different commercial banks (and, possibly, retailers) together.

6.1.2 Network Topologies.

The network *topology* refers to the physical and logical way in which the computers in a network are connected together. Although there a number of proprietary ways, the following three are the main topologies in common use (refer Figure 7-1). Note that these topologies usually refer to a LAN configuration.

§ The *star* network is driven by one central computer to and through which all other computers communicate. Although this allows for central co-ordination and control, it requires a very reliable central computer and lots of cables.

§ The *ring* network consists of a continuous loop connecting all computers. Signals travel in a given direction and all computers have equal access to the data. A special version of the ring network is the *token ring* whereby a special code, the token, is passed around the ring. This token serves as the data holder and computers can send information only after grabbing an available i.e. empty token, adding their data and passing the token back onto the network.

§ The *bus* network is currently the most popular configuration. A central data cable is used, to which each computer (and other devices such as printers and routers) can be attached. Although bottlenecks can occur, its popularity stems from its inherent robustness: devices can be added or removed without affecting the rest of the network. Data clashes (two computers attempting to send information simultaneously) can prevented by a variety of means.

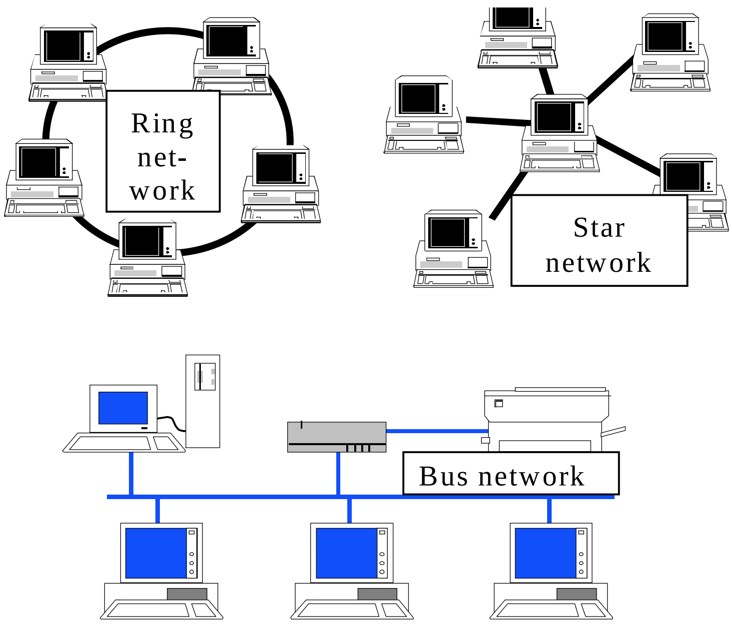


Figure 6-1: Network topologies

6.2 Telecommunication Devices

Regardless of the network topology that has been implemented, the same basic equipment is used to connect the different computers and to ensure error-free data transmission between them.

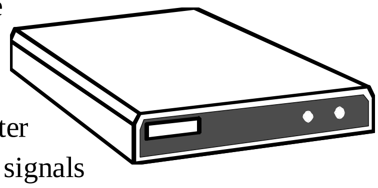
- *Network cables* are the physical wires by which computers are linked together. The most common types are:
    - *Twisted pair*: thin insulated copper wires, combined in one single cable. This is similar to the wire used for voice telephone connections.
    - *Coaxial cable*: (or *coax*) a thin copper wire inside a tube of insulation material, surrounded by a sheath or mesh of conducting wire, again insulated on the outside. This is similar to the wire used to connect antennas to video or TV equipment. Because there is less possibility of interference, it allows greater volumes of data to be transmitted in a given time – the amount or volume of data that can be transmitted over a network connection is referred to as *bandwidth*.
    - *Optical fibre or fibre-optic*: a translucent and flexible material through which laser light can travel over long distances. This fibre is much more difficult to work: it requires special connectors as well as lasers and sensors (with electronics-to-light converters) at each terminal. Although this technology is more expensive, laser light can be switched on and off a lot faster than electricity (and it travels ten times faster), resulting again in a much greater bandwidth.
    - *Wireless*: not all computer devices need a physical cable connection. Because of the cabling costs and hassles, engineers have explored many methods of transmitting data without the use of wires. For short distances, infra-red signals work well albeit slowly – the same technology as your VCR remote control. For longer distances and higher bandwidths, radio frequencies or other parts of the electro-magnetic spectrum are used. Satellite technology is increasingly being used for digital data transmissions, especially in conjunction with Global Positioning Systems (GPS).

- *Network interface cards (NICs)* are necessary when computers are connected directly to other computers by means of digital network cables (as opposed to the situation when two computers are connected to each other via a telephone link). Their primary function is to make sure that there are no transmission conflicts with the other computers linked to the network, since data may be simultaneously sent and received by many different computers all linked to the same network. In addition, the network card usually fulfils an error-checking function, to ensure that uncorrupted data is received at its destination.

- *Multiplexers* allow a single channel to carry data transmissions simultaneously from many sources, by merging them at one end of the channel and then separating the individual transmissions at the receiving end of the channel.

- *Front-end processors (FEP)* are used in bigger networks that are centrally controlled by large computers – often mainframes. In order to give the expensive mainframe more "time" to concentrate on application processing, it needs to be relieved from the rather mundane task of network control. FEPs handle all or most communication processing such as error-checking, data conversion, packaging and transmission control.

- *Routers* and *bridges* are computers dedicated to the translation of network protocols and standards between different networks. They are becoming important as more and more organisations are linking their own networks to those of other organisations. They may be using
  - different operating systems (Novell, Unix or Windows NT),
  - other technologies (coax or fibre-optic),
  - or different protocols (proprietary or public standards set for computer communications).



- Finally, the *modem* allows a computer to communicate with another computer by means of the public voice telephone network, rather than by using digital cabling. This requires the conversion of digital computer signals (used inside the computer) into analogue sound signals (that can travel over the voice telephone lines) – this process is called *modulation*. At the other end of the line, these sound signals are converted back into digital signals – or *de-modulated*. The word *modem* refers to this modulation / demodulation process. You may have heard this “modulated signal” when listening to a fax machine, which is really a scanner/printer/modem in one. Since the modem replaces the network card, it usually carries out similar error-checking functions to ensure the correct transmission of data.

Trivial fact: More than 5000 satellites are orbiting the earth and most of them are involved in telecommunications.

6.3 SA Public Telecommunications Services

Because telecommunication services are a critical part of any country’s infrastructure, most governments have been very protective towards their telecoms. Paradoxically, this protectionism often resulted in high tariffs (monopolies!), thus reducing the overall competitiveness of local businesses. Recently more and more countries have started to privatise these services and allowed competition to drive prices down. The South African public telecommunication services are controlled by Telkom, although its legal monopoly is being phased out. The following are the main data network services provided by Telkom.

6.3.1 Public Switched Telephone Network (PSTN) Services

The oldest data service provided by Telkom is the *Datel* service, which provides a connection between computers by means of the standard *Public Switched Telephone Network (PSTN)* i.e. the same as the normal voice telephone traffic. This requires the use of built-in or external modem equipment that modulates the digital signal into an analogue audio signal (and de-modulates it back at the receiving end). This service is quick and easy to set up since it is available anywhere where there is an ordinary voice telephone point. The main drawbacks are the limited transmission speed, high error rate and the lack of security. Customers may choose between a *dial-up* or *leased line* connection.

6.3.2 Diginet

Diginet is a dedicated digital data service from Telkom that provides reliable and efficient point-to-point (i.e. not switched) data connections. It differs from the Datel network in that the transmission path is entirely digital: a combination of fibre-optic, microwave and coaxial cable. Because the signal does not have to be translated into analogue form, no modem is required, resulting in a cost saving. However, its main advantages are the higher transmission rates and a substantial reduction in transmission errors. The standard Diginet service allows for 64 kpbs (*kilobits per second*) though an enhanced service called *Diginet-Plus* has been designed to transfer up to 1920 kpbs, which allows slow-scan TV and video conferencing signals to be transmitted in real-time.

6.3.3 Public Switched Data Network (PSDN) Services

Saponet is Telkom's *Public Switched Data Network (PSDN)*. The *Saponet-P* service relies on a *packet-switching* mechanism whereby all data transmissions are broken up into smaller, standard-size units or *data packets*. Each of these packets is then routed independently to their destination. The path travelled by the packet depends on the available capacity and bottlenecks. At the destination, the original transmission is reassembled out of the constituent packets. A *Packet Assembler & Disassembler (PAD)* is responsible for the breaking up of a message into packets and the opposite process of reassembling packets into a message at the destination. This PAD can be a separate hardware device or a software program.

6.3.4 X.400 and Telkom400

Telkom400 is a VAN on top of the X.400 infrastructure. It supports electronic message handling and *electronic data interchange (EDI)*. *EDI* is the automated computer to computer application exchange of structured business data between different organisations. An international standard defines common business documents such as order forms, invoices or electronic funds transfer documents that are exchanged directly between the computers of the respective business partners.

6.3.5 ISDN and ADSL

Now that most of Telkom's telephone exchanges have become digital, Telkom is able to provide new functions and services. One all-digital connection that has sufficient capacity (*bandwidth*) to support speech, video conferencing, facsimile, data and image transfer. This connection is called an *ISDN line (Integrated Services Digital Network)* and is currently available in selected metropolitan areas. Much more popular is the newer Asymmetric Digital Subscriber Line (ADSL) which allows a broadband connection (at least several hundred kilobits/second) over your standard telephone line while keeping the line available for voice telephone calls. It is called "asymmetrical" because the standard allows for much greater "download" than "upload" speeds; this reflects the typical home user pattern. Higher volumes and transmission speeds of up to 150mbs – typically needed by mid-size and larger businesses – are available through Telkom's *ATM Express* service.

6.4 The Internet

The Internet is probably the most exciting, the most popular, most visible and definitely the "coolest" information systems development of the decade.

6.4.1 What is the Internet?

The origins of the Internet can be found in the early sixties, when the US Department of Defence sponsored a project to develop a telecommunications network that would survive a nuclear attack. It had to link together a diverse set of computers and work in a decentralised manner so that, if any part of the network were not functioning, network traffic would automatically be re-routed via other network nodes. This project quickly grew into a popular academic network linking virtually all major research institutions and US universities. Soon other countries jumped onto the bandwagon, thus linking academics and researchers across the globe. True to the academic ethos, it quickly became a means for global information sharing. By now, businesses also got a piece of the action. This was spurred on by the trend to network the personal computers in home and business environments and the development of more user-friendly, graphical interfaces: the web-browser and the Windows operating system.

The *Internet* (or, more colloquially, *the Net*) consists of a huge and fast-growing number (hundreds of thousands) of *inter*connected *net*works linked together. Currently more than 100 million users are connected to the Internet. The popularity of the Internet can be explained by the amount of information it makes available: the equivalent of many libraries of information is stored on millions of computers (*Internet hosts*), much of it free of charge to all Internet users. This information is provided by educational institutions, governmental agencies and organisations, individuals, and increasingly by businesses. Hence, the Internet is frequently referred to as the *Information Highway* or the *Infobahn*.

But the Internet is more than just a huge information resource. Its initial purpose was to act as a communications network and it fulfils that role well. It is the transport mechanism for *electronic mail*, the transfer of computer files, remote computer access and even allows for voice calls. Businesses quickly realised the potential of the multimedia-enabled Internet for marketing purposes. Of late, more and more business transactions are being conducted via the Internet: *electronic commerce (e-commerce)* is the latest revolution to be embraced by the Internet community.

6.4.2 Electronic mail

Probably the most popular Internet service is *electronic mail*, more commonly known as *e-mail*. This consists of the sending of messages composed on the computer, via a network, directly to the computer of the recipient who reads the message on his/her computer. Knowledge workers with access to e-mail write five to ten times as many e-mail messages as hand-written notes. The following are just some of the advantages of e-mail.

- *Reliability*: although there is no guarantee, you will normally receive quick feedback if the address does not exist or there is a similar delivery problem.
- *Efficiency*: many short-cut tools exist to increase your efficiency when composing messages. You can use your computer's cut-and-paste function, you can have managed address books and lists, when replying to another message you can automatically incorporate any part of the message to which you are, etc. And it is just

as easy to send a message to one as to a whole list of addressees. (Admittedly, this results in a lot of abuse and information overload on the recipient's side.)

- *Digital*: e-mail is composed on a computer and remains in computer-readable format all the way to its destination. Thus one can also easily incorporate other computer data such as graphics or document files.
- *Cheap*: because the capacity of the Internet and disk storage is increasing all the time, the cost of a sending and storing a one-page e-mail message is negligible.
- *Speed*: messages are generally delivered across the world in a matter of seconds.

The e-mail address

Just like with ordinary postal mail (now usually referred to as *snail-mail*), you need to know the recipient's address before you can send your message. Internet *e-mail addresses* have a standard format: username@domain. The *username* is often the name that your addressee uses to connect to the network, e.g. "jvanbelle" or sometimes a long number. This username is allocated by the LAN administrator. The *domain* identifies the file server, which acts as the local post office for your recipient's e-mail. The domain consists of several parts, separated by full stops or *dots*. The international standard for domain identification is <name of LAN server>.<name of organisation>.<type of organisation>.<country code>.

- The country code is the international two-letter code for the country e.g. *au* for Australia, *za* for South Africa, *sa* for Saudi-Arabia, *uk* for Great Britain, etc.
- The two most common types of organisations are *co* for a commercial organisation and *ac* for an academic institution . Less frequent are *org* for (not-for-profit) organisations, *mil* for military, *net* for networks and *gov* for government agencies.
- Each country has a national Internet naming body that allows its organisations to chose their own name, as long as no one has claimed the same name before. Examples of South African domain names are anc.org.za, uct.ac.za, fnb.co.za.
- Large organisations often refine the domain further by adding the name of their LAN servers, e.g mail.uct.ac.za.

Examples of possible e-mail addresses are: JaneDoe@stats.uct.ac.za (Jane working in the statistics department at the University of Cape Town in South Africa); info@anc.org.za (information department at the ANC, a political party) or SoapJoe@marketing.bt.co.uk (Joe Soap in the marketing department of British Telekom in the U.K.).

The US Americans, having "invented" the Internet, use a slightly different way for their addresses. They leave off their country code (*us*) and use *com* for commercial organisation or *edu* for educational institution. Since the majority of Internet users hail from the US, you will encounter many addresses such as JWood@mit.edu or Bill@microsoft.com.

Netiquette

Just as in any other social interaction environment, there are some rules and guidelines for appropriate social behaviour on the Net: *Netiquette* (etiquette on the Internet). The following are some illustrative examples pertaining primarily to e-mail.

- *Shouting*¸ THE PRACTICE OF TYPING ENTIRE SENTENCES IN UPPER CASE is generally seen as novice (*newbie*) behaviour and frowned upon. Perhaps it stems from the disgust with old teletypes and mainframe terminals that did not have lower-case characters.

- The use of *emoticons* to indicate emotive content of a sentence is highly recommended. Typed text does not reveal any body language and a joking remark can easily be interpreted the wrong way. Whenever one writes something in jest or with humorous intent, it is advisable to add an emoticon. An *emoticon* (an icon indicating emotional content) consists of a series of text characters which are meant to be rotated a quarter turn and represent a laughing :-) (i.e. equivalent to J or the *smiley*) winking ;-) or sad face :-(L.

:-)	Happy face
:-(	Sad or sorrow
;-)	Wink
:-0	Shock
:-\	Sarcasm
:^]	Wide grin
:-x	Blowing a kiss
:'(	Teary-eyed
:-P	Sticking tongue out
8-)=	Beard & glasses
:--)%	Boy on skateboard
<g>	Grin
<w>	Whisper
{{}}	Hug you

BTW	By the way
IMHO	In my humble opinion
FWIW	For what it's worth
SO	Significant other (partner)
BRB	Be right back
FAQ	Frequently Asked Questions
RTFM	Read the f*** manual
TTYL	Talk to you later
IRL	In real life
F2F	Face to face
LOL	Laughing out loud

- *Flaming* is the carrying on of a heated personal emotional debate between two or more individuals on a public Internet forum. A *flame war* is generally a sign of immature behaviour by individuals who cannot take perspective and should really take the discussion off-line.

- *Netizens* (inhabitants of the Internet i.e. frequent net surfers) often use standard but, to the non-initiated, cryptic abbreviations. Examples are: BTW = by the way ; ROFL = rolling on the floor with laughter ; TPTB = the powers that be ; BRB = Be Right Back. This vocabulary has been adopted and expanded with the growth of Short Message Service (SMS) use on cellular phones.

6.4.3 The Web

The Internet service that has received the most attention from the public media is the *World-Wide Web* or *the Web* for short (sometimes also called *WWW* or *W3*). The Web is a vast collection of multimedia information located on Web servers attached to the Internet.

Its popularity is due to a number of reasons.

- Information links are transparent. Links to any other piece of information located anywhere on the Internet can be inserted in a web document. A simple click of the mouse takes the reader completely automatically from one Web server to another, quite possibly in another country.

- Information can be presented in a *hypertext link* format whereby one can jump immediately from one concept to a related concept or explanation. No need to read text in the traditional top-to-bottom sequential way.

- It allows for *multimedia* information. A Web document can incorporate rich and colourful graphics, animation, video clips, sound etc. Just think of the marketing opportunities!

- The Web supports interactive applications. Web applications can request information from visiting users and documents can include programming instructions. Users can even download small programs (often written in *Java*) that could perform some processing on the user's computer or display special visual effects.

Reading or accessing information on the Web is called *surfing the Net* because one jumps from one hypertext link to another following whatever takes your fancy. In order to *surf* the Net you need some special *browser* program that understands the Web protocols and formats and presents the information to suit your computer monitor. You also need an access point or connection to the Internet. Your Internet connection may be automatic if your computer is connected to a (corporate) LAN that connects directly to the Internet, or it may be by means of a special subscription to a business that specialises in providing Internet access for others: the *Internet Service Provider (ISP)*. Access to the ISP for individual users is usually via a dial-up connection i.e. using a modem and telephone.

Once a *newbie* (new user) is connected to the Internet (*online*), she faces the daunting task of finding her way amongst the huge variety of information offered. The easiest way in is usually by means of a *search engine:* a Web site that tries to catalogue the information available on the Internet. By entering one or more search words, the engine will provide you with a couple of adverts and a list of documents that contain the word(s) for which you are looking.

All information on the Web is uniquely identified by the *URL (Uniform Resource Location)*, which is really the full Internet address of a Web document. The URL consists again of the Web server's domain address, followed by the access path and file name on the server. Examples of URLs are www.hotbot.com/sports/main.html (the main page on the sports section of the HotBot search engine) or http://www.commerce.uct.ac.za/informationsystems/ (containing details about UCT's department of information systems). Note the similarities and differences between an URL and an e-mail address.

6.4.4 Other Internet services

A number of other services are available on the Internet. The *Usenet* consists of ongoing discussion fora (or *newsgroups*) on an extremely wide variety of topics, from forensic psychology to Douglas Adams, from Star Trek to cryptography. The discussion happens entirely by means of e-mail and, when you subscribe to a given newsgroup, you can browse through the contributions of the last few days and reply with your own contribution.

More specialised services exist, such as *ftp (file transfer protocol)* for the transfer of large computer files, and *telnet*, the remote access of computers elsewhere, but they are used less frequently. In any way, these services are now being performed transparently by most Web browsers. Similarly, older services such as *Gopher* and *Veronica* have really been replaced almost entirely by the Web.

6.4.5 Internet protocols and standards

Different computers and networks can communicate via the Internet because a number of basic Internet communication standards have been defined. Any network connected to the Internet will translate its own standards and protocols into those used on the Internet by means of a bridge.

The most fundamental and "lowest level" protocol is the *TCP/IP (Transmission Control Protocol/Internet Protocol)*. This protocol is also the *native* protocol of computers using the Unix operating system, which explains why Unix computers are so popular as Internet servers.

On top of TCP/IP are the "mid-level" protocols defined for the various Internet services. Perhaps the best known of these is *http (Hypertext Transmission Protocol)*, which specifies how the Web information is made available and transmitted across the Internet. Other protocols and standards are *STMP* and *MIME* (for e-mail) or *ftp*.

Information made available via the Web is usually formatted using a special standard: the Hypertext Markup Language (HTML), which actually consists of plain text files with visual formatting commands inserted between the text. Most desktop productivity software allows you to save your document directly in the HTML format. Special HTML editors allow much finer control over the final layout of your Web document. A later development is Extensible Markup Language (XML), which increases the flexibility of web documents by allowing them to be viewed not only using a web browser, but also on different platforms such as a PDA or cellular telephone.

6.5 South African Perspective

The internet is being used in South Africa to help in the prevention of child abuse. Ordinary citizens who are outraged by the high levels of child abuse and wish to make a positive contribution towards combating and preventing the problem, can now volunteer their assistance. A website has been launched at www.volunteerchildnetwork.org.za, which offers volunteers the opportunity to identify the skills they have that could be useful to organisations, and to connect them with organisations that need their assistance.

A similar type of business operating in Gauteng gives tourists the opportunity for hands-on work in wildlife conservation, by placing volunteers with various rehabilitation centres, conservancies and nature reserves.

6.6 Beyond the Basics

Your cellphone may be all you need to gain entry to World Cup 2006 soccer matches. Two Austrian companies have combined their expertise to develop a paperless ticket system which allows users to pay for tickets via the Internet, and a few seconds later receive an encrypted entry code via SMS to their cellphone. The user then gains access to the event by passing the display of the cellphone, containing the encrypted code, over a special scanning device at the entry gate.

In order to allow for the various standards of different cellphone manufacturers, users must enter the name of their cellphone model when ordering tickets. The developers claim that 95% of all existing handsets are able to use their system. So far it has been successfully tested at the Football Expo 2002 in Cannes, and at a nightclub in Austria. However, they don't say what will happen if your cellphone is stolen, or if you accidentally erase that vital SMS!

6.7 Exercises

6.7.1 Search Engines

- The Internet is vast and information is usually located using search engines such as Google, Yahoo!, Lycos, WebCrawler or Ananzi. Give the name and URL of two other Internet *search engines*, of which at least one must be South African.

- Take your date of birth ("DOB") and search the Internet to see if you can find a home (personal) page of another person who shares your date of birth, or a page reporting on an event that happened on your DOB. Give the URL of the home page that you have located, as well as the name of the search engine you used.

- Think of your favourite hobby or sport. Locate a web-site in South Africa (use www.ananzi.co.za) that is devoted to your interest and give the name of your sport/hobby and the URL of the main (index) page of the site you have found.

- Go to Independent On-Line (www.iol.co.za). Search the site for the most recent article that mentions your place of birth and give the full TITLE and date of the article. [If your birth place is not found, search for the nearest big town to your place of birth.]

6.7.2 Cellular communications

In South Africa, more people have cellphones than have access to computers. What implications does this have for the development of our telecommunications infrastructure? Do you think this will have any significant impact in reducing the "digital divide" and improving access to local and global information resources?

7. Databases

Often one hears about the purchase of a company with few physical assets for large sums of money. Why are investors often prepared to pay an enormous premium over the asset value of a company instead of just buying the same fixed assets and starting up a competing company themselves? There are three main reasons: companies may have extremely efficient business processes, they may have valuable intangible property such as patents or trademarks, or they may have a very valuable information database of customers. Company executives are increasingly realising the value of the information that is contained in the databases of their information systems. This chapter explores the database component of information systems in more detail.

7.1 From File-based Systems to the Database Approach

7.1.1 The File-based Approach

Many small (personal computer) applications, as well as a large number of larger *legacy* (i.e. older) corporate information systems take a file-based approach to data storage. The function-oriented information system stores all its data into its own files. The structure and integrity of these files is maintained within the application.

As a typical example of the file-based approach, let us take a look at the information systems of a commercial bank whose identity shall remain anonymous. The bank has developed a sophisticated system to process its cheque accounts. This system maintains, *inter alia*, its own customer information. The bank has another, entirely separate system for its credit card accounts. This system obviously also keeps customer details in its own files. There are other, stand-alone systems for mortgage bonds, savings accounts, notice deposits etc. Each of these systems was developed independently and probably even runs on different computer systems. None of the information is shared between the applications. What are the problems?

Imagine the typical scenario of a bank customer who moves house. She notifies the bank's help desk of her change of address, and the next month (with luck) her cheque account statement arrives at the new address. However, the savings account statement is still sent to the old address. On enquiry, she is told that the bank was unaware of the fact that she also had savings account and changed only her information on the cheque system; so now they have to enter the change of address separately on the savings account system. Surprise! The next month, her *mortgage bond* statement is still sent to the old address … This is, however, not the only problem. Imagine what would happen if the customer accidentally issues a cheque for an amount exceeding her overdraft. A bank clerk bounces the cheque, resulting in an embarrassed customer, only to discover later that this customer has in fact a large amount invested in various deposit accounts. The irate customer may well decide to change bank and the bank loses a profitable customer! In addition, the bank probably loses many marketing opportunities (such as cross-selling) by its inability to identify multiple account-holding customers.

7.1.2 The Database Approach

What is the solution? The *database* approach. All customer information should reside centrally in one database, and only account-specific information should be stored separately. All the system applications that require customer information should access the same customer database. In fact, no individual application will be allowed to access this database directly. A spcialised system, the *database management system (DBMS)*, will control all access to the database and be responsible for security, integrity, data formats, backups and other technical issues. Any application requiring or updating data sends a request to the DBMS, which will then extract data from, or update, the database.

7.1.3 Advantages and Disadvantages of the Database Approach

The database approach has some *disadvantages:*

- It introduces an additional layer of software between the application and the database, often resulting in a slower access to the data.
- System designers and functional users loose some freedom and control over their data, since they can no longer decide exactly what and how data will be stored. All changes or additions to the database have to be cleared by the Database Administrator (DBA).
- The reliance on one single database increases the vulnerability of the organisation: the lack of redundancy, industrial espionage, a higher level of complexity and size.
- A DBMS introduces additional costs: a typical DBMS licence is very expensive and requires specialised, highly-paid staff.

On the other hand, the *benefits* of the DBMS usually outweigh the disadvantages by far.

- The performance penalty exists only if a file-based application is extremely well designed. In most cases, the designers of a DBMS have done a lot of research and spent much time in optimising the data access routines. As an example: sorting of data using a very non-intuitive but highly effective method is often hundreds of times faster than the obvious ways generally adopted by the non-specialist application designer.
- The centralisation of data facilitates risk management: it is much easier to back-up, monitor or audit one central database than thousands of separate files.
- The database is independent of the individual applications. The DBA can easily say, add a new field (or change an existing field) in the database without affecting the applications. Where the same file was accessed or shared by different applications, each application had to be individually modified to accommodate a change in file layout. When the database structure changes, this will generally not affect the DBMS calls programmed into the existing applications.
- The integration of data in a single logical DBMS view (although it may physically be stored in many different databases) allows for better management decision support. It is now possible to have the complete picture or profile of a customer; or to relate employee performance to sales.
- There is no more, or much more controlled, data redundancy and hence data should be more consistent.

- A DBMS offers many additional tools to access and manipulate the data. It will typically include powerful security features, backup and disaster recovery tools, database programming and query language interfaces.
- It is usually easier to upgrade or adopt new technologies. When the DBMS vendor upgrades the DBMS to include the new developments, these become available automatically to all applications without major redevelopment efforts. Thus an organisation may be able to implement object-orientation, e-commerce, client/server or enterprise-wide systems without costly system conversions.

7.2 Data Structures

In chapter 2, we saw that the smallest data element is the *bit*: a yes/no, true/false or any possible choice between two options. We also found that, in practice, a *character* is really the smallest practical data element: a character can be a letter, digit or punctuation symbol. Most textual and numerical data can be represented using characters. However, there are larger units or groupings of data.

Business information systems currently deal mostly with large amounts of structured textual (and numerical) data: customers have a name, address, account balance, and place orders that in turn again contain standard elements such as order date, product item descriptions and amounts etc. The efficiency of storing and retrieving this data can be increased by structuring it into a standard format and grouping similar data items together.

7.2.1 Database.

The totality of the data collected by an information system is called the *database*. Although the ideal is to have a single database for the entire organisation, in practice organisations may have a number of functional databases that may not be entirely compatible. The customer order system may have a database of customers, orders and shipments while the human resources system may have a completely separate database with employee information, job positions, training and salaries.

7.2.2 Table and file

Normally, the database will be structured into smaller logical or physical units: tables or files respectively. E.g. the order database may use one file to keep customer information, another to keep track of orders, yet another with account details and probably a file with product details. As we will see later, the *table* is really a *logical* concept applicable mainly to the popular network and relational databases. The *file* is a *physical* way in which data is stored on the computer.

7.2.3 Record

Within a table (or file), information will be organised in the form of *records*. Each record represents one instance of a real-world entity or transaction. E.g. in the customer database, there may be a record containing all the data about Joe Smith (including his address, contact numbers, credit status), there will be another record with the data for Jane Doe and so on, one record for each of the customers.

7.2.4 Field

The information within a record is structured into separate *fields*. In the above example, Joe Smith's record would have at least four fields: his name, his address, his contact telephone number and his credit status. In practice, his name may be split into at least three separate fields: one for his surname "Smith", one for his first name "Joe", one for his designation "Mr" and probably one for his initial(s). Similarly, the address will usually be split into several fields to separate e.g. the postal code, the town and the street. This separation will make it easier to extract subsets of the data, such as all the sales for a given area, or to print out customer address labels sorted according to postal code.

7.2.5 Characters and Bytes

Finally, the data inside a field will be encoded in a number of characters (for textual data) or bytes (for numerical and multimedia data).

When designing information systems, a lot of attention must usually be given to the logical design of the database. As an illustration, we will look at some of the considerations involved with fields.

7.2.6 Some Field Design Considerations

Fields can have a *fixed length* (such as the postal code) or a *variable length* (such as general text comments, or a sound track in a multimedia database). Because fixed length fields are much easier to work with from a technical perspective, system designers often will try to impose a fixed length on fields that are really variable length fields. E.g. the information system will reserve 30 characters of space for the "city" address field. Shorter names such as "Cape Town" will then automatically be "padded" with extra empty spaces (resulting in some wasted database storage space), but the simpler design (resulting in performance improvements) will usually offset the marginal cost increase. On the other hand, a problem results when a city name exceeds the sample 30 characters space limit. To take an extreme case: not many information systems will cope with the place called "Taumatawhakatangi-hangakoauauotamateaturipukakapikimaungahoronukupokaiwhenuakitanatahu" in New Zealand, or, to take a slightly less extreme example, one of the authors often has problems fitting his first names "Jean-Paul Willy Georges Dominique" on standard forms!

Another problem is often to identify uniquely each record. How would one identify a customer record? A first thought is to use the *name* of the customer. However, any large organisation is likely to have several customers with the same name: in Cape Town alone there are more than 5000 persons with the surname Abrahams or Smith (and, contrary to popular belief, only about half as many Mohammeds or van der Merwes). A common solution is to look for some guaranteed unique field such as an identity number, a combination of fields (e.g. name and date of birth or address) or by artificially generating a unique code for each customer: the dreaded "customer code" (or, in the case of student records: your student number). The field that uniquely identifies a record is called the ***primary key*** field and is very important in database design, not only when searching for a record, but also to link one data table to another (e.g. when linking customers to their orders).

7.3 Database Models

Just as computer hardware and software development languages have seen different technological generations, database and DBMS technology have also undergone major changes. This manifests itself primarily in the conceptual database model i.e. the type and nature of the relationships that are allowed between different data tables.

7.3.1 The Hierarchical Data Model.

The *hierarchical data(base) model* is the oldest and conceptually simplest model. This structure allows only for one type of relationship, the "parent-child" (or one-to-many) relationship. In addition, there can be only one single relationship between tables. This structure can also be visualised or represented using the image of a tree.

For instance, a customer (the "parent" entity or *root*) can place one or several orders (= "child"). Each order, in turn, will consist of one or several line items (the different products or services that are ordered). In this model, it is very simple to trace the various orders placed by a customer. However, it is more difficult to investigate the correlation between, e.g. the sales of different products (line items) according to geographical area (address of customer) or sales person.

7.3.2 The Network Model

The *network data model* accommodates the "many-to-many" relationships often found in the real world. It allows the explicit linking of sets of entities by means of network relationships.

In a university environment, the relationships between courses and students could not (or with great difficulty) be accommodated in a hierarchical database. Each student can enrol for one or several courses, whilst each course will have an enrolment of zero, one or, hopefully, many students. Student Xannie Du Toit may enrol in the 3 courses Quantitative Philosophy, Exobiology and Data Warehousing; the course Exobiology may have students Jim Mbeki, Xannie Du Toit, Yusuf Arafat and Wang Ching.

However, although the network model allows more complex relationships to be defined than the hierarchical model, it is significantly more complicated than the other models to design and maintain.

7.3.3 The Relational Model

The *relational data model*, pioneered by Codd, is founded on a sound logical set-theoretical basis. Although it took well over a decade for his ideas to find widespread acceptance, almost all major DBMS in use today support the relational model almost in its entirety. Although a detailed discussion of the relational model is outside the scope of this course, a simplified example below will illustrate some of the basic concepts and features for a partial university administration system.

The relational model requires that all data is stored in *data tables*, with unique key fields (the *primary* key) and all other data fields in the table entirely and fully dependent on the key fields. In the example below, there are a large number of tables (the relational model tends to generate a large number of tables). The student table has the student number as the key field.

The order or sequence of individual records is of no concern. Students do not have to be stored in alphabetical or any other specific order, though they may be sorted for reporting purposes.

Tables can be linked, by reference to their primary key fields, in any possible way. Links between tables do not have to be predefined when the database is designed, providing structural flexibility and efficient information retrieval. Each link between tables is a *relationship* and consists of a separate table; e.g. the course enrolment table is really the "enrolment" relationship. There could be other relationships between the same two tables, e.g. a "tutor" relationship whereby some postgraduate students have been appointed as tutors for certain undergraduate course.

The inclusion of a primary key field from another table is called a *foreign key*. E.g. the current degree code in the student table is an example of a foreign key. (This model assumes that an active student can be enrolled for only one single degree.)

Normalisation is a step-by-step process of ensuring that a database structure conforms to the requirements of the standard relational database models. One might be tempted to include course prerequisites in the course table by means of a course prerequisite field. However, some courses may have more than one prerequisite (e.g. Econometrics could require Statistics 1A and Macro-economics 2 as prerequisites). This would require two or more course prerequisite fields. The latter contradicts the first normalisation rule - no repeating fields are allowed.

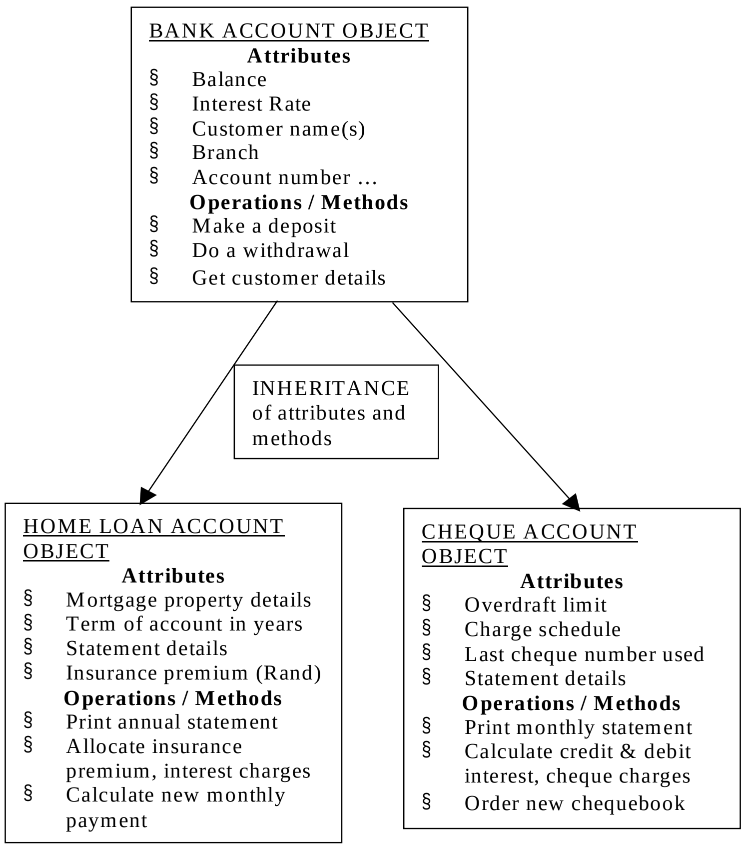
A typical example to illustrate the use of a relational database is that of student enrolments at the university. There will be a *student* table containing the student number (the key field), surname, name, year of first registration, activity status (currently registered or not) and current degree code (foreign key). Similarly, there will be a *course* table which contains course codes (key field), course names, level of course (1^{st} year, 2^{nd} year etc.), type of course (first semester, second semester, full-year, summer term), responsible department (code), number of credits, etc. There will be many other "primary" or entity tables such as lecturers, venues, lecture and tutorial groups etc. The power of the relational model is that it allows *any* type of relationship. E.g. in a small university, different students could be assigned individual tutors, who are senior students, for the various courses. This assignment (in effect, a relationship) could be stored in a "tutor assignment table" containing at least the following fields "tutored student" (foreign key = student number), "tutor" (foreign key = student number), "tutored course" (foreign key = course code). This would be very difficult to achieve in the network model. Note that it is quite possible, indeed very likely, that there will be many relationship tables with exactly the same fields (e.g. "students enrolled in course" and "tutors assigned to course"; or "required courses for degree" and "optional courses for degree").

7.3.4 The Object-Oriented Model

The *object-oriented (OO)* approach was introduced in the chapter on software. Remember that an object encapsulates both the data and the methods or operations that can be performed on the data. Although business databases were not initially considered to be good candidates for OO, more and more applications are benefiting from the use of *object-oriented database management systems (OODMBS).*

Two particular strengths of the OO model are the capability to handle *multimedia* more easily and the feature of *inheritance*. Multimedia, such as pictures or sound, are more easily handled by OODBMS because it is much easier to store the methods, or procedures, to access and edit the data within the object than it is to include those methods permanently as part of the DBMS. As such, OODBMS are popular for engineering and scientific applications. However, product and human resource databases can equally benefit from picture and photograph fields.

The other advantage is that the OO model allows specialised objects to inherit object attributes and methods from their *parent*. A banking example can illustrate this. A generic "bank account" object would have the attributes of "owner details", "account number", "balance", "interest" etc. Specific types of accounts, such as home loans, cheque and saving accounts, inherit the common account attributes and methods. In addition, each account type would have its own specific attributes and methods.



7.3.5 Free-form databases

Another attempt to deal with unstructured data and information is the *free-form database*. Textual (and sometimes multimedia) information can be entered in logical chunks and related to other pieces of information, often using hypertext principles. These databases feature powerful indexing and searching tools. Most free-form databases are stand-alone end-user applications but, in a way, one could consider the entire web to be one huge distributed free-form database. A free-form database differs from a knowledge-based database in that the latter must be able to interpret the knowledge to allow for limited reasoning, inference, specialisation or inheritance.

7.4 Database management

In order for a database to provide and secure efficient data storage and retrieval, there must be careful control of what data is to be included and how it will be maintained, who has access to the database, and how errors can best be prevented or resolved.

Normally, a specialist job function will be created for a *Database Administrator (DBA)*, the person who is responsible for looking after the computerised corporate database(s). The main responsibility of this person is to define the standard data elements and structure of the database (i.e. table and field structure). She will also look after the integrity and safety of the *contents* of the database, and may be responsible for the maintenance and fine-tuning of the DBMS software.

An important component of the DBMS is the *data dictionary* or *data encyclopaedia*. This describes in detail all data elements in the database, i.e. all data tables, field names (and synonyms or *aliases*), descriptions/definitions, field types (text, numeric values, monetary units, boolean, dates), field lengths, key fields, relationships and dependencies between fields and tables, etc.

The database approach distinguishes a number of different *views* or perspectives of the organisational data.

§ The *physical* view (or *data description*) of the data is concerned with where and how files, tables and records are stored. A large database may be split or *distributed* physically over different computers or storage devices; what may seem to be fields of the same record may actually be stored separately; often used records or fields may be stored differently to less frequently used data; various different indexing methods may be used to assist in locating records more quickly etc. The physical data view is the concern of the DBMS (and the DBA) only.

§ The *logical* data view or *conceptual schema* represents the conceptual structure of the data, as seen from an organisation-wide point of view. This would entail all the data fields that are required for each table, their data dictionary names and descriptions, their key fields and the relations between tables. System developers need to know what data is available in order to design their system, and users need it in order to define their information requirements. Most of this information is available in the DBMS's data dictionary.

§ The *subschema* represents the partial or limited view of the data by an individual user or application. A student marks processing application (or lecturer) should not be concerned with a student's personal or financial details, hence the DBMS will only enable access to the academic record components of the student database.

7.5 Database Architectures

Various models or *architectures* can be used to design an information system. This architecture is a decision that must be taken up front about the overall functioning of an information system. It affects the choice of hardware, software and the network configuration.

Although there are many ways to look at database architectures – indeed, the above database models are also an architectural decision – we will look at the decision which is related to *where* most of the data processing should take place

Most business systems have multi-user, networked databases. The user operates a workstation that requires access to the corporate database. The latter is normally located on a separate, larger computer. With the evolution in technology, specifically the increasing power of the user workstations, a decision has to be made about which computer will perform the bulk of the data processing.

7.5.1 Centralised processing

In a *centralised processing* environment, the entire processing load is performed by the central computer, usually a mainframe, to which a number of terminals are connected. This central and powerful computer is therefore usually referred to as the *host* computer. The host controls the data storage and the communication. The application program itself (e.g. a booking system) also runs on the host computer, which performs the various checks and does all or most of the data formatting. The terminal itself does almost no data processing, apart from the most basic screen display formatting instructions.

Although this model was very popular in the early days of mainframe computing, it is now very much on the wane. It is still found in travel agents (airline booking systems), libraries and Computicket offices.

7.5.2 Distributed processing

In the *distributed computing* environment, there is no single host computer that controls all of the organisation's data. All data resides on individual workstations or, more often, on the file servers of the LANs of the functional departments or local branches that actually need the data. These departments' computers are then responsible for *all* the data processing. This is the exact opposite of centralised computing. Distributed processing is made possible by the development of powerful microcomputers with high-capacity hard disks.

In reality, there are two versions of distributed processing. The more common approach is to *divide* the entire corporate database in smaller partitions or sections. These partitions are then distributed on the local network or data servers across the organisations. An alternative approach is to keep *local copies of the entire database* on the different local servers. On a regular basis, usually during the night shift, the servers contact head office and co-ordinate their changes so that, by the next morning, all distributed databases reflect the changes made throughout the organisation.

As an example, a national bank could split its customer account database into regional databases, perhaps one for each province. The transaction details for each account would be stored in the database of the province where each customer's regular branch is located. Only when a customer performs a banking transaction at a branch outside her home province, would there be a need for one regional database to make telecommunications contact with another.

7.5.3 The client-server model

The *client-server* model is a compromise between the two extremes of centralised and distributed forms of processing. Here the processing workload is shared between a central computer and the local workstation.

Generally, the central computer is responsible for maintaining the database. It runs the database management system and performs all related functions such as backup, data integrity, access control and security. This computer issues the required data to the various workstations that ask for it, and is therefore called the *server*. The local workstation, the *client*, receives the data from the server and is responsible for the presentation of the data. The term *client* can also refer to the software that resides on the local workstation i.e. the software responsible for communicating with the server and formatting the data for on-screen display and editing.

An ideal example of the client-server model is the World-wide Web on the Internet. Various *web servers* around the world hold data available for Internet users to see. Anyone connecting to the Internet gains access to the web by means of a *web browser*, which constitutes the client software. The web browser initiates the contact with the web server, who sends the requested data (a multimedia document in html format) to the client. The client's web browser then interprets the various formatting instructions found in the document to present it in the manner most appropriate for the client computer.

Thin and fat clients

Depending on the amount of processing done by the client, we can distinguish between a *thin* and a *fat* client. A *thin client* does little else than the formatting and display of the data; the real business application software, as well as the data management function, is performed by the server. This is quite close to the old centralised processing model.

At the opposite end of the scale is the *fat client*, where the application software resides on the client computer. All data is processed and checked locally and only the final data records are transmitted back to the data server. The server runs only the database management system software; all application software is run on the client.

Two-tier versus three-tier

The client-server model described above is the traditional *two-tier* (or two-level) model, with one large server connected to many clients. In a large organisation, it may not be feasible to split the processing load between the server and the client. What can be done if the database is very large and needs to be accessed by many users but needs to be kept centralised? If the organisation's applications are too complex to be delegated to the client, none of the above models will work. There is too much work for both the server and the client, but the need for one central database precludes the option of distributed processing.

This is where the case for a *three-tier* client-server model can be made. In the *three tier* model, an extra level (or tier) is inserted. At the highest level is the enterprise or central database server, which runs the data management system to perform all the pure data-related processing tasks. This server communicates with a number of intermediate, local servers that run the specific business applications. These servers are usually organised by functional department or geographic business unit. Finally, the client is responsible for the presentation and local editing of the data. (In some cases, more than three computers may be involved in data processing, in which case this is known as an *n-tier* model.)

A simplistic example is the situation of the inventory database of a large, national organisation. Because this data is vital to most functional units within the organisation, it makes sense for the database to reside on one central data server. Each of the applications which makes use of this database, such as billing, receiving, stock control, etc. could be located on the various departmental servers located throughout the organisation. One of these servers might even be a web server that encodes all data in such a way that it can be made available via the internet to customers who wish to check stock availability. Finally, each user will interact from his personal computer with the application residing on his departmental server.

7.6 South African Perspective

The Automated Fingerprint Identification Systems (AFIS) is a mobile system connected to the police database in Pretoria, that can track down a person’s criminal record in a matter of seconds. The system is being used by police on the East Rand to identify suspected criminals, as well as to assist in recovering stolen cars. Assistant commissioner Gert de Lange commented in a newspaper interview that by enabling police to check 100 cars simultaneously, crime can be targeted with a minimum of inconvenience for motorists.

7.7 Beyond the Basics

Amazon.com has over 20 million customers and has revolutionized the bookselling business, becoming a household name almost overnight. Amazon.com succeeded because of the way it presents information to customers, not just because it was one of the first companies to sell books via the Web. In fact, it would be difficult to label Amazon.com a bookseller or even a retailer. It has no brick-and-mortar stores, no warehouses, and little inventory of its own. What Amazon.com does have is information (lots of it) about customers and what they've purchased, driven by a foundation of very, very large databases. Amazon.com uses this information to ensure that customers have a valuable online shopping experience. For example, Amazon.com proactively recommends books to customers based on previous books they've purchased, a profile they've filled out, and buying trends among customers who have similar profiles. The same information capacity is used to support sales of products such as CDs and clothes.

Amazon.com is an example of a new breed of company whose core business is information and whose chief competitive advantage is the sophistication of its information systems. Companies like Amazon.com are dramatically changing the business landscape because they know how to integrate databases, operational systems, and the Web to cement relationships with their customers, suppliers, and partners.

7.8 Exercises

7.8.1 Database management system

Pete Anderson owns a small chemist's shop in Wynberg, and recently replaced his cash tills with a PC-based sales system from Mikrotek Systems that makes use of a product price file, containing product codes, descriptions and prices, which is updated by his bookkeeper on a weekly basis.

Pete is so impressed by the accuracy and speed of this system, that he has been looking at other computer systems that might be suitable for his business. For a reasonable price he can buy a separate customer accounting system from Aardvark Computing, which will keep track of his customers' account details and balances, and print monthly statements. As part of the same deal, Aardvark will also provide him with a stock control system, to be used for ordering stock and keeping track of what is still available in his storeroom (i.e. has not been moved into the shop for display or sales).

As he explains it to you, stock orders would be entered on the **stock system**. When new stock is received, the quantity available in the store would be increased, and when stock is moved onto the shop floor, the quantity available in the store would be decreased. Below a certain stock level, new orders would be automatically generated.

The **sales system** accumulates totals of sales per day for each product, so that Pete will be able to identify fast-moving lines and move stock out of the storeroom as needed.

When a sale is made on account, the cashier will simply write the customer's account number on a copy of the sales docket, which the bookkeeper will then enter into the **customer accounting system** the following day.

Pete's son is studying IS, and says that it would be better to install a single integrated database system which combines all of his business data. Pete is not sure whether his son really knows what he is talking about, and has asked you to explain why using a database system would be even more efficient than the solution outlined above, for managing his stock, sales and accounts.

- Describe three examples of how business activities and record keeping could be enhanced by the use of an integrated database
- Outline two "queries" or reports that could be useful in managing the business, which combine data from two or more of the subsystems (stock, sales, customers).
- Design a set of database tables to be used in a new integrated database system that includes stock, sales and customers. Base your solution on the empty tables provided below.

<u>Note</u>: Pete needs to keep a record of account holders' names, addresses and telephone numbers. In addition, account sales to customers must be recorded in the database. Each sale

should produce an invoice document which contains an invoice number, date, customer details, and details of items purchased (item description, quantity sold and value (quantity x price)). Pete will also keep a record of every product that he stocks (item description, quantity in stock, price). To assist you in getting started, the optimal solution will consist of 4 tables as labelled below. Complete the exercise by entering all the required fields in the tables and drawing lines to indicate the links between the tables. You can indicate primary keys by putting a "P" at one end of the line linking the appropriate fields in the tables.

Customer Table

Stock Table

Invoice Table

Invoice Details Table

CASE STUDY: GREENFINGERS GARDEN SERVICES

Refer back to the Greenfingers Garden Services case study that was introduced at the end of Chapter 3.

(a) Identify the business entities (people, objects or events) about which you would want to store data. List some of the data fields that would be appropriate for each of these entities, and their data type (eg text, number, graphic, etc).

(b) It is preferable to capture data as early in an automated business process as possible, since paper-based recording and later data capture can introduce human error. With this in mind, who are the people who would be responsible for data capture in a new computerised information system, and where and when should this data be captured. (Hint: consider the point at which data is currently first recorded on paper.)

(c) Apart from a standard PC with keyboard and mouse for office use, when would other devices such as PDAs or cellphones be appropriate, and what sort of interface would they use?

(d) The classification of applications by function distinguishes general-purpose applications, business applications, scientific applications and miscellaneous applications. Give examples of how each of these application types could be used within Greenfingers Garden Services to support business activities and planning.

(e) Communication of information between work teams, branches, consultants, clients and central administration is a major problem in the existing manual system. Use a diagram to show how a combination of data communication methods could support the exchange of information between them.

(f) Suggest a suitable email address for the business, and list the ways in which email could be used to enhance business communications.

(g) How would the implementation of a DBMS make Alice Cooper's business administration easier?

Section III: IS Applications

Although computer-based information systems are a relatively recent phenomenon, having been around less than half a century, we can already distinguish a number of stages through which they have progressed.

- During the nineteen fifties and sixties, the main focus of the systems was the automation of operational data flows: the era of *electronic data processing. (EDP)* These systems assisted operational (white collar) staff with their information work.

- In the seventies and early eighties, the extraction of the data for managerial decision making became much more pronounced and this introduced the need for *management information systems* and *decision support systems*. This was made easier by the maturing of the technology, in particular the existence of more powerful mainframe computers with plenty of disk storage that could support a database approach to applications. Information systems started to assist and improve the quality of managerial decision making.

- The late eighties and nineties saw the rise of *end user computing* which necessitated *distributed access* to data. This is also the period where the limitations of functionally oriented applications were being felt due to the increasing competitiveness in the markets, and to the associated rapid increase in required response time. Major redesigns resulted in the advent of more integrated, process-oriented enterprise systems. During this period, more and more organisations used the capabilities of systems based on innovative technologies to develop new products or services, or dramatically alter the way in which these were being delivered to the customer. This is the birth of strategic information systems: systems that are deployed to gain a competitive edge in the market.

- Increasing globalisation, coupled with the sustained increase in the capabilities of the computer and communications technologies, has led to more pronounced emphasis on the *integration* of information systems within (*intra*-) and between (*inter*-) organisations. There is much greater *convergence* between communications, computer and media technologies whereby a number of information processing technologies are linked internally and externally. The continued miniaturisation and networking is likely to make information systems much more mobile, embedded and *pervasive* in the work and home environment. The use of international standards and maturing of underlying technologies will shift the emphasis even further from the technology (the *how*) towards the management, human and deployment issues (the *what* and *where*).

With the growth of the internet, *electronic commerce* is playing an increasingly important role in linking organisations with their customers and their business partners, and is becoming an essential component of the IT strategy of modern businesses. E-commerce enables market expansion with minimal capital outlay, improves procurement and marketing and increases consumer choice; but there is still a need for universally accepted standards for information quality and security, and the provision of sufficient telecommunications bandwidth.

This section of the textbook will examine different types of IS applications in more detail, focusing on how they are used within and beyond organisational boundaries, as well as the growing business importance of electronic commerce. Since these applications are used by human beings, and so are vulnerable to deliberate abuse or accidental misuse, we will also address a number of *security* related issues.

8. Business Support Systems

As discussed in Chapter 1, different types of information systems are used by the various management levels of an organisation. They support the objectives of the business by increasing the efficiency of business processes, cutting supply costs, improving levels of customer service and improving managerial decision-making.

- Transaction Processing Systems record routine transactions within the different departments of an organisation;
- Management Information Systems draw from the TPS to monitor and control business performance;
- Decision Support Systems and Executive Information Systems assist managers with complex decision-making tasks;
- Strategic Information Systems make use of information technology to gain competitive advantage;
- an increasing number of Intelligent Systems are being incorporated within business processes to extend IS capabilities;
- Data Mining and On-Line Analytical Processing can be used to search through organisational data to uncover previously unknown patterns and trends.

8.1 The Decision-Making Process

Across all levels of the organisation, information is used as the basis for decision-making by operational and management staff. Figure 8-1 illustrates the various steps of the typical decision making process.

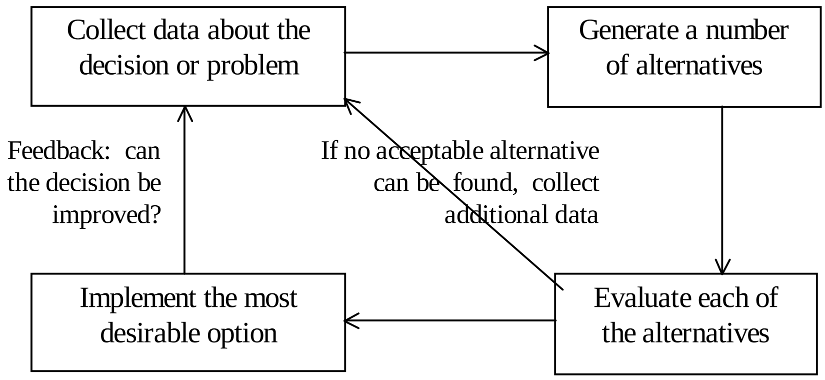


Figure 8-1: Steps in the decision-making process

The type of decision to be made generally depends on the level within the organisation. Clerks typically make routine decisions based on clear guidelines. Top-level managers are faced with more uncertainty and the decision process is correspondingly much more unstructured.

This *dichotomy of information work* is reflected in Figure 8-2, which contrasts the two extreme types of decision, sometimes referred to as Type I and Type II decisions. In practice, most decisions fall somewhere between these two extremes and share some characteristics of both Types I and II, although decisions made by clerical staff are likely to be closer to Type I, and decisions made by senior management will incorporate more Type II characteristics. Because of this, the information systems used at higher levels of the organisation tend to be more complex: it is far simpler to automate the decision as to when paper for the photocopier should be re-ordered, than to decide whether to introduce a completely new product.

Although the different types of information systems may be described under separate headings, integration between them is vital if the information flows within the organisation are going to successfully meet the needs of a wide range of users, who may be making decisions affecting more than one functional area of the business, based on data from a variety of different sources.

Type I	Type II
Many transactions/decisions	Relatively few transactions/decisions
Low value or cost per transaction	High value or cost per transaction
Well-structured and detailed procedures and guidelines	Ill-structured and vague procedures and guidelines
Output, objectives and evaluation measures well defined or specified	Output, objectives and evaluation measures less defined
Process-oriented	Problem or goal oriented
Emphasis on efficiency: "*do the thing right*"	Emphasis on effectiveness: "*do the right thing"*
Processing of mainly structured data	Handling of concepts, information
Predominantly clerical workers	Managers and professionals
Examples: processing of orders, payments, first-line customer queries	Examples: planning, crisis management, design

Figure 8-2: The dichotomy of information work: two decision extremes

8.2 Batch vs Online Processing

In early commercial systems, data was usually entered into an organisational information system in **batch mode,** mainly because computer technology had not yet been developed to support more advanced systems. Here the practice was to manually record each business transaction, and then later enter the corresponding data into the computer. At regular intervals (e.g. at the end of each day) the master files would be updated to show the new balances, and related customer documents such as invoices would be generated. Management requests for information about the state of the business would be based on the most recently updated files. This approach gave rise to a number of problems: poor authorisation checks; incorrect data recorded on the original invoice would only be picked up much later; new errors could be introduced at the data capture stage; documents could go missing before they were captured; and management information was usually out-of-date.

On-line entry systems overcame some of these problems. By capturing data electronically at the time that a transaction occurs, authorisation and data correctness can be automatically verified, and the opportunity for human errors to be introduced at a later stage is removed. However, updating of master files still takes place at predetermined intervals, and not at the time of each transaction, so management reporting remains unreliable. Nevertheless, this type of system remains popular for applications such as payroll, where information only needs to be produced periodically.

With decreasing computing costs and the need to remain competitive, **on-line update** (or **realtime**) systems have now become the norm. Each transaction is recorded directly on to the computer (often by means of a bar code scanner); the data is immediately validated and the relevant master files are updated. To achieve this, each point-of-sale (POS) terminal must be connected via a network to the central database containing customer records, stock records, and other sales-related data. As soon as the transaction has been completed, invoices and other documentation are produced. Opportunities for fraud are limited, since data is validated at the time of entry and source documents cannot disappear before their details are captured. Although some reports such as customer statements may only be needed periodically, the data in the database is always up to date and is available to managers at any time.

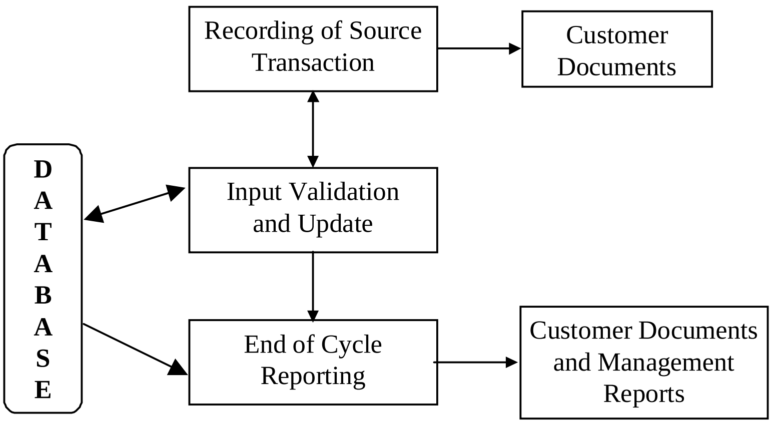


Figure 8-3: On-line transaction flow

In recent years, online transaction processing has broadened to include transactions entered via the Internet.

8.3 Applications at Different Management Levels

8.3.1 Transaction Processing Systems

Transaction Processing Systems support simple processing of large amounts of structured data. This data is mainly of internal origin, resulting from numerous routine transactions that occur in many different business areas. Common modules of a TPS include:

- Order processing: orders for goods or services can enter the system from customers, salespeople, or other internal departments.

- General ledger: details of all transactions affecting the accounts of the company are recorded to simplify bookkeeping and reporting.
- Accounts payable and receivable: data generated from sales journals or purchase orders can be used to improve debt collection and cash flow.
- Inventory management: along with updating of stock levels, IS is commonly used for tracking of materials and for linking the organisation to suppliers and purchasers.
- Payroll: employee details, earnings, deductions, leave accrual etc.

8.3.2 Management Information Systems

Management Information Systems (MIS) are systems that use the data generated by the TPS to help lower and middle management in their decision making. MIS use a variety of techniques to process, summarise and present the information in the form of useful reports: tables, statistics, graphics, etc. Many MIS can easily be customised and new reports are readily created on demand. Because many businesses are still organised on a functional basis, many MIS tend to focus on specific functional areas e.g. a marketing MIS, a human resources MIS etc. The decisions taken by middle management are more complex than pure operational decisions. They involve a longer, medium-term time span (typically looking several months ahead), influence a large number of individual operational decisions (e.g. price setting, carrying or dropping new stock items, changing procedures etc.) and are less structured than operational decisions, though they do tend to follow certain patterns and be of a recurrent nature. These decisions are called *tactical management decisions*. They typically affect the whole or a major part of a functional department (e.g. the entire marketing department) and involve more significant resources than operational decisions.

A particularly useful feature of MIS are the so-called *"exception reports"* which list only unusual or abnormal transactions, namely those that fall outside the normal pattern; instead of many, many pages of detailed data, the manager sees only those items which may require special attention or corrective action. An exception report for a bank manager might list all transactions exceeding one million rand; or those bank departments who have exceeded their budget by more than 10%.

Organisational support provided to business managers by the MIS commonly includes financial planning and budgeting, investment management, financial controls, marketing management and the provision of customer service.

8.3.3 Decision Support Systems

Decision Support Systems (DSS) are systems that assist managers with very specific types of decision-making situations. Though they are often used by the same managers who also rely on MIS, a distinguishing feature is their modelling capability. DSS use various mathematical and statistical models to help the manager generate alternative decision options and evaluate their outcomes. Another difference between DSS and MIS is their time perspective: an MIS typically produces reports based on *historical* information where a DSS allows the manager to see the *future* impact of his decision. Table 8-4 lists some more differences between MIS and DSS.

	MIS	DSS
Problem type	Mainly for more structured problems or *programmed decision-making*.	Good at handling unstructured problems.
Support	Provides only the information necessary to make a decision.	Supports all stages in the decision making process, including the modelling and evaluation of various decision alternatives.
Approach	Typically based on regular, structured reports.	Excels at interactive and ad-hoc queries.
System	Often based on printed reports, via batch mode, delivered to managers on a regular basis.	On-line and real-time interaction, mainly screen oriented.
Speed	Requires a greater turn-around time and is less flexible in terms of report format changes.	Quick
Development	By IS staff.	Often by end users.

Table 8-4: Some differences between MIS and DSS

When information is required to support management decision making, the user of the DSS is able to interact directly with the computer via a graphical user interface or control language to request the relevant data, select and operate the appropriate decision model and generate the output report in the format required. The following diagram of a DSS shows the three main components; the database, model base and user interface.

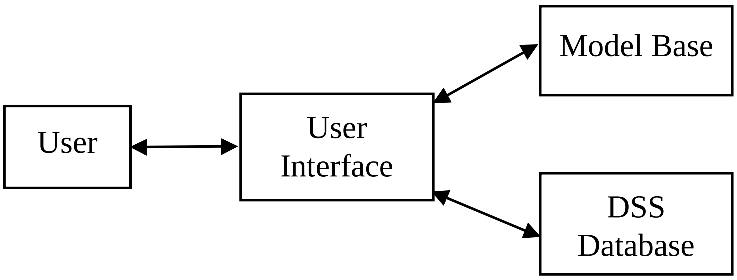


Figure 8-5: Components of a Decision Support System

DSS Database. This database contains current and historical data from all the relevant business applications. However there are a number of good reasons why organisations do not allow the DSS to access the operational database used by the transaction processing systems, but rather construct another database for this purpose. One key reason for limiting access to the operational database is that DSS requests often require many passes of the database to select the required data. This activity will impact on the service the DBMS can provide to on-line applications in areas where response times are critical. In addition, while DSS systems normally download a copy of data for analysis and seldom update the database, management is always concerned about the security and integrity of the operational database and prefers to limit access to a minimum. Finally it makes good sense to maintain a database specifically for DSS queries. In the DSS database, some data need be held only in summary form while certain historical records must be retained for a five year period to allow for trend analysis. In some cases the data may come from different databases, sometimes held on different hardware and software platforms, and the transfer (and potential reformatting) of data to a common DSS database enables queries to be generated combining data from these varied sources. With the demand for end-user access to current and historical information, many organisations are building *data warehouses*, which store large quantities of data obtained from different functional areas of the organisation.

Model base. This is a library of analytical tools that can be used to evaluate and represent data. Typical examples are the standard business functions (for example to calculate discounted cash flows and depreciation), statistical functions (means, standard deviation and variance), data retrieval tools to select, sort and summarise, and the ability to test possible scenarios through sensitivity analysis and goal seeking.

User Interface. In the past managers communicated their report requirements to programmers who coded the request and delivered the required output. The nature of management decision making is such that response time is often critical. In addition the solution to problems of this nature is iterative, as one report may trigger the need for alternate investigations into other areas of the business. Often senior managers use a 'chauffeur', an analyst or skilled end user to assist them in developing the required DSS output. Obviously the most suitable DSS environment is to have the decision maker interface directly with the DSS. Graphic user interfaces and the increased level of computer literacy within the management hierarchy, have made this possible.

When a user requires a report or enquiry to be performed by the DSS, he or she will enter the request in a high level, user friendly business language. For example, by clicking the mouse on options and items in list boxes, the user can pick fields, choose selection criteria, detail sequence and request the level of detail for a particular report. The user interface software will then translate this request into the code required to perform the process using the required data and business rules. These user interfaces also offer sophisticated output formatting with, for example, the results being presented in text format or as business charts.

8.3.4 Executive Information Systems

Decisions made by top-level executives are often too unstructured to be adequately supported by a DSS. For this reason, Executive Information Systems (EIS) have been developed, which provide rapid access to both internal and external information, often presented in graphical format, but with the ability to present more detailed underlying data if it is required.

An EIS will continuously monitor selected key performance indicators that have been identified as critical to the success of the organisation. The user will be alerted to any significant changes that occur, and "drill-down" capabilities will then provide further levels of detail underlying this information. Trend analysis can be done using forecasting models, usually through the integration of the EIS with a DSS system.

8.4 Strategic Systems

An important special type of organisational information system is used to secure or sustain competitive advantage in the market place: strategic information systems. Although these systems generally form part of a more generic business marketing strategy, the information technology is actually a critical enabler or support element to achieving success in the market. The following three possible strategies are typically distinguished.

- **Low-cost strategy**: use of the information systems to produce significant cost-savings and thus offer services/products at a lower price than competitors (or increase profit margins). One typical example is the use of alternative marketing or distribution channels such as using the *Internet* for receiving orders and eliminating middlemen such as wholesalers and retailers. Another example is having more integrated or even completely redesigned logistics processes such as having a fully automated on-demand production line where parts and components are supplied on a *just-in-time (**JIT**)* basis by the suppliers, often using an *Electronic Data Interchange (**EDI**)* system.

- **A differentiation strategy**: use of information systems to provide a distinctive quality or otherwise add value to your products or services. Technology can enhance quality through better manufacturing processes (e.g. a quality control system or automated manufacturing) or add value by increasing the information content or *information intensity* of the service/product. Other possibilities are the use of computer and communication technologies to enhance after-sales support e.g. automated (self-)diagnostics, remote diagnostics, direct internet support and help-line.

- **A niche marketing strategy**: using information systems technology to service very small, isolated or exclusive markets that have specific demands. A good example is the publishing industry: the ability of the internet to reach individuals with extremely specific interests for whom there would otherwise be no cost-effective marketing or distribution channel allows the marketing of extremely specialised books. Another example in the publishing technology is the production of small print runs of "customised textbooks on demand" whereby course lecturers can compile individually customised textbooks made up of different modules tailored to their specific curriculum requirements.

8.5 Intelligent Systems

The traditional approach to solving problems using a computer is to provide instructions to the machine (in the form of a program) detailing exactly how the task is to be performed. However, some tasks are seen as too unstructured (ill-defined) to be programmable. For example imagine writing a program to control a robot housekeeper. The number of possible situations the robot needs to identify and respond to are so great that conventional programming techniques are totally inadequate. Add to these problems the concept of approximate or fuzzy logic. Pure propositional logic (things are either true or false) is too exact for real world problems where humans are required to make guesstimates based on probabilities.

The ability of computers to work intelligently (and not just follow a set of standard instructions) has fascinated scientists, researchers and sci-fi writers since the early 1950s, and *artificial intelligence* (AI) is the branch of computer science concerned with understanding the nature of human intelligence with the goal of simulating aspects of it with a computer.

While we still know very little about how the brain functions, there are four areas of AI research that have made some progress towards the goal of an intelligent machine:

- **Natural languages:** the ability for computers to understand the spoken word
- **Robotics:** where machines perform co-ordinated physical tasks
- **Visual perception:** the ability of machines to recognise visually shapes and objects
- **Expert Systems:** systems developed to simulate the decision-making behaviour of humans in a narrow area of expertise.

8.5.1 Expert Systems

Expert systems (often termed knowledge-based systems) are the category of AI which has been used most successfully in building commercial applications. As discussed earlier, attempting to provide computers with the intelligence to handle complex real world environments is beyond our current capabilities. However expert systems are knowledge intensive programs that capture the expertise of a human within a narrow problem domain.

In order to address a particular problem area (for example to diagnose a disease in a sick patient) the expert system must have a knowledge base (a database of facts, intuition and rules about the knowledge domain) and an inference engine (software capable of manipulating knowledge contained in the knowledge base). Since knowledge takes many forms and shapes (facts, rules, relationships between facts and rules, probabilities, defaults and exceptions, models, contradictory statements and many other non-structured items), standard database models such as the relational model are not always suitable. Several different *knowledge-based databases* have been developed for use in expert systems, although despite attempts at standardisation, most of them use their own proprietary ways of representing and dealing with the data.

There are already many commercial examples of expert systems being used across a range of applications such as the diagnosis and treatment of medical conditions, the evaluation of loan applications, and the identification of mineral deposits.

8.6 Data Mining and OLAP

8.6.1 Data warehouses

Business managers have only recently started to realise how much valuable information is hidden inside the many different databases underlying their information systems. Data warehouses can be used to correlate and analyse the information contained in different databases within the same organisation. Usually, a copy of the continuously changing transaction data within the various operational databases is made periodically into one single, huge database: the data warehouse. This data warehouse then contains detailed historical data for all or most of the organisation’s operations. Powerful statistical and charting tools assist managers in comparing and analysing the data.

Effective construction of a data warehouse must provide facilities to integrate data from different functional areas of the business, which may be represented using different formats. Software programs will extract data from its original source, convert it into a uniform format and then store it in the warehouse.

Sometimes it is technically not feasible or it is too expensive to merge the data from many databases. In those cases, some benefit can already be had from focussing on the organisation's most important databases, usually the ones relating to customers and sales. Such a mini data warehouse focussed on one particular functional area is called a ***data mart***.

8.6.2 On-line analytical processing

Imagine a marketing manager trying to analyse this quarter's sales to discern trends and pinpoint problem areas. How can the data be analysed? There are many possible views.

- According to different product groups.
- Using the time dimension, comparing the different months.
- Looking at the cost components and contribution to income.
- Comparing sales budgets, projections, actual sales and variances.
- Analysing sales according to geographic region.
- Evaluating the various marketing channels: wholesales, sales force, brokers and the corporate market.

On-line analytical processing (OLAP) is concerned with the real-time analysis of large corporate databases to find trends and inter-relationship by managers and decision-makers. The user formulates complex queries and searches by means of sophisticated, interactive front-end applications such as statistical packages, spreadsheets or decision support systems.

Because traditional database models are not very good at handling and displaying many different dimensions of business data for simultaneous analysis, **multidimensional** analysis technologies are used to filter and aggregate subsets of the data. Advanced statistical analysis tools and graphical interfaces are incorporated to facilitate data visualisation, often using *hypercubes* to display multidimensional information.

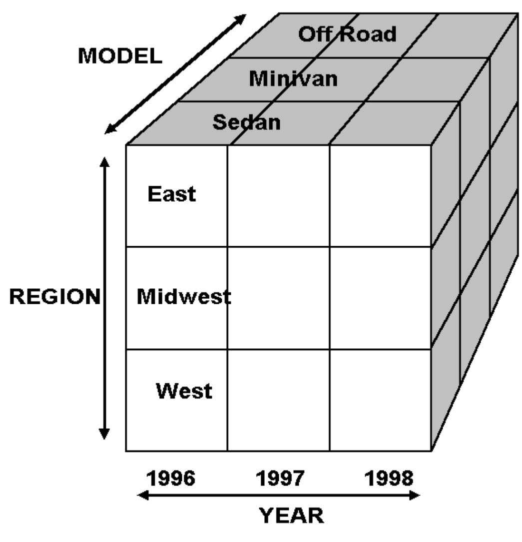


Figure 8-6. Example of a hypercube (www.ssa-lawtech.com/ wp/wp2-3.htm)

The raw data is often derived from traditional application databases, but because of the huge amounts of data processing involved, a separate server may be used to store and process the data subsets being used for analysis. This approach gives rise to a *three-tier* model, which includes the server or mainframe which hosts the organisational database, the workstation on the manager's desk through which queries are submitted, plus a dedicated OLAP server holding relevant subsets of data in multidimensional databases. Unlike an executive information system, this does not usually provide the ability to "drill down" to the level of the original transactions underlying a query result.

8.6.3 Data mining

The huge amount of information and the many possible different perspectives often make it very difficult for humans to discern meaningful trends within the masses of data in the data warehouse. Statisticians have developed a number of methods that automate the discovery of non-random trends and significant inter-relations. *Data mining* is the use of these statistical methods, packaged in a single computer package and let loose on their own, without human intervention, to discover deep or hidden data interrelationships.

8.7 South African Perspective

An example of a locally developed system that supports business transactions, management control and decision-making is Digitot, a computerised beverage-dispensing system. Traditionally, the hospitality industry loses between 10% and 25% of revenue on alcoholic drinks, due to spillage, pilferage and "freebies", and frequent manual stocktakes are necessary. The Digitot system, which is integrated with a point-of-sale system, uses electronic tot measures to digitally dispense and count each tot and automatically update stock levels. Flexible reporting over selected periods can analyse this data to determine when stock has gone missing and who was responsible for the loss. Data analysis can also reveal patterns in customer preferences and identify products that offer value for money, which can be used as the basis for promotional marketing.

8.8 Beyond the Basics

Neural networks are proving increasingly valuable in complex decision-making, where a large number of factors must be simultaneously considered and human inconsistency or prejudice could affect the decision outcome. Furthermore, they are able to adapt to changes in the business environment over time. The neural network consists of many cooperative processing elements, that are "trained" using a large number of historical transactions (the data that was evaluated and the outcome that was reached) in order to establish criteria that can be applied to future decisions. The weighting of these criteria will subsequently change over time, since each new application of the neural network may affect the previous relationship between elements.

Neural networks are particularly useful when processing complex data for which no established decision rule is known, or when there are too many variables to consider. In this case, it is easier to let the network learn from examples.

Neural networks are being used:

- in investment analysis: to attempt to predict the movement of stocks currencies etc., from previous data. There, they are replacing earlier simpler linear models.
- in monitoring: neural networks have been used to monitor the state of aircraft engines. By monitoring vibration levels and sound, early warning of engine problems can be given.
- in marketing: neural networks have been used to improve marketing mailshots. One technique is to run a test mailshot, and look at the pattern of returns from this. The idea is to find a predictive mapping from the data known about the clients to how they have responded. This mapping is then used to direct further mailshots.

8.9 Exercises

8.9.1 Processing methods

Compare a batch processing system (such as might be found in a hardware store) with a realtime processing system (e.g. in a bank), in terms of the authorisation methods used to check the identity of the customer, how the initial transaction details are captured, the completeness of transaction data, opportunities for human error to enter the process, availability of data for managerial decision-making.

8.9.2 Organisational information flows

Construct a diagram to show how data and information flow between the different types of organisational information systems (TPS, MIS, DSS, EIS), and their users, data stores and environment.

8.9.3 Fuzzy logic

Fuzzy logic refers to a type of expert system which caters for non-binary decision-making (i.e. not simply a yes/no answer). For example, when you buy a car, you might be satisfied (in varying degrees) with petrol consumption falling within a *range*, rather than arbitrarily selecting a cutoff point below which it is okay and above which it is unacceptable. Search on the Internet or in an IS textbook to find a simple explanation of the concept of fuzzy logic, and an example of how it has been implemented in commercial devices.

9. E-Commerce

Business was quick to grasp the marketing and business potential offered by the Internet. Initially, businesses used the Internet to facilitate communication by means of e-mail. This was quickly followed by tapping the web's potential for the dissemination of product and other marketing information. The provision of advertising space (*banners*) on frequently visited *web sites* is the main source of income for *search engines* (sites allowing you to search the Internet for information) and *web portals* (web sites that provide additional value-added personal services such as news, financial information, weather forecasts, items of interest etc.)

A number of specialised companies have realised that the Internet can be a direct and extremely cost-effective channel of distribution. Some companies already have a physical infrastructure and use the web to enhance their distribution channel e.g. you can now order your pizza, bank statements or movie tickets via the web. Other, *virtual* companies have almost no physical infrastructure and are mere “conductors” for the flow of products of services.

Important categories of e-commerce include:

- Business-to-consumer (B2C) in which organisations provide information online to customers, who can in turn place orders and make payments via the internet
- Business-to-business (B2B) in which business partners collaborate electronically
- Consumer-to-consumer (C2C) in which individuals sell products or services directly to other individuals.

The technologies that are needed to support electronic commerce include the network infrastructure (Internet, intranets, extranets), software tools for web site development and maintenance, secure ordering and payment methods, and resources for information sharing, communication and collaboration. When e-commerce is done in a wireless environment, such as through the use of cellphones, this is referred to as **mobile commerce** (m-commerce).

9.1 B2C e-Commerce

Electronic retailing is similar in principle to home shopping from catalogues, but offers a wider variety of products and services, often at lower prices. Search engines make it easy to locate and compare competitor's products from one convenient location and without being restricted to usual shopping hours. Electronic malls provide access to a number of individual shops from one website. On-line auctions have also proved a popular way of disposing of items that need a quick sale.

Business-to-consumer commerce allows customers to make enquiries about products, place orders, pay accounts, and obtain service support via the Internet. Since customers can enter transactions at any time of the day or night, and from any geographical location, this can be a powerful tool for expanding the customer base of a business. However, the existence of a website does not guarantee that customers will use it, or that they will return to it after a first visit. Firms investing in electronic commerce need to consider a number of factors in developing and maintaining their e-commerce sites.

A successful web site should be attractive to look at and easy to use. In addition, it should offer its customers good performance, efficient service, personalisation, incentives to purchase and security. Inadequate server power and communications capacity may cause customers to become frustrated when browsing or selecting products.

Many sites record details of their customers' interests, so that they can be guided to the appropriate parts of the site. Customer loyalty can also be developed by offering discussion forums and links to related sites, and by providing incentives such as discounts and special offers for regular customers. And if you expect customers to purchase goods, and not just browse, then it is vital that customers should have complete confidence in the security of their personal information, and in the ability of the web store to deliver the goods as requested.

Much of the business value of the Internet lies in the ability to provide increased value to customers, with the focus on quality of service rather than simply price. By opening additional channels of communication between the business and its customers, businesses can find out the preferences of their customers, and tailor products to their needs. Customers can use the Internet to ask questions, air complaints, or request product support, which increase customer involvement in business functions such as product development and service.

However, although businesses may increase their markets while gaining from reduced advertising and administration costs, problems that have emerged include alienation of regular distributors, difficulty in shipping small orders over large distances, fierce competition and inadequate profit margins. Because of the delivery problem for physical products, many successful e-commerce firms have focused on the delivery of services, such as banking, securities trading, employment agencies and travel bureaus. Of course, every problem can be regarded as an opportunity – a local software developer has created and marketed a route scheduling application which provides optimised route sheets, with maps for individual routes and step-by-step driving instructions for effective and timeous order management, based on powerful geographical information systems to provide a user-friendly interface.

B2C e-commerce has also made it easier for firms to conduct market research, not only by collecting shopping statistics, but also by using questionnaires to find out what specific groups of customers want. This in turn has enabled the personalisation of products to meet customer preferences.

9.2 B2B e-Commerce

Business-to-business e-commerce comprises the majority of electronic transactions, involving the supply chain between organisations and their distributors, resellers, suppliers and other partners. Efficient management of the supply chain can cut costs, increase profits, improve relationships with customers and suppliers, and gain competitive advantage. To achieve this, firms need to

- Get the right product to the right place at the least cost;
- Keep inventory as low as possible while meeting customer requirements;
- Reduce cycle times by speeding up the acquisition and processing of raw materials.

Information technologies used to support business-to-business e-commerce include email, EDI and EFT, product catalogues, and order processing systems. These functions may be linked to traditional accounting and business information systems, to ensure that inventory and other databases are automatically updated via web transactions. **Intranets** provide a facility for members of an organisation to chat, hold meetings and exchange information, while at the same time sensitive information is protected from unauthorised access by means of a firewall. An **extranet** provides a means of access to the intranet for authorised users such as business consultants.

Electronic data interchange (EDI) involves the electronic exchange of business transaction documents over computer networks, between organisations and their customers or suppliers. Value-added networks provided by third parties are frequently used for this purpose. Documents such as purchase orders, invoices and requests for quotations are electronically interchanged using standard message formats, which are specified by international protocols. EDI eliminates printing, postage and manual handling of documents, reducing time delays and errors, and thus increasing productivity. It also provides support for implementing a Just-in-Time approach, which reduces lead time, lowers inventory levels, and frees capital for the business.

Marketing to other businesses is done by means of electronic catalogues and auction sites, which can increase sales while reducing advertising and administrative costs. From the buyer's perspective, reverse auctions can be used to advertise *requests for quotation* in a bidding marketplace in order to attract potential suppliers. Third party vendors can make use of *group purchasing* to aggregate a number of separate small orders in order to increase negotiating power.

Collaborative commerce involves long-term relationships between organisations in areas such as demand forecasting, inventory management, and product design and manufacture. However, this presents a number of business challenges such as software integration, compatibility of technologies, and building of trust between firms.

9.3 C2C e-Commerce

Auctions are the most popular method of conducting business between individuals over the Internet. (Unfortunately, auction fraud was also the most common type of crime reported to the Internet Fraud Complaint Centre in 2002.) Other C2C activities include classified advertising, selling of personal services such as astrology and medical advice, and the exchange of files especially music and computer games.

9.4 Electronic funds transfer

Electronic payment systems can be used to transfer funds between the bank accounts of a business and its suppliers, or from a customer to the business. In retail stores, wide area networks may connect POS terminals in retail stores to bank EFT systems. In most cases, an intermediary organisation acts as an automated clearinghouse, which debits and credits the relevant accounts.

The most popular payment method used by individual consumers is the credit card, which requires the merchant to pay a commission to the bank on each transaction. For transactions involving small amounts that do not justify the payment of commission, merchants may accept electronic money in the form of digital cash. In this case, the customer "buys" money from the bank in the form of a unique cash number, which is transmitted to the merchant at the time of purchase and "deposited" in an account at a participating bank. In South Africa several banks have developed their own forms of digital cash, such as e-bucks from First National Bank.

Figure 9-1. Stages in an e-commerce transaction (www.artboomer.com/images/commerce.asp)

An important issue in electronic commerce is the security of Internet transactions. Data is commonly encrypted to reduce the vulnerability of credit card transactions. Secure Sockets Layer (SSL) and Secure Electronics Transaction (SET) are two of the standards used to secure electronic payments on the Internet. Secure sites usually have URLs that begin with *https* instead of the usual *http*.

9.5 Current issues in e-commerce

For e-commerce to succeed, companies need to make large investments in hardware and telecommunications infrastructures that will be up and running 100% of the time, and software that is easy to use and reliable. A number of early participants in the e-commerce market suffered financial losses because their technology was not able to handle the huge numbers of transactions to be processed. Internet customers are often impatient, and will move to a competing site if the response is too slow.

Gaining the trust of customers can be difficult - the seller is often reluctant to despatch goods before payment, and the buyer may be reluctant to pay before receiving the goods. In South Africa, the speed of electronic ordering is often negated by delays in physical delivery.

Societal problems have also emerged, with children, gamblers and shopping addicts enjoying unrestricted access to electronic commerce sites. A German cannibal posted a web advertisement seeking a victim who was willing to be killed, sliced and eaten – and apparently found one! (reported in www.iol.co.za, 18 December 2002). The laws governing electronic commerce are still in their infancy, and international standards need to be developed in areas such as information privacy and taxation.

Since e-commerce supports global business transactions, it presents the challenge of customising web sites to appeal to people of different nationalities and cultures (and even different languages). South Africa's leading role in e-commerce in Africa can probably be attributed to the fact that it has a relatively advanced telecommunication infrastructure and a large number of English-speaking users.

9.6 South African Perspective

Because a website can easily be developed as a front for a fraudulent company, businesses need a way to guarantee their authenticity to potential customers. Thawte Consulting, the company established by Mark Shuttleworth after graduating from UCT and later sold to market leader Verisign, provided (among other products) *digital certificates* which serve two purposes: to ensure that no sensitive information can be viewed by unauthorised users, and to provide users with assurance regarding the ownership of the site. By providing certificates at a lower cost than its competitors, but with similar technological and security standards, Thawte rapidly established itself as the second largest provider of digital certificates.

These non-forgeable Secure Sockets Layer (SSL) certificates are issued and digitally signed by a company such as Thawte, which has verified that the website really is owned by the organisation requesting the certificate. Once the digital certificate has been installed on the site, the SSL uses complex encryption techniques to scramble confidential information.

9.7 Beyond the Basics

Encryption is the process of converting readable data into unreadable characters to prevent unauthorised access. Encrypted data can be safely transmitted or stored, but must be decrypted before it can be read, by using an *encryption key*, which is sometimes the same formula that was used to scramble it in the first place. Simple encryption methods include:

- Transposition: in which the order of characters is switched, for example each pair of adjacent characters is swapped.
- Substitution: in which each character is replaced by some other predetermined character.
- Expansion: additional letters are inserted after each of the characters in the original text.
- Compaction: characters are removed from specific positions and then stored or transmitted separately.

Most encryption programs use a combination of all four methods.

Private key encryption relies on both sender and recipient having access to the same encryption key. *Public key encryption* makes use of two keys: a message encrypted with your public key can only be decrypted using your private key. This means that you can safely communicate your public key to business contacts, who are then able to send you confidential data that can only be read using your private key. Security agencies in the United States have lobbied for some time for private keys to be independently stored, so that encrypted communications could be monitored when national security is considered to be at risk.

9.8 Exercises

9.8.1 B2C e-commerce

What advantages does the customer stand to gain from B2C e-commerce, compared with traditional business models?

Can you think of any potential disadvantages?

9.8.2 C2C e-commerce

Give reasons why internet auctions are a common source of fraud, and suggest control structures that could be put in place to reduce this problem.

9.8.3 B2B e-commerce

Explain how B2B ecommerce could contribute to each of the alternative strategies for competitive advantage (low-cost, differentiation, niche marketing) that were described in the previous chapter.

10. Security and Social Issues

We all know why computers are taking over from human processors. They are much cheaper in terms of their cost/performance, can handle large volumes of transactions at great speed, do not make mistakes, are not members of workers' unions and do not take holidays or sick leave. In the early 1980's the computer was still an object of some mystery, hidden in large buildings and operated by specialist personnel. Today the computer is everywhere: in every office and many homes; and individuals with limited or no computer expertise are becoming a minority.

However, computers also offer new opportunities for fraudulent and illegal activities. Well publicised computer crimes of the last decade have included:

- **The Equity Funding Disaster**. The top management of Equity Funding created billions of dollars of bogus insurance policies and sold them on to re-insurers. The motivation was to survive a serious cash flow problem and the intention was to buy back the policies and hide the fraud when the business began making money again. Unfortunately the problem persisted and the fraud grew to such proportions that the company actuary calculated that soon they would have insured more phony people than the entire population of the United States.

- **Mamalodi Sundowns vs Standard Bank**. The owner of a South African football team required funds to purchase players and support an extravagant life style. His girl friend was working in the head office of a large bank and was responsible for allocating inter-branch transfers of funds from one account to another. Over a three year period she transferred over R10 million into accounts controlled by her friend and covered the fraud by moving new funds into the accounts previously stripped. Like most frauds of this type, they can remain undetected for many years until the staff member is not available to continue the manipulation. The individual went on holiday for a week and her replacement noted some irregularities and called in the auditors to investigate.

- **The Rifkin Caper**. A computer contractor to a Californian bank used his inside knowledge to find the necessary passwords to authorise electronic transfers of money, and made a $12 million transfer from a client's account to a Swiss bank account under his control. He then travelled to Switzerland and purchased diamonds with the funds. Back in the USA he was apprehended in a police trap while trying to sell the diamonds. Of interest is the fact that the client only discovered the loss of the original funds when police enquiries concerning the diamonds began. The contractor's name was Rifkin and he almost escaped going to prison because of technical irregularities in police arresting procedures. He has since served his time in jail and is now a computer security consultant.

Because much of the data processing that takes place in an information system is not visible to the naked eye, controls must be built in to ensure that business transactions are correctly recorded and processed. This chapter also looks at some of the threats faced by computer systems, and discusses how the computer has changed our daily lives, both at work and in the home.

Some of the issues that are addressed in this chapter include

- security within the organisation: fraud and access control
- security beyond the organisation: hackers and viruses
- computers and unemployment
- operational problems and errors
- computer monitoring and invasion of privacy

10.1 Security Within the Organisation

Security risks within an organisation include the processing of fraudulent transactions, unauthorised access to data and program files, and the physical theft or damage of equipment.

10.1.1 Fraud

Computer fraud is increasing at an alarming rate. **Fraud** can be defined as the manipulation of the records of an organisation to conceal an illegal act (normally the theft of funds or other assets). Computers can make it easy for employees in particular to defraud the organisation, in particular when the level of security and internal control is lax. In manual systems, a common control to limit fraud is to involve two or more people in a process, each one effectively controlling the activities of the others. We call this control process separation of duties. For example in a payroll system one might give an individual the authority to approve increases, another the task of updating the computer and the third the responsibility to distribute funds to employees. Without collusion between them, it would be difficult for any one of these individuals to steal funds from the payroll system and hide his tracks. Unfortunately, in many computer systems, too many separate functions have been computerised and often there is a single clerk responsible for running the entire payroll process. In these situations, anyone who has access to the application can take the opportunity to commit fraud. The most common fraud tactics are:

- **Entering fictitious transactions**. Most frauds are committed by employees using the system in the normal way to enter fictitious transactions. No special technical knowledge is required and the employee relies on the fact that management supervision of the process in weak.
- **Modification of computer files**. Normally requires a little more technical expertise as this would involve, for example, the increase or reduction of amounts held on the master file, which cannot be changed within the application without an appropriate transaction (such as a payment).
- **Unauthorised changes to programs**. This type of fraud is usually limited to staff with programming expertise. A common example is the s**kimming or salami technique**. In a payroll system this would entail deducting a small amount from each individual salary cheque and adding the total to a select individual's payment. The secret behind this technique is that employees are unlikely to notice a change in their salary (PAYE and other deductions often cause regular variation in the total) and the total payroll will balance (the total amount being paid is the same.)

How does an organisation limit fraud? Experts suggest a three-pronged attack. Firstly the organisation must stress the need for honesty and ethical behaviour in all business activities. Managers must lead by example, new employees must be screened and staff training must support this theme. The second concern is the level of opportunity in the organisation to commit fraud. There must be strong internal controls, separation of duties, restricted access to sensitive applications and constant management supervision. Audit trails are used to record the origin of every transaction, and sequential numbering ensures that records cannot be deleted or reports destroyed. Finally, where a case of fraud is discovered, action must be taken against the offender. Many organisations prefer not to prosecute employees suspected of fraudulent behaviour because of the negative publicity they will receive in the press. This in itself encourages criminals to repeat the activity in their new working environment knowing the likelihood of punishment is remote.

10.1.2 Unauthorised Data Access

Password protection is the most common method of protecting corporate data. Nevertheless, fraudulent transactions are often carried out by unauthorised users who manage to gain access to the corporate network by using the login details of another user. One way of achieving this is through a **terminal spoof -** a simple yet effective approach to finding other user's passwords. A terminal spoof is a program that runs on a machine and looks like the normal login screen. Once a user has given his or her user-id and password, the terminal spoof will record both on the local disk or server, give what looks like an authentic error message (such as invalid password – please re-enter) and then passes control to the real login program. The criminal will pick up the passwords later to gain access to the system masquerading as the unfortunate victim.

Other criminals simply make use of an unattended computer that has been left on by a user who has logged in to the network and then left the office. Time-out or screen-saver programs with password protection provide a simple barrier to this approach. In addition, locked doors are a traditional means of excluding undesirable visitors.

Other dangers of which managers should be aware include the **Trojan horse**, in which code is added to a program, which will activate under certain conditions. For example, a computer consultant in Johannesburg had a client in Durban. He placed a Trojan horse in the payroll program so that it would malfunction while processing the June payroll. They would fly him down, all expenses paid, to fix the problem and stay for the Durban July horse race. Once this had happened for the third time, another consultant was used who uncovered the offending code.

Another risk is the **Back-door technique**. When programmers are building systems, they may try to bypass all the access security procedures to speed up the development time. In some cases, these "back doors" have not been removed and the programmer can gain illegal entry into the production system.

10.1.3 Sabotage and Theft

When computers were the size of small houses and hidden in secure computer installations, then theft of computer hardware was rare. Today, PCs are on most desks and in many cases they have to be physically bolted to the table to prevent their disappearance. One famous case of theft involved a laptop computer stolen from the back seat of a car in the USA in early 1991. On the hard disk was the master plan for Desert Storm, the details of how the United States and her allies would attack Iraq.

Mobile computing devices are especially vulnerable to theft, and limiting of physical access to equipment is the most effective first line of defence. Restrictions to entry can be based on electronic locks, activated by means of magnetic disks or swipe cards, or on advanced **biometric** devices that identify the individual based on characteristics such as fingerprints or the pattern of the retina. (In each case, the security mechanism would obviously be linked to a database containing details of authorised users.)

Another form of theft relates to the copying of programs and data resources in an organisation. Obtaining customer lists together with the details of the amount and type of business can obviously assist companies to encourage customers away from their competition. Theft of software is a major problem in the PC world where users often make illegal copies of the programs rather than purchase the package themselves – this practice is known as **software piracy.** This type of theft is more difficult to identify, since the original product has not physically disappeared as with the theft of computer hardware. Where software piracy is discovered, the owner of the computer on which the software resides (often the employer) is held to be legally responsible for the presence of pirated software.

The last category of computer theft covers the illegal use of computer time. In the past computer operators were often caught processing work for third parties or users were doing their own work at the office. Computer hackers spend their time searching for networks to which they can gain access. Having breached the security controls, they often browse around the databases in the installation but may not do any damage. In these instances, the only crime they can be charged with is the theft of computer time.

10.2 Security Beyond the Organisation

10.2.1 Hackers and Firewalls

Hackers are users from outside the organisation, who penetrate a computer system usually through its communication lines. Although some hackers are content merely to demonstrate that they have bypassed network security, there is a high risk of malicious damage to data, stealing of sensitive information (such as customers' credit card numbers) or entry of fraudulent transactions by the hacker. Hackers may also instigate a **denial-of-service** attack, in which a targeted web site is inundated with requests for information initiated by the hacker, rendering it inaccessible for genuine business customers.

A **firewall** is an additional system that enforces access control policy between two networks, especially between a corporate network and the Internet. The firewall monitors all external communications, checks user authorisation and maintains a log of all attempts to access the network. They can also be used to check for the presence of viruses, for the downloading of unauthorised software, and to guard against denial-of-service attacks.

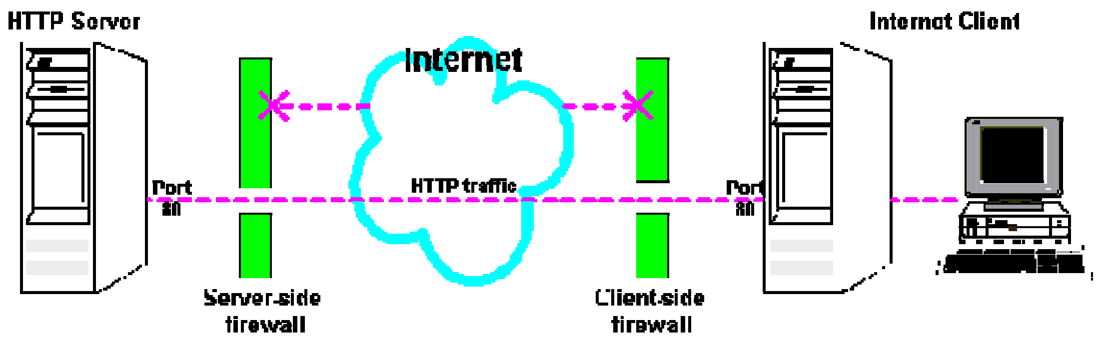


Figure 10-1. Diagram of a firewall (otn.oracle.com/products/ ias/daily/Aug20.html)

Data which is in the process of being communicated is also vulnerable to eavesdropping. **Encryption**, which scrambles data into an unreadable form, can be used to improve data privacy and prevent any unauthorised changes to the message, as well as protecting the confidentiality of data within the organisation.

10.2.2 Viruses

A computer **virus** is a program that invades a computer system, normally by residing in corrupt files. The virus has the ability to replicate itself and so spread to other files and computer systems. Some viruses are benign and merely advertise their presence, but others corrupt the files they infect and even destroy entire databases.

There are three main types of viruses. The original viruses were mainly systems viruses. They resided in the boot sector of a disk (the first place the computer looks when loading the operating system) or in the operating system utilities. These viruses were usually easy to find and clean. One problem was that they loaded into memory as soon as an infected machine was switched on and could often hide themselves from the anti-viral software.

The next generation of viruses attached themselves to executable files. When an infected program is run, the virus resides in memory and infects all new programs run until the system is switched off. These viruses are difficult to counter, especially on a network as common files are often infected. Even when the file server is cleared of infected programs, users have copies on their personal hard drives, or a infected copy of the program in memory when the virus check is performed on the server.

One area most users with which felt safe was the accessing of non-executable files such as word processing documents. Unfortunately there are now a number of *macro viruses* that can attach themselves to documents and spreadsheets. Even receiving a simple letter as an e-mail attachment can infect your machine. Some of the more well known viruses include:

- ***Michelangelo***. This virus infected many machines in the early months of 1992. The virus was primed to activate on Michelango's birthday (6th March) and had the capability of destroying all files on the hard disk of infected PC's. News of the virus made headlines and many businessmen and home users rushed out to purchase programs to check and clean viruses from their installations. On the day, some infections did occur but the main winners were the vendors of virus detection software.

- ***Stoned***. A very common virus in the late 1980's it came in many forms, some harmless while others corrupted files by attacking the directories and allocation tables. The main theme of the virus was to legalise the smoking of cannabis and normally the message "Your PC is now Stoned" would appear on the screen.

- ***Jerusalem***. Deletes all programs that are run on Friday 13th.

- ***Concept***. A macro virus, attached to word processing documents.

- ***EXEBUG***. A nasty little bug that may corrupt your hard drive. This is a systems virus and can infect the CMOS of your PC. Very difficult to find and eradicate as it uses "stealth" technology to hide from virus checkers.

With increasing globalisation and interorganisational communications, viruses are able to spread faster and further than ever before. Recent examples include Melissa, ILoveYou, and the Nimda virus, which make use of multiple methods of transmission. The real mystery about viruses is why they exist at all. Some experts suggest that computer hackers are motivated by the challenge of "beating the system" by writing programs that can bypass virus protection systems and take control of each individual machine. A more likely motive is to induce computer users to purchase legal copies of software. The only real winners in the new world of computer viruses are the companies selling computer software.

In the early 1980's the illegal copying of PC software, or *software piracy* was rife as there was no real business advantage to purchasing the software (except a copy of the official reference manual). Today it is estimated that about 50% of the PC software used in the USA has been illegally copied and the situation in South Africa is likely to be worse. One of the major motivations for buying software rather than copying from a friend is that the shrink-wrapped product is guaranteed to be virus free.

The best line of defence against viruses is the regular use of up-to-date anti-virus software, which will scan files for viruses and remove them if found.

10.3 Operational Problems and Errors

Computers are often seen as "super humans" in that they can perform their tasks at high speed and great accuracy. However the computer has its own, very specific weaknesses.

10.3.1 Dependency

Dependency may become a problem at two levels. Firstly, users of on-line, real-time systems are often totally reliant on the computer to perform their tasks. For example, visualise a busy Saturday at the local Pick 'n Pay supermarket when the back office computer malfunctions. All the point of sale terminals are linked to this machine to obtain price and other information and until the problem is fixed, no sales can be processed. Not a pleasant situation for shoppers and store managers alike. All organisations reliant on their computer to perform critical business activities must have a contingency plan to cover such emergencies, from the simple malfunction of a unit of hardware to a major disaster such as a fire in the computer installation.

At an individual level, employees who are accustomed to using a computer as a source of information, may lose confidence in their own judgement or decision-making abilities. When the computer is offline then all business activities grind to a halt, even though many of those processes could have continued based on principles and procedures that are not power-dependent!

10.3.2 Illogical Processes

Most conventional computer programs are made up of simple commands to instruct the machine (expert systems being one exception). When a computer error occurs, it could be as a result of hardware malfunction or the corruption of data. However this seldom results in an incorrect report or enquiry as the hardware and software are designed to detect this loss of integrity and provide an appropriate response (stop processing or generate an error message). Computers do not make calculation errors or read the incorrect data. But we have all heard stories of customers receiving telephone bills for outrageous (and incorrect) amounts and banks transferring amounts to the wrong accounts. These problems invariably originate from errors made by computer users or errors in the programs written to control the process. While humans make mistakes, sometimes on a regular basis, they have the advantage of working intelligently (although this is not always obvious). A clerk in a manual debtors system will probably realise there is an error when the telephone bill is over R1,000,000 and will check the client's detailed records before dispatching the account. The computer blindly follows the instructions in the program. However we can provide the computer with some sensitivity to problems by adding reasonability checks. For example it could highlight all amounts that appear to be too large (or small) in an exception report for the supervisor to check prior to distribution.

The bottom line is that the information provided by a computer should be more accurate and reliable than output from a manual system, but much depends on the expertise of users and computer professionals in the development and operation of the system. One classic example of a computer error occurred when one of the authors was working in the computer department of a large oil company. A colleague made a change to the layout of the customer statement to add a place for comments to be included, and tested the change by putting in a "Happy Christmas and Prosperous New Year" message. Needless to say he forgot to remove the message for the next monthly run and 25,000 customers were wished "Happy Christmas" in the middle of July.

In a number of studies focused on threats to computer systems, the largest percentage of financial losses were not from computer crime (20%), disasters (15%) or sabotage (15%) but from employee ignorance or negligence (50%). Management is often focused on external threats and natural disasters but the threat is from within. The recommendations from this research highlighted the fact that motivated, well-trained and supervised employees will go a long way towards reducing computer problems in the work place.

10.4 Computer Monitoring and Privacy

One of the major advantages of commercial computers is that given a large quantity of data about the organisation's business activities, it can then analyse the data from many different perspectives and provide management with valuable information as to the status of the operation. If people are part of this system, either as customers, employees or even operators, the computer can use the information at its disposal to report on the activities and performance of each individual. The question is, how far can this process go before it becomes an invasion of privacy?

10.4.1 Computer Monitoring

As transactions are processed in a computer system, the program could store the code of the operator in the transaction to record who performed the activity. At a later date we may want to check on some aspect of the transaction and could check which operator was on duty at the terminal. We could also take all the transactions over the month and summarise them by operator code to evaluate the amount of work done by each operator. We could also analyse the number of mistakes, and the times when operators logged into the system and logged out.

With the introduction of workflow systems where documents are scanned into the system and routed to various workers, there is some justification for monitoring the pace and progress of activity on the network. However there are negative aspects as well. Monitoring can be stressful to certain individuals and there is a school of thought that suggests that workers who are being monitored change their work patterns and work quicker rather than better (issues such as customer consideration may be ignored as they appear to waste valuable time).

This all sounds much like George Orwell's "1984", a book about a future world where every thought and action were watched by Big Brother. Currently, one of the major issues of conflict between workers and management in the USA is whether supervisors should be allowed to read e-mail addressed to their subordinates. When e-mail is transmitted across the country, its privacy is protected by law, but within a business, e-mail is held to be the property of the employer, since it was created during the employer's time and using the employer's resources.

10.4.2 Invasion of Privacy

The other side of the coin is where organisations obtain information about an individual and use it for commercial advantage. You may be surprised to find out how much information about you is stored in computers around the country. Your school and university will hold a lot of personal information. You will have applied for a job or two, opened a bank account, purchased a house and applied for water and electricity supplies. You will have a few insurance policies, be seeing a doctor and dentist, have an account at a number of stores and own both a regular and cell phone. All these organisations will have information about you, and some of this information could be classed as sensitive such as your overdrawn bank account and the time you were caught for driving under the influence (mentioned on your school report).

This information has value. Direct mail businesses would like to post you catalogues and flyers detailing their latest products; and credit bureaux can use the data to assess your credit standing. More sinisterly, bureaux specialising in computer data matching are buying data from many sources to create a complex profile for each individual.

Most countries now have strict privacy laws to protect their citizens. For example the Federal

Privacy Act in the USA states that:

- Individuals are free to determine what information is being held by an organisation
- They can prevent the use or distribution of their information to other organisations without their consent
- They can view, obtain copies and correct their information
- Information can be collected and used only for necessary and useful purposes
- Information must be kept current and accurate
- Safeguards must be provided to ensure the data is secure and not misused
- Individuals can institute claims for damages they suffer as a result of wilful or unintentional violations of these rights

Similar legislation was introduced in South Africa in 2002, giving all citizens the right to know what data has been stored about them, what it is being used for, and to insist that incorrect data be rectified.

Although many issues have been resolved and the rights entrenched in law, others are very topical, controversial and as yet undecided. One example is the debate as to whether there should be censorship on the Internet. Should the network be an open medium for the free exchange of ideas and information? Or should legislators take responsibility to regulate content and activities such as child pornography. The debate continues.

10.5 Computers and Unemployment

James Martin calculated that computer processing was about on a par with manual processing in terms of cost performance in 1978. Since then computer processors have doubled in power every two years with little or no increase in cost. If the motor industry had advanced at the same speed as computers over the past 50 years, a Rolls Royce would cost less than R10 and run for a year on a single tank of fuel. Obviously these advances have provided business with cheap, reliable processing power but they have also begun to impact on employment levels. Early growth in computer processing had little effect on jobs. The introduction of computer systems called for new skills as large amounts of data needed to be captured. While some of the repetitive transaction processing was now automated, clerical workers could now supervise and control the processing cycle. Computers were hailed as machines to take the drudgery out of work and in most cases this was so.

With today’s widespread use of computers, there are a number of changes to employment patterns that are credited to the computer revolution.

As anticipated, the clerical workers in many companies are gradually becoming knowledge workers, requiring new skills to operate and manipulate computerised applications. The numbers of these employees has shrunk over time as computer applications propagate throughout the organisation.

The number of blue-collar workers (employees in the manufacturing function) is falling. In some cases this is a result of improved processes and productivity but the impact of automation and the introduction of robotic assembly is also a factor.

The impact of computerisation is most felt in the area of middle management when sophisticated MIS and DSS systems have provided top management with easy access to information without the overhead of layers of supervisors and managers. The outcome of this change is a sharp reduction in the layers of management in most organisations and the arrival of large numbers of middle aged managers at the unemployment queues.

Opinions are mixed about the long-term effects of computerisation on employment. Some experts predict that job losses from technological advances are always offset by increased demand for skills in other areas. The jobs are there but some individuals may need re-training. The other side of the coin is that computer technology can improve productivity while reducing costs, and staff is often the major cost to the organisation. The new reality may be that more and more people will lose their jobs to computers as corporations fight to remain competitive.

10.6 South African Perspective

Spam is the equivalent of junk mail sent via the internet: electronic messages are sent automatically to computer-generated e-mail lists. The recently promulgated Electronic Communications and Transactions (ECT) Act of 2002 protects individuals against unwanted spam, by requiring any company that sends unsolicited commercial communications to provide the recipient with the option of being removed from the mailing list, and to disclose the source from which the his or her details were obtained.

During January 2003 the first charge was laid in terms of this section of the Act, against a marketing company which continued to send unsolicited emails after having been requested not to do so. Companies or persons found guilty of such an offence are liable for a fine or imprisonment for up to 12 months, but the cost to the taxpayer may be disproportionately high. In this case, since the charge was laid at a Johannesburg police station, and the marketing company is based in Cape Town, a search and seizure warrant would have to be issued in Johannesburg and sent to Cape Town for approval by a Cape Town magistrate, after which a member of the SAPS would carry out the warrant and obtain a copy of the company’s database to be used as evidence. Although a successful conviction may act as a deterrent to other South African companies in the future, the global nature of the internet makes it virtually impossible to control electronic communications through legislation.

10.7 Beyond the Basics

Biometrics is the technique of electronically measuring a physical characteristic of an individual and automatically comparing that measurement with an equivalent value stored in a database, in order to identify the individual. Among the many physical characteristics that have been used for biometric measurement, the three that have given the most consistently successful results are retinal scanning, iris scanning and finger imaging.

Retinal scanning involves bouncing a beam of light off the back of the eyeball, using a scanning device that rotates six times per second to build up a map of the blood vessels that are present. The information is then digitised and stored in an easily retrievable database.

Although this technology requires close proximity of the individual to the scanning device, it provides a unique and stable method of identification. *Iris scanning* measures the arrangement of structures within the coloured circle that surrounds the pupil of the eye. It also provides a unique and permanent template, but is more demanding than other methods in term of equipment cost and memory requirements. *Finger imaging* is the 21st century implementation of the fingerprints that have been in use for decades, and is based on the generation of a unique byte code from the scanned image of a fingerprint. This technology still requires physical contact with the scanning equipment, and the results can be distorted by dirt or skin damage.

10.8 Exercises

10.8.1 Viruses

- The **Nimda worm** spread rapidly across computer networks during September 2001. Use the internet to find out three methods that it uses to infect computer systems.
- Suggest three precautions that you could take to reduce the risk of your PC becoming infected with a virus.
- Read the email message that follows, and then use the internet to find out whether such a virus actually exists.

From:
Subject: Urgent - Virus alert

```
Virus Planet!

To those who are using handphone !!

Dear all mobile phone's owners,

ATTENTION!!!  NOW THERE IS A VIRUS ON MOBILE PHONE SYSTEM.

All mobile phone in DIGITAL system can be infected by this virus.
If you receive a phone call and your phone display "UNAVAILABLE"
on the screen (for most of digital mobile phones with a function
to display in-coming call telephone number), DON'T ANSWER THE
CALL. END THE CALL IMMEDIATELY!!! BECAUSE IF YOU ANSWER THE CALL,
YOUR PHONE WILL BE INFECTED BY THIS VIRUS.

This virus will erase all IMIE and IMSI information from both your
phone and your SIM card which will make your phone unable to
connect with the telephone network.  You will have to buy a new
phone.

This information has been confirmed by both Motorola and Nokia.

For more information, please visit Motorola or Nokia web sites:

http://www.mot.com
http://www.nokia.com/

There are over 3 million mobile phone being infected by this virus
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in USA now.

You can also check this news in CNN web site: http://www.cnn.com

CASE STUDY: CREAM ADVERTISING

Cream is a large and well-established advertising company, with corporate clients in all the major South African cities. Over the last decade, Cream has developed a reputation for the creation of avant-garde and witty advertising campaigns, predominantly on television and in glossy magazines, and has scooped several prestigious national awards. Much of their success is ascribed to the diversity of talents and personalities within the company, and a strong ethos of teamwork. A lot of time is spent in meetings and informal discussions between staff, and the pervading culture within the organisation is that work should be not only challenging but also fun.

Information technology is used to support various separate business functions:

- Accounting and administration, including the general ledger, accounts payable and receivable, and payroll.
- Graphic design for the development of new conceptual material.
- Word processing and presentation software for writing copy and making presentations to clients
- E-mail for communications and internet browsing to keep up with advertising trends.

Cream does not have an in-house IS department, and relies on the support provided by vendors and outside consultants to maintain their systems and solve any computer-related problems.

A brief overview of their business activities is as follows:

- The general manager, Jade Smith, contacts existing client by phone at least once a month to check that they are happy with the performance of their current campaigns, and perhaps make suggestions for future changes to content or media.

- All members of staff listen to industry gossip, and if a competitor's advertising campaign appears to be badly received, Jade is informed and decides whether to contact the client to market Cream instead. If so, she sets up an appointment for the marketing manager, Tim Mabusa, to give a standard presentation showing examples of previous work. Tim also provides a glossy brochure detailing the expertise and abilities within the firm, but his enthusiastic personality is a vital ingredient of the sales talk.

- When a new campaign is initiated, Jade will appoint one of her senior staff as project manager, and the two of them will meet with the client to discuss the form that the campaign should take (content, media, etc), and provide an initial (estimated) quotation. In many cases this meeting involves travel to other cities, which adds to costs and seriously impacts their availability for dealing with other business issues.

- A fee of 20% of the initial quote is payable before any further work on a new campaign is undertaken. A project team consisting of the project manager, a graphic designer and a copywriter will then work closely together to create several alternative ad outlines. These are presented to the client for discussion and possible reworking before the final quote is submitted and production begins on the advertisement.

- Cream take care of all the liaison with publication media, and confirm to the client the periods and costs involved. The actual account for publication or broadcasting is submitted directly to the client, and Cream is not involved in the client's financial transactions other than the money charged by themselves for work done. Payment of the final quoted amount less the initial fee is due within 30 days of completion and invoicing.

As the business has grown, so more and more time is being spent on travel, telephone calls and faxes. A lot of coordination is needed to keep track of the various elements of each campaign, and make sure that actual advertising material, publication arrangements and accounting are all being attended to. Holdups frequently occur because the initial 20% fee has not yet been debited, or else it has been received but the project team have not been informed that they can proceed; and several TV ads have received unsatisfactory broadcast times because bookings were made late. Staff are tired rather than stimulated, and Jade is concerned that the quality of their work will be affected. She is wondering whether the introduction of additional technology to support the business processes would free her staff to focus more on their creative abilities.

(a) Give practical examples of how information systems could be used to support the business at each of the management levels.

(b) If you were Jade Smith, what business strategy would you select (low-cost, differentiation, or niche marketing) and why? How could IS be used to support this strategy?

(c) What opportunities would there be for the use of groupware, both within and beyond the company?

(d) In what ways could the implementation of e-commerce replace or enhance the existing business activities of Cream?

(e) A network infrastructure that supports e-commerce also exposes the organisation to added security risks. Suggest ways in which these risks could be minimised.

Section IV: IS Management

Since the birth of commercial computing, organisations have been developing computer applications to meet the needs of their users. Initially this process was almost entirely machine orientated since the high costs of computer hardware made it necessary to maximise the usage of this scarce resource.

Initially computers were used as sophisticated record keeping devices. As their price performance became more attractive so more and more secondary applications were found. Gradually each organisation’s portfolio of computer applications has grown to the point that many could not function without the use of this electronic device. Organisations are using Information Systems to boost competitiveness and growth.

This transition has also seen the evolution of information architectures. Today’s information processing environments tend to be integrated, decentralised and highly complex. They require detailed planning as to what hardware infrastructure should be established and which new applications should be developed. They require high quality systems to be developed as the maintenance load in some organisations is threatening to draw on all the resources of the IS department.

Advances in computer technology have resulted in computers becoming thousands of times faster, cheaper and therefore more productive than machines of the late 1950’s. Unfortunately improvements achieved in the development of applications software have not kept pace, with the result that developing and maintaining in-house applications has become the major cost facing today’s IS departments.

IS development projects require careful planning and the use of sophisticated tools with which to build new applications, and management techniques to ensure systems are delivered on time, within budget and to the user’s expectations. The successful introduction of new systems also depends on the handling of change management within the organisation and the establishment of reliable procedures both for routine business activities and for coping with unexpected occurrences.

11. IS Planning & Acquisition

We know why organisations acquire new computer systems. In most instances computers are cheaper and more efficient than people when it comes to performing common, well defined tasks such as deciding when stock items should be reordered or generating customer statements. And as the productivity gap widens with each new advance in computer technology, new and innovative ways are being found to reduce costs through automation.

The question is "how does an organisation recognise the need for a new computer system?" Forces that highlight the need for change could come from the business environment (such as increased competition or new government regulations) or from within the business itself (for example where growth is beyond the capacity of the current system or new products are identified). Increasingly opportunities to automate arise through the introduction of new and innovative technology which can provide major cost reductions, improved management information and better service to customers. In most medium to large organisations there is a formal strategic planning process; and the new directions and changes identified in the 3 to 5 year business plan will enable the organisation to identify the computer systems required to support these applications in the future.

Once the need for a new system has been identified, plans must be developed to ensure that the new system can be successfully integrated with existing business processes, and that it will provide an acceptable return on investment for the organisation. Finally, effective project management is essential if systems are to be produced that correctly fulfil the requirements of their users without exceeding the constraints of time and budget.

11.1 Frameworks for Analysing Information Systems

There are many frameworks for analysing and studying information systems. Many of the commercially inspired frameworks are tied to a specific *system methodology*: they are very specific, often proprietary, approaches to analysing information needs, designing and developing information systems that address these needs. In addition, there have been many academic frameworks developed, each suitable for specific types of analysis e.g. strategic planning, comparative analysis, historical analysis, etc.

To give you an idea of these frameworks, we give you three examples.

11.1.1 Value chain analysis

In value chain analysis, the organisation is seen as a large input-output system, in which the inputs are the raw materials or services brought into the organisation, which are processed in some way, marketed and sold as outputs. Each point of this chain is analysed to uncover opportunities where value can be added or costs reduced. Although the complete model of the value chain usually includes both primary and support activities, the greatest level of return can be expected through the implementation of IS within the primary activities.

- **Inbound logistics** include the receiving, warehousing, and inventory control of input materials.

- **Operations** are the value-creating activities that transform the inputs into the final product.
- **Outbound logistics** are the activities required to get the finished product to the customer, including warehousing, order fulfillment, etc.
- **Marketing & Sales** are those activities associated with getting buyers to purchase the product, including channel selection, advertising, pricing, etc.
- **Service** activities are those that maintain and enhance the product's value including customer support, repair services, etc.

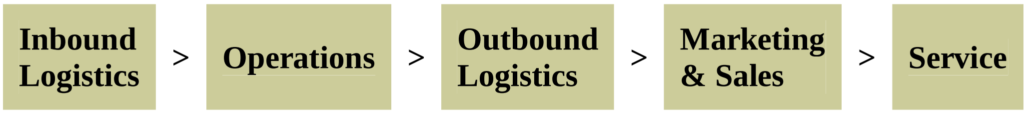

Figure 11-1. Primary activities within the value chain

11.1.2 The Zachman Framework

Zachman developed a framework aimed at a more systematic delivery of information systems, modelled loosely on the way buildings are constructed from an architectural point of view. According to Zachman, information systems need to be considered from six different perspectives (or dimensions).

- **Data:** which data *entities* do you want to capture and what are the *relationships* between these entities?
- **Function:** which (business) *functions* need to be addressed and which *arguments* does each function have?
- **Network**: which *nodes* need to be supported and what *links* exist between them?
- **People**: who are your *agents* and what are their *tasks* or *work*?
- **Time**. *when* do things happen and to which *cycles* do they conform?
- **Motivation:** what are the *ends* or goals and by what *means* will you get there?

Each of these dimensions is then examined at a number of different levels, to identify the system requirements and how they can best be implemented.

11.1.3 Strategic Importance Grid

The strategic importance grid looks at the entire information systems portfolio of an organisation i.e. all the systems currently in operation as well as the future systems currently under development or being planned. The critical focus of this framework is the assessment of whether a significant portion of an organisation’s systems is of a strategic nature and classifies the organisation accordingly into one of four possible categories on the IS strategic importance grid as shown in figure 11-2.

	Systems Currently in Operation	Systems under Development/ Being Planned
Predominantly of a Strategic Nature	STRATEGIC	TURN-AROUND
Predominantly of an Operational Nature	FACTORY	SUPPORT

Figure 11-2: Strategic importance grid

The main use of this table is to assess the importance of the IS strategic planning in the overall strategic business plan. It can also be of use when doing strategic competitor analysis or when assessing significant shifts in IT budgets. Try to find an example of a South African company for each of the four categories. As you try to place these examples, you will notice that the boundaries between the cells are not definitive: some companies will occupy boundary positions between cells whereas others will fit a certain category almost perfectly.

11.2 IS Planning

The various components of an organisation's information systems (hardware, software, databases, networks, and people) need to be successfully integrated in order to provide the right information at the right place and time. This is not going to happen by accident. An ***IS architecture*** is needed to define the IS resources that will be used to support the business strategy, and the standards that should be adhered to in order to ensure compatibility within the system.

The starting point for IS planning should be the clear identification of the application needs of the business, based on the information that is required by management. The activities that are managed by the IS department, such as the prioritising and scheduling of system development projects, must be in line with overall business goals. Alternative software products and acquisition options need to be evaluated before a decision can be made about the hardware and operating system that would be most appropriate.

Computer hardware should then be assessed on the basis of its compatibility with existing and future systems, its expandability and reliability. Other important issues include the availability of technical support, estimation of operating costs, and the financing method (e.g. leasing or buying) that is to be used.

11.2.1 Cost-benefit analysis

Cost-benefit analysis can be used to assess and prioritise new system development projects, by measuring the financial impact of proposed systems. Tangible benefits could include reduced inventory and administration costs, higher processing volumes, reduction of bad debts and improved cash flow. Intangible benefits such as improved customer satisfaction and better decision-making are more difficult to measure, but could be of significant value.

Typical costs that have to be considered in evaluating projects are

- Development costs, including staff training and conversion from the previous system
- Equipment costs, including space and air-conditioning requirements
- Operating costs such as staffing, insurance and power.

The reason for undertaking a cost-benefit analysis is to ensure that over the lifetime of the system, its benefits will exceed its costs, even though costs are likely to exceed benefits during the initial stages. The calculation must take into account the time-value of money (net present value) when determining the break-even point for the system, since interest would be earned (or saved) on the capital that will be invested in the project.

11.2.2 Funding of IS

The are three basic options available for the funding of an organisation's information systems: as an unallocated cost centre, as a cost centre, or as a profit centre.

The traditional model of an **unallocated cost centre** means that IS is regarded as an organisational cost, for which an annual budget is allocated in order to meet the costs of system development and maintenance. Other departments are likely to have little influence over the spending of the IS budget, the prioritising of projects and the standard of service that is delivered.

When the IS department operates as an **allocated cost centre**, then internal accounting is used to allocate IS costs to the departments using them. This makes it easier to identify areas of demand within the organisation, and may reduce the number of requests for (unnecessary) projects.

A **profit centre** approach means that the IS department must compete with outside vendors in providing IS services to the organisation. This often results in increased efficiency of the IS department, but may reduce the time spent on less profitable developmental work, reducing the ability to provide innovative and potentially strategic IS capabilities.

11.3 Software Acquisition Options

11.3.1 In-house development

Most large organisations have their own IS department, which is responsible for the development and support of the computer systems used to support the company's strategic goals. The methods commonly used during ***in-house development*** are covered in detail in the next chapter. However, this approach depends on highly skilled employees, and because of the time and cost involved, it often results in a backlog of projects awaiting development. If IS staff do not have the necessary technical expertise, or are too busy to attend to low priority projects, then alternative system development methods may need to be considered.

11.3.2 Commercial packages

The acquisition of off-the-shelf ***software packages*** provides a low-cost alternative to in-house development, since the cost of development has been spread over a number of users. The software can be examined and tested prior to purchase, minimising the risk involved, and user training and support are often commercially available. Even if some customisation is required, a package can be installed in a very much shorter time frame than if an equivalent system is developed from scratch. In general, if a suitable package is available, then this is the best option for acquisition of software.

11.3.3 Outsourcing

Outsourcing involves the purchasing of a service, in this case software development, from another company. With rapid changes in technology and high turnover rates for IS staff, it becomes increasingly difficult to maintain high levels of expertise in-house. Outsourcing allows an organisation to focus on its core competencies, while benefiting from the expertise and economies of scale that can be provided by the outsourcing company. Contracts and service level agreements need to be clearly defined, and in many cases organisations will outsource only their more general systems, while retaining control over strategic projects. In this case, additional contract staff can be used to provide skills that are not available internally.

A recent trend is towards the use of ***application service providers*** (ASPs), who maintain a range of software programs on their own computers. These are made available to customers via a web interface, and are a cost-effective solution for the provision of software that is used infrequently or from varying locations. The principle underlying this approach is that just as a company would not consider producing electricity privately to meet its own needs, but finds it easier to pay a supplier based on usage, so the company can pay for the use of applications which have been developed, installed and maintained by an ASP.

11.3.4 End-user computing

With the growth of computer literacy in the workplace, plus decreased costs of computer hardware and user-friendly development tools, ***end-user computing*** has become an important factor in system development. Faced with frustrating backlogs in the IS department, or inspired by the opportunities presented by new technologies, an increasing number of users are attempting to develop their own systems. The majority of user-developed applications tend to be personal or departmental in function, and often do not adhere to organisational standards. Data validation and security may be poor, backup and recovery procedures are often missing, and lack of documentation means that if the developer leaves the organisation, then the system is likely to fall into disuse. In response to these concerns, user support centres may be established to provide training and assistance for users.

11.4 Project Management

Project management differs from general business management in that a project has a beginning and an end, between which a definable set of activities must occur. Most projects are once-off efforts, so previous experience is likely to be limited, and the high degree of interaction between participants and tasks adds to project complexity. In order to meet these challenges, special project management tools have been developed to assist with project planning, resource allocation, scheduling and review.

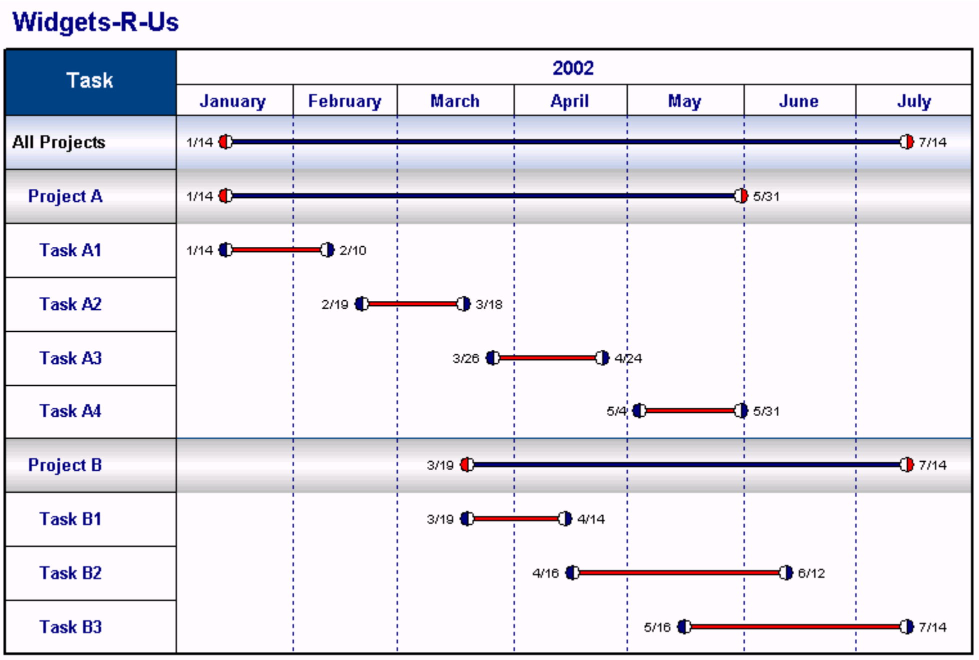

Figure 11-3. Example of a Gantt chart

The first task of the project manager is to define the scope of the project, the tasks to be accomplished and the order in which they should be done. This information can be represented using a ***Gantt chart*** (see Figure 11-3), which also reflects the start and end dates of major tasks and the staff involved. Dependencies between tasks then need to be identified, since any hold-up at a critical point might affect the completion time of the project as a whole. A ***network diagram*** or ***Pert chart*** shows the minimum and maximum time that might be needed for each task, as well as which tasks must be completed in sequence and which can be addressed in parallel, so that the impact of delays can be accurately assessed. ***Risk assessment*** techniques can be used to identify risk factors and implement strategies for minimising the potential problems associated with systems involving complex technology or where user requirements are not clearly defined.

The progress of a project must be monitored throughout its lifespan, usually on the basis of *deliverables* submitted at the end of each phase. Comparisons with the budgeted time and cost are made at frequent intervals, so that problems can be identified and corrected (or the project abandoned) as early as possible.

Another important element in project management is the acquisition and training of staff and the development of relationships both within the team and with the future users of the system. This can be supported through the organisation's intranet together with the effective use of groupware applications such as email and electronic meeting support.

It should be apparent from these examples that more than one software tool is required to provide the different perspectives needed for effective project management. Many of the same tools can also be used to improve general business efficiency, for example in the periodic scheduling of jobs and employees by operations managers.

11.5 People Aspects of Systems Development

The systems development process will involve IS professionals, management, end users and outside vendors.

Management. Decisions as to which computer systems are to be developed and the allocation of IS resources to current projects must be made by general management with advice from the IS department. One way this can be achieved is to form a computer steering committee with representatives from top management, managers of the various business functions and the IS manager. The *chief information officer* will manage IS resources (including staff), liaise with top management and advise on strategic opportunities.

Historically IS developers have a poor record in terms of delivery of new computer systems on time and within budget. The appointment of a *project manager* (who may be a systems analyst with the required project management skills) will help to keep the project on schedule.

IS professionals. The *systems analyst* plays the part of an intermediary in the development process, providing the link between users and the programmers and technicians who will build the system. The analyst’s role is to develop the user requirement and detailed design specifications and to provide continuity and management support throughout the project. He or she must therefore have a strong understanding of the business together with the required technical skills. In addition the analyst must possess the management and behavioural skills to supervise and communicate with people.

In many organisations the analyst’s role has been split into that of the *business analyst*, normally an individual with a strong commercial background who will perform the analysis function, and the *systems designer*, a technical analyst who will develop the detailed specifications of the system.

Programmers work from the detailed program specifications developed by the analyst, and code and test the required program modules.

In large organisations there are individuals in technical roles who will provide support for development projects in the design and implementation stages. For example the database administration function will provide expertise in designing and construction of the database, network specialists will assist in the design and implementation of local or wide area communications, and the web administrator will be responsible for the development, delivery and integration of web resources.

Internal auditors will be needed to review the controls of the system.

End-users. These are the people who will ultimately use the new system. In the past they were largely ignored once the analyst felt their requirements were known. Modern practice dictates that users be involved in every stage of the development project. This involvement has two main objectives. Firstly the user can define what he wants and give details of the user interface. In addition user involvement breaks down resistance to change. Making the user part of the development team ensures a commitment to the successful implementation of the application.

In many cases, end-users are also assuming a role as system developers, although the responsibility for network, database and hardware management is likely to remain under the control of a centralised IS department.

Outside vendors. Outside organisations may be providing hardware, software or their consulting expertise. Many organisations use outside contractors as analysts or programmers to help in development projects. Contractors are useful when an organisation lacks technical skills in an area or has a shortage of staff. The problem with contract staff is that the knowledge and skills developed during the project can disappear when the contractor leaves. Adequate documentation and training of in-house personnel are the obvious solutions.

11.6 South African Perspective

Clover Dairies, the oldest and largest dairy company in South Africa with over 6500 employees and a turnover exceeding R3 billion, distributes its products across a widespread customer base. Early in 2003 they invested in the Heat customer service system to support centralised information requests, order processing, claim handling, invoice and credit note queries, complaints, account administration and customer requests, as well as conducting customer and product surveys. According to the ICT systems manager at Clover, the decision to buy this particular product "was based on several criteria, including cost-effectiveness, product-effectiveness, the strategic importance of the product to Clover, its functional fit, and the levels of service and support available". Heat will also be integrated into Clover's existing business planning and control systems as well as its telephony system, and will be accessible via a web interface over its network connection.

11.7 Beyond the Basics

There are various issues to be considered when planning for e-commerce applications.

- Rather than the traditional cost-benefit approach, web initiatives may be seen as a strategic investment to be used as a platform for future business activities.
- As part of the overall information architecture of the organisation, a top-level decision must be made as to whether the entire site will be developed and maintained as a single project (either in-house or outsourced), or whether only core functions will be initially planned and developed, allowing departments to extend it later as required.
- An extended group of users needs to be considered in planning a web-based system: surfers who are browsing the Web, customers who wish to make online purchases, suppliers and recipients. Many of these are not usually regarded as direct users of traditional IS applications. Accessibility issues are also raised, to allow for the possibility of external users who are physically or mentally handicapped.
- Even though the benefits resulting from a website are difficult to quantify, the effectiveness of the site in fulfilling its purpose must be evaluated in the same way as any other IT investment, to ensure that business requirements are being met and problems are identified.

11.8 Exercises

11.8.1 Value chain

For each stage of the (primary) value chain, how could IS be used to cut costs or add value to business activities?

11.8.2 Software acquisition options

The different software acquisition options available to organisations include in-house development, commercial packages, outsourcing and end-user development. Compare these three approaches in terms of each of the following factors:

- **Cost control**: how well can costs be estimated at the start of a project, and how successfully can budgets be enforced?
- **Availability of expertise**: how likely are you to run into difficulties if the project turns out to be more complex than was initially envisaged?
- **Quality of the final system**: can you be sure that the final system will meet your requirements, and will do the job without errors?
- **Documentation and training**: will these be available when the system is first used, and at later stages if required (e.g. for new staff)
- **Maintenanc**e: how easy will it be to make changes to the system in five years time? In ten years time? What if you need to integrate other systems with this one?

12. System Development

This chapter will provide you with an overview of the systems development process. First we describe in detail the traditional **Systems Development Life Cycle** (SDLC), encompassing the stages through which each system should pass, from the initial survey to hand-over of the completed system.

Pressure for rapid development and future maintainability of systems has resulted in a number of alternative approaches to systems development, ranging from development by end-users, to the incorporation of formal methods to improve the quality and efficiency of the development process.

12.1 Systems Development Life Cycle (SDLC)

Systems development could be seen as the simple process of writing programs to solve the needs of the user. Unfortunately the user knows what he wants but has no technical expertise while the programmer understands the computer but not the user environment. This communication gap between the customer and the service provider must be handled by an intermediary, the systems analyst. Broadly speaking therefore the systems analyst translates user's needs into detailed specifications for implementation by the programmer.

Over the years the software manufacturing process has become more formalised:

> "The basic idea of the **systems development life cycle** is that there is a well defined process by which an application is conceived, developed and implemented. The life cycle gives structure to a creative process. In order to manage and control the development effort, it is necessary to know what should have been done, what has been done, and what has yet to be accomplished. The phases in the systems development life cycle provide a basis for management and control because they define segments of the workflow which can be identified for managerial purposes and specify the documents or other deliverables to be produced in each phase." [Davis and Olson, 1985]

The number of stages and names to describe those stages differ slightly between organisations; but the SDLC normally covers the activities shown in figure 12-1, each with a primary purpose.

12.1.1 Preliminary Investigation

The **preliminary investigation** is carried out to determine the scope and objectives of the new system and to investigate whether there is a feasible solution. New applications normally originate from end-user requests and are weighed against the other requests for IS resources before approval to develop the system is granted. At this stage an analyst or small project team is authorised to investigate the real potential of the new application. During this brief study the analyst must investigate the problem and the existing system sufficiently to be able to identify the true extent and purpose of the new application.

In order to ensure that the new system would be of greater benefit to the organisation than other competing requests for proposals, a **feasibility study** must be performed covering the following three major areas:

- Economic feasibility to measure the costs and benefits of the new system.
- Technical feasibility to ensure that the organisation has sufficient hardware, software and personnel resources to develop and support the proposed system.
- Operational feasibility, the willingness and ability of management, users and Information Systems staff in the organisation to build and use the proposed system.

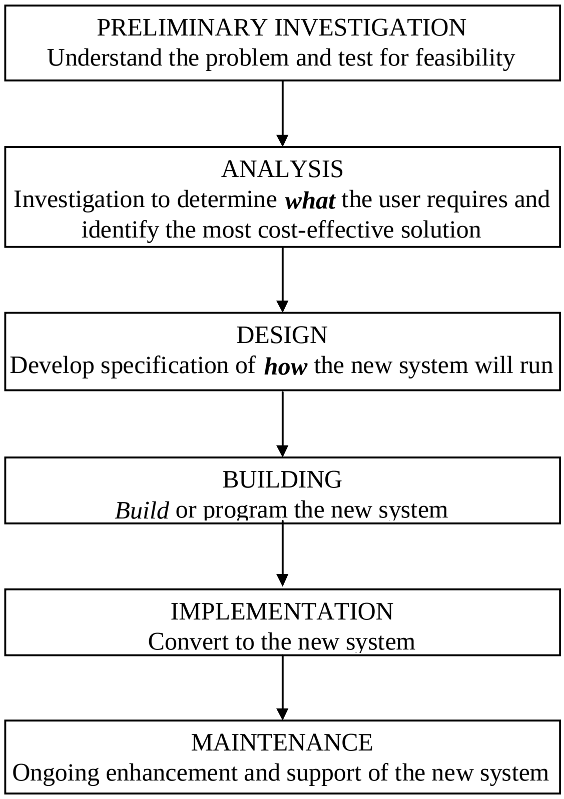

Figure 12-1: Systems Development Process

Issues such as the size and complexity of the new system and the skills and availability of user and IS staff, will determine the level of potential risk to the organisation in developing the system.

The output from this preliminary investigation is a statement of scope and objectives (often termed the **project charter**) together with a feasibility report. This document is submitted to management where a decision is made as to whether or not the development project should continue.

12.1.2 Systems Analysis

In this stage the analyst investigates the needs of the user and develops a conceptual solution to the problem. One human failing we all tend to exhibit is to rush into proposing solutions before we fully understand the problem we are trying to solve. It is therefore important for the analyst to develop a broad, conceptual solution to the problem (what needs to be done) prior to launching into the detailed physical design where we specify how the system will work.

In the past analysis tended to be very much a pragmatic affair with success more dependent on the experience and capabilities of the analyst than on any formalised approach. The analysis phase should include the following discrete steps:

- **Understand** how the existing system operates. This information can be obtained by observing people at work, interviewing users, and studying procedure manuals and other supporting documentation, questionnaires and visits to other organisations.

- **Document** the current physical system. A major problem in the past was how to record all the detail about the system. Most of it could be found only in the analyst's head or draft notes. Here the basic tools of structured systems analysis such as the data flow diagram (DFD), the entity relationship diagram (ERD) and data dictionary (DD) can be used to represent graphically and record the data and procedures. We will discuss these later in the chapter.

- **Define** the problem areas. These may include such issues as poor response times in the existing system, poor presentation of current information, high costs or weak controls in the current system, waste and sometimes duplication.

- **Identify** new requirements. The analyst must attempt to identify new user requirements and look for new and improved procedures that can be incorporated into the system.

- **Identify** possible solutions. Having derived objectives for the new system from the previous stage, the analyst now develops a conceptual model of the new system in conjunction with the user. This may involve the investigation of alternative physical designs, such as whether to remain with the existing manual system, or to choose a centralised or decentralised approach to the application.

- The culmination of the analysis stage is the preparation of the formal **user requirement specification** (URS) that incorporates a logical model of a system that will meet the user's requirements. A large proportion of the functional description and data specifications is best communicated from the analysis stage to the design stage through the graphic and electronic output from the structured tools used in the analysis process (data flow diagrams, entity relationship models, decision trees and the data dictionary).

- Again management is required to **review** the status of the project and to make its go/no-go decision.

12.1.3 Systems Design

The analysis stage of the SDLC has clearly identified what must be done in order to meet the user's requirements. One important decision that must be taken at this point is whether to "*make or buy*" the new software application. In the past, most large organisations developed their own applications as no two organisations were exactly alike, and they could afford the investment in systems developed around their user's needs.

Today the picture is changing as custom-built software is becoming very expensive to develop and even more so to maintain. Computer applications are large, complex and integrated and many businesses have become non-competitive because of their inability to develop systems that adequately support their business activities.

On the reverse side, **packages** (pre-written software applications) are becoming more common and can be customised to meet the needs of each organisation. With major benefits in terms of speed of installation, cost, low maintenance and low risk, more and more companies are switching to packaged applications software. It is at this stage in the SDLC that the "make or buy" decision must be taken. We have analysed our user's requirements and can use these as selection criteria in searching for an appropriate package to purchase and install. Where there is no suitable package available we can still look to other innovative ways of obtaining the software, such as hiring contract staff or appointing a software house to build the system for us. Purchasing pre-written software will obviously mean the detailed systems design, coding and testing phases of the project are bypassed, depending on the need for customisation of the final system. In later courses we will look at the package selection process in more detail.

The objective of the **design stage** is to determine exactly how the new system will work, and to communicate this information in a document referred to as the detailed systems specification. If we take the analogy of an architect building a house, in the analysis stage he has determined the feasibility of the project and identified the owner's requirements in terms of the positioning of the house on the plot, size and architectural style, number of rooms and so on. The architect may even have built a small model to demonstrate the look and feel of the new dwelling. Once the owner is happy that the proposed house meets his requirements, the architect must communicate the detailed design to the builders. This would entail the drawing of a detailed plan of the house, specifying exactly how every part of the building is constructed and defining dimensions, materials, construction techniques etc.

We need to go through the same process when designing computer systems. This includes the design of:

- the technical platform on which the software will run. The new application may need new hardware, operating systems software and network connections
- output reports and enquiry screens
- input forms and data capture procedures
- physical file and database layouts
- description of the workings of each program module
- new clerical processes and procedures that will be required to interface with the new system.

Whereas in the analysis stage the emphasis was on identifying the user's needs with little concern for the way the computer would be used, the design stage also requires user involvement for the approval of detailed design, but the physical constraints imposed by the computer are also of major importance. Gane and Sarson [1979] define the objectives of structured design as follows:

"The most important objective of design, of course, is to deliver the functions required by the user. If the logical model calls for the production of pay cheques and the design does not produce pay cheques, or does not produce them correctly, then the design is a failure. But given that many correct designs are possible, there are three main objectives which the designer has to bear in mind while evolving and evaluating a design:

- **Performance**. How fast the design will be able to do the user's work given a particular hardware resource.
- **Control**. The extent to which the design is secure against human errors, machine malfunction, or deliberate mischief.
- **Changeability**. The ease with which the design allows the system to be changed to, for example, meet the user's needs to have different transaction types processed.

The output from systems design is a detailed design specification incorporating technical, input, output, data and process specifications. In the past, much of the information was communicated in written form which was difficult to understand and often ambiguous. Imagine the builder having to construct a house from a written description. Like the output from analysis we have a number of innovative tools to help users and developers understand and communicate the workings of the system. These include data models and data dictionaries, screen and report layouts, structure charts and pseudo-code. We will look at most of these later in this chapter.

12.1.4 Systems Build

In this stage we program the new system. If the system has been purchased "off-the shelf", this phase would consist of the customisation of the system. The success of the implementation stage is heavily reliant on the previous stages. If the analysis stage was poorly enacted, the system may not be what the user requires. Poor design will make it difficult for the programmer to construct the system, and it may be inefficient and difficult to maintain.

However, if the required effort and expertise is invested in analysis and design, there will be a precise specification of what to build available to the IS programmers and technical staff.

Unlike the previous stages, the programming stage can be undertaken as a number of separate tasks, performed in parallel. Programmers can code, data base administrators set up the database, hardware suppliers install and test networks and equipment, and we can begin to train the end-users to prepare them for the implementation phase. With so much happening, and with the need for some tasks to be completed before others begin, the analyst must develop a detailed project implementation plan to ensure tasks are scheduled and delays are quickly identified and addressed. Programming includes the following steps:

- database construction
- program coding and testing

- systems testing to check the system can handle expected loads and meets physical performance criteria
- finalise manual procedures

12.1.5 Systems Implementation

This entails the transition of the completed system into the operational environment, and includes the following tasks (some of which will already have been started in earlier phases):

- installation and testing of any new hardware, systems software and network infrastructure
- train users and operations staff
- transfer data (data conversion)from the manual or old system to the new database where necessary
- perform acceptance testing. This requires careful planning to ensure all data flows, error procedures, interfaces, controls and manual procedures are tested
- complete project documentation

The change over carries some risk, as failure of the new system may result in the organisation being unable to do business, There are a number of approaches to converting from the old system to the new. The least risky is to run the new system in parallel with the old until the new system is stable. There is obviously a cost to running both systems. Another approach is to convert one part of the organisation at a time (for example one branch office at a time). This method (known as the pilot method) reduces risk and allows the development team to focus on one area. This approach can cause some integration problems as part of the organisation is running on the old system and part on the new. A similar approach is the phased implementation method where organisations convert to a large system one step at a time. For example they may start with the stock system, then implement debtors and finally the order entry system. Some organisations use the **big bang** approach and just switch over from the old to the new system. This option is obviously high risk as there is no system to fall back on in an emergency.

When the new system has been in operation for a few months, a **post-implementation audit** should be carried out. This audit must ascertain whether the project has achieved the initial objectives specified in terms of:

- meeting initial scope and objectives
- anticipated costs and benefits to the organisation
- user satisfaction with the new system
- performance (response/turnaround time, reliability)
- adherence to standards
- quality of final product
- project performance in terms of cost and time.

This exercise will help to highlight problems that require maintenance of the new system and provide valuable feedback to IS management and project teams to assist in future development exercises.

12.1.6 Maintenance

Finally resources will be required to maintain and enhance the system over its operational life which can vary between 4 and 10 years. There is normally a formal hand-over of the system from the project team to the maintenance team. This will ensure that there is a defined time when the project is completed and that all the required documentation is produced. There are many systems in existence that are still supported by the original developer; and all knowledge of the system exists only in that individual's head. The problem is that when this person leaves (or worse gets run over by a bus), there is no one with any knowledge of the system and the organisation is at risk.

Research has shown that this is the most expensive stage of the life cycle as **program bugs** (as a result of poor design or bad coding and testing) or **enhancements** (poor analysis of user's requirements or changes to the business) require continual analysis and programming effort.

The following table summarises the important tasks in the six stages of the SDLC and highlights the main deliverables from each task.

Stage	Tasks	Deliverables
Preliminary Investigation	Problem Definition Scope and Objectives Data Gathering Risk Assessment Feasibility Analysis	Project Charter Feasibility Study
Systems Analysis	Data Gathering Systems Modelling User Requirements Definition	User Requirements Specification
Systems Design	Make or Buy Decision Physical Systems Design Technical Design	Detailed Systems Specification
Systems Build	Programming and testing Platform Implementation	Production System
Systems Implementation	User Training Data Conversion Systems Conversion Post-Implementation Review	Live System
Systems Maintenance	Fix system "bugs" System enhancement	Working System

Figure 12-2: SDLC Tasks

12.2 Development of Structured Methodologies

New and innovative systems development techniques are frequently proposed by researchers and practitioners and, over time, these formal methods have replaced the traditional pragmatic approach to developing computer systems.

12.2.1 Structured Programming.

In the 1960's, the major concern in IS development environments was the efficient utilisation of expensive computer hardware. Programs were written in low level languages with little or no support documentation and, over time, the code became almost impossible for maintenance programmers to understand and fix. So arose the need to introduce a set of standard rules and procedures for writing programs, often referred to as structured programming. Some of the key techniques in the structured programming approach include:

- a limited set of simple control structures (to control branching and looping)
- standard naming conventions for data and procedures
- self documenting programs.

Structured programming techniques ensured that programs were easier to write and test and much easier to maintain.

12.2.2 Structured Design.

In the mid 1970s the focus in systems development moved from program coding to systems design. Computer applications were becoming more complex with the introduction of large on-line, integrated systems.

IS researchers, and in particular Larry Constantine, studied the problems of program size and complexity, and determined that, as a problem grew in size, so there was a more than proportional growth in the complexity of the problem and therefore in programming time. He advocated that all systems should be made up of small modules each no longer than fifty lines of program code.

Fragmenting a problem into a number of modules can be done in many ways; and he urged that the best technique would be to segment the program by function (task) with each module being as functionally independent of other modules as possible. This would ensure that changes to one program module were unlikely to affect other modules.

This technique was known as **structured design;** and a graphical representation of the modules and their relationships known as a structure chart, was developed to assist in the process.

12.2.3 Structured Analysis.

In the late 1970s the focus in systems development moved again, this time to the analysis stage. IS professionals had formalised the design and coding of computer software but had neglected the most important development issue – what are the user's real requirements. Written specifications were the main source of communication throughout the project. In the same way that architects would never attempt to describe a building in a letter, so analysts needed tools and techniques which could be used to define and communicate the user's requirements to the systems design stage. These structured tools and techniques included:

- **Data Flow Diagrams** (DFD). These diagrams are used to show how data flows between the various processes in the system. DFD's are an excellent communication tool as they are simple enough for users to understand and yet detailed enough to form the basis for the systems design process. A number of DFD techniques has been developed since the original work was published by Tom De Marco in 1978. However, they all basically perform the same task. Data flow diagrams are one of the most used and popular IS charting techniques.

- **Entity Relationship Diagrams** (ERD). Entity relationship diagrams identify the major objects about which data is stored and chart their interrelationship. Like most formal techniques, its major value is that it forces the analyst into a structured and detailed investigation of all the data used in the system.

- **Decision Trees and Pseudo-code.** These tools enable the analyst to express process logic clearly and unambiguously. In the detailed analysis of an information system, the analyst often has to describe a logical process that the future system will have to perform. Examples of these could be the way that a personnel system calculates pension benefits for employees or a sales system calculates sales commissions. Decision trees are diagrammatic representations of the process logic, showing the conditions that need to be tested and the resulting activities in a simple tree-like structure. Pseudo-code can be described as "structured English". It permits the analyst to define process logic using English language couched in the logical structures inherent in program code. In reality it eliminates the verbosity and ambiguity from the English narrative.

- **Project Dictionary**. This tool enables the analyst to capture and catalogue the entire system specification on computer with the obvious advantages in reporting, cross-referencing and updating. In a database environment, data is no longer the property of each individual application but managed centrally as a corporate resource. Vast amounts of information about this data needs to be maintained, for example field names, types and lengths, validation rules, data structures and relationships. As systems move from the development to production environment, this data about data is transferred from the project dictionary into a production data dictionary to enable the database administrator (DBA) to build and maintain the corporate database.

As we will discuss later, most of the new computer assisted software engineering (CASE) tools are now built up round a project dictionary.

12.3 Alternative approaches to developing systems

Over the past 40 years, efforts have been made to improve the quality of new systems and to reduce the time and effort expended in their development. The following section provides an overview of some of the significant tools and techniques developed for this purpose.

12.3.1 Prototyping

One technique that has been incorporated successfully into the SDLC is prototyping. As the name suggests a **prototype** is a mock-up or model of a system for review purposes.

Looking at the traditional SDLC, one of the major problems is that the user is asked to provide detailed requirements prior to the system being built. Once a system is implemented he may find flaws in his original requirements or may see the possibilities of a new and improved approach.

For applications such as general ledger and payroll, the requirements are normally well understood (and usually standardised enough to suggest the use of packages) but many other areas such as personnel are unstructured and would benefit from the prototyping stage.

The two main approaches to the use of prototypes in the SDLC are:

- **discovery prototyping** where the analyst builds a skeleton of the final product in the analysis stage of the project in order that the user may better understand the workings of the final system. This prototype is normally built with a fourth generation language and while it is likely to include mock-ups of screens and reports, it is seldom a fully working model. The building and refining of the prototype is an iterative process between analyst and user and stimulates discussion on the functionality of the final product. Once the analyst and user are happy that the system's requirements have been identified, detailed requirement specifications are developed and the prototype is no longer required. In some instances the prototype may serve as the specification.

- **evolutionary prototyping** where a working model is built with the intention of later refining it into the operational system. While this technique would appear to have great advantages in terms of productivity, the original prototype is often thrown together and not properly designed.

Prototyping can offer IS developers many advantages in that it assists in clarifying user's requirements, improves user communication and commitment, should improve the functionality and quality of the user interface and will assist in identifying problems earlier in the development life cycle.

Where prototyping can be problematic is that it raises the user's expectations that systems are quick to build and changes are easy. In addition there is a lack of experienced prototypers and quality prototyping tools.

12.3.2 Joint Application Development (JAD)

One major problem in systems development projects is the lack of real communication, understanding and consensus between users, management and the development team. Instead of the traditional one on one interviews spread over weeks and often months, the JAD approach involves a series of highly structured workshops where stakeholders focus on any one of the planning, analysis, design and implementation stages of the life cycle. One obvious advantage of this approach is a reduction in the time it takes to develop systems. However the real benefits of JAD come from better user requirements through improved communication and conflict resolution. Successful JAD sessions often depend on the competence of the session leader (termed the facilitator), the scribe (who is responsible for documenting the output from the sessions), strong top management support and a mix of participants with expertise and responsibility for the area under discussion.

12.3.3 Computer Assisted Software Engineering (CASE)

There is a famous saying, “The cobblers children have no shoes.” and this is very relevant to IS. Here we have a classic example of a group of IS professionals, dedicated to computerising the organisation in which they work, while developing these computer systems via manual means.

CASE environments attempt to address this problem by offering a set of integrated electronic tools for use in the SDLC. During the first phase of system development, CASE products provide the analyst with computerised tools to complete and document the analysis and detailed design stages of the development project by graphically modelling the data requirements and the business process flows that the intended application has to address. These models attempt to give a visual representation of a part of the business operations, following one of many modelling standards. The resultant application model is then used as a blueprint for the actual implementation in computer code. The tools that are geared specifically for this modelling phase are referred to as *upper-CASE or U-CASE* tools.

Lower-CASE tools specialise in the second phase of system development: the actual generation of executable applications or advanced prototypes. This is typically achieved through the use of a generic application generator, although CASE tools tend to be independent of any specific database management system.

Integrated or *I-CASE* aims to automate both phases i.e. a combination of upper and lower-CASE tools in one single package.
Most CASE environments use an electronic project dictionary as a repository and can include:

- graphic tools for charting diagrams such as DFD’s, ERD’s and Structure charts
- 4th generation languages or application generators to assist with prototyping
- data dictionary facilities to record and maintain data about data, processes and other system details
- quality control facilities to check specifications and code for correctness
- code generators to reduce programming effort
- spreadsheet models to assist with cost/benefit analysis
- project management tools to plan, monitor and control the development cycle.

When CASE environments were originally developed in the mid 1980s, IS managers viewed them as a possible “silver bullet” to resolve the growing demand for computer systems. The promise of CASE was better quality systems, reduced development time, enforced standards and improved documentation.

As yet CASE tools have failed to make a major impact. CASE environments are complex, the cost of implementing CASE is high (both in terms of the CASE software and analyst training) and many organisations are looking to other solutions (packages and object orientation) to resolve their applications backlog.

12.3.4 Object Oriented Development (OOD)

Using the traditional development approach where the analyst designs procedures focused on the user's requirements can result in systems that are costly to develop and inflexible in nature. The **object oriented approach** attempts to build components (objects) that model the behaviour of persons, places, things or concepts that exist in the real world and then to build systems from these components. We do not design and build unique systems for motor cars or televisions; they are mostly built up from a set of common, interchangeable components. Even when components are unique they are very similar to other components. In the same way we can construct computer systems from building blocks reusing objects from other systems, making modifications to similar objects or obtaining objects from commercial component libraries.

The OOD paradigm is only now gaining momentum in the market place and most programming languages and methodologies do not support OO development. One exception is Small Talk, the language credited with pioneering the OOP (object oriented programming) concept. Today many of the popular programming languages are appearing with OO versions (for example Pascal, C++, Visual Basic and even COBOL).

12.3.5 Other development tools

The above-mentioned new programming approaches were not the only attempts to improve developer productivity. The following presents some other development tools and approaches. Note that, since distinctions between the categories cannot always be perfect, some tools could be classified in more than one category.

§ *Visual programming tools.* The power of graphical user interfaces and object-orientation has spawned a number of high-level *front-ends* or *shells* to enable non-programmers to generate their own straightforward applications. These *visual programming tools* allow for the construction of applications by selecting, connecting, copying and arranging programming objects. For simple applications, there is no need for any code to be written at all since all required objects can be copied from a large library with all commonly used, pre-configured objects and their associated standard methods.

§ *Report generators* are generally associated with database management systems and allow users to create ad-hoc, customised reports using the data in the database by specifying the various selection criteria and the desired report layout.

§ *Application generators* consist of standard building blocks that can be combined or customised to create the required systems. The user specifies the inputs, the output requirements and the various data validations and transformations. Screen and report *painters* allow on-line, visual layout of input and output modules. Generally, these generators are supported by a comprehensive database management system that integrates the data dictionary, graphics and reporting modules as well as other utilities such as data and process modelling, security facilities, decision support modules and *query-by-example (QBE)* languages.

§ *Logic programming for knowledge based systems.* Programmers quickly discovered that conventional programming languages were inadequate to develop advanced *knowledge-based* applications, such as expert systems and other artificial intelligence systems. These systems require reasoning capabilities and have knowledge representation requirements that are difficult to implement using procedural languages. This led to the development of *logic programming* languages such as *LISP* and *Prolog*. The use of these languages is generally confined to researchers and scientists. Today, a number of shells has been developed that allow the automatic generation of straight-forward knowledge-based systems.

§ *End-user applications.* Today's end-user productivity applications have extensive programming capabilities and allow for customisation by means of *macros* (pre-recorded sequences of commands, keystrokes) and *formulae*. A spreadsheet is essentially a model developed by an end-user whereby the equations (or data transformations) have been programmed by means of formulae. Many of these formulae look similar to the statements in programming languages. The following statement would calculate someone's weekly wages taking into account an overtime rate of 50%, using Microsoft Excel or Access.

```
= IF ( hours > 42 , hours * wage , 42 * wage + ( 1.5 * wage ) * ( hours – 42 ) )
```

12.4 Critical success factors

Regardless of the development approach that may be used, a number of factors have been identified that are critical to ensuring the success of a systems development project:

- well defined system objectives
- careful test of feasibility
- top management support
- user involvement to ensure strong commitment
- rigorous analysis to ensure detailed, unambiguous user requirements
- sound detailed design to ensure an efficient, quality, maintainable system
- project management to ensure the development team is managed and controlled.

12.5 South African Perspective

Research by a group of Scandinavian computer scientists has suggested that prototyping is better suited than the traditional SDLC to systems development projects undertaken in developing countries. Although the SDLC provides a rigorous development methodology intended to generate clearly defined system requirements, it does not take into account problems resulting from social and cultural factors. These include the uncertain availability of technical skills, user anxiety about technology, and the need for adaptability of the final product to differing local conditions. A further dimension to this approach is the need to train users in basic computer literacy skills and to inform them about the business role of IS *before* any attempt is made to elicit system requirements. Once workers have been empowered in this way, they are able to provide more valuable participation in the development of a system. Developers must also see the project as a mutual learning experience, since they need to understand how future changes in the business environment may affect system requirements.

12.6 Beyond the Basics

Web pages can contain multimedia effects and interactive capabilities, and the development of web pages involves using a variety of special components. Among the jargon and acronyms that you may encounter are the following:

- *Hypertext Markup Language (HTML)* is not actually a programming language, but has specific rules for defining the formatting of text, graphics, video and audio on a web page. *Tags* are used to indicate how a page should be displayed on your screen, and the details underlying links to other web pages.
- Interactive elements such as scrolling messages, pop-up windows and animated graphics are controlled by small programs, generally *scripts, applets* or *ActiveX controls*. Basically, a script is an interpreted program that runs on the client computer, as opposed to an applet, which is a compiled program running on the client computer. ActiveX controls are object-oriented technologies that allow components on a network to communicate with one another.
- Information is sent and received between your computer and a web server via the *common gateway interface (CGI*), which is the communications standard that defines how a web server communicates with outside sources such as a database. CGI programs are frequently written using scripting languages such as JavaScript, which is simpler to use than the full Java language.
- Web pages created using *dynamic HTML* can automatically update their content on the client's machine, without having to access the web server, making them more responsive to user interaction. *Extensible HTML* (XHTML) uses XML technology to display web pages on different types of display devices, while *wireless markup language* (WML) supports browsing on PDAs and cellular telephones. Finally *wireless application protocol* (WAP) specifies how wireless devices such as cellular telephones communicate with the Web.

12.7 Exercises

12.7.1 Stages of the SDLC

Read the following article, and then briefly explain, for each stage of the SDLC, which of the standard activities appear to have been omitted or not completed when developing the system, and what effect this had on the quality of the final product.

From: Machlis, S. "U.S. Agency Puts $71m System on Ice", Computerworld, 12 May 1997.

The U.S Agency for International Development (AID) last week confirmed that it suspended overseas use of a new computer system plagued by integration snafus, data transmission bottlenecks, and response times so slow that employee efficiency suffered. For now, 39 field sites will go back to using the agency's old system for core accounting services and procurement contracts while problems with the Washington-based computers are ironed out. "We need to get the core functionality established", said Richard McCall, AID's chief of staff.

The New Management System (NMS), budgeted at $71 million, has been under fire since it was deployed in October of 1997. The AID inspector general's office criticized NMS for data errors and slow performance. In some cases, users had to spend days trying to process a single transaction.

The new system can't handle the large amount of data that passes among AID offices, McCall said. The agency must decide whether to boost expensive satellite network bandwidth to handle real time transactions or move to some batch processing. "I don't think people understood the amount of data that would be transmitted over the system", he said.

Designers also initially failed to gasp the difficulty of integrating legacy accounting systems. "We thought we had three primary accounting systems," McCall said. But numerous infield alterations to basic systems over the years meant the agency had closer to 80 different accounting systems. Some of the resulting data didn't import correctly into the new system.

In addition, McCall said, system designers should have stayed focused on core requirements instead of trying to immediately add features that users requested after early tests. For example, some overseas employees wanted to be able to call up data from any foreign site. Although that is an attractive feature, he said, "that taxes the system. You don't really need that now."

12.7.2 Systems conversion

Four different methods have been described for the conversion to a new system: the parallel, pilot, phased or "big bang" approach. Compare these four alternatives in terms of the likely time frame involved, level of risk incurred, and user "buy-in" to the new system.

13. Using Information Systems

Many factors can affect the ability of an information system to fulfil its goal of supporting business processes. Before an information system is developed, its purpose must be aligned with the goals of the business, a cost benefit study should be completed, and user requirements must be carefully analysed to ensure that it will provide the appropriate functionality. During the system development process, organisational standards need to be adhered to in respect of the various deliverables of the SDLC and the overall IT architecture of the organisation. But over and above these planning and acquisition issues, the final measure of success for an information system depends on how it is *used* – are employees happy to incorporate it into their data processing activities; does it deliver the information that they need; is the integrity of information guaranteed; can human or technical problems be identified and corrected? No matter how carefully a system has been developed, there are still potential problems associated with its use in the real world, which need to be included in an IS management strategy.

13.1 Change Management

One of the main reasons that information systems fail, is that users resist change. Many individuals believe that their skills and experience will be of less value in an automated environment, which threatens their job or status. Users may refuse to adapt to new methods of working, or while using the new system may attempt to undermine its efficiency. Acceptance of the system can be significantly improved through the implementation of a change management strategy.

During the ***systems analysis*** phase, users should be involved in the identification of problems that occur in existing systems, and given the opportunity to express their own information requirements. If they are made aware of shortcomings in the old system and of how these will be alleviated when the new system has been implemented, then they are more likely to accept the change. Where decisions need to be made between alternatives, users should be part of the decision-making process rather than being presented with a unilateral solution.

The ***design*** phase of the SDLC involves the "make or buy" decision. The evaluation of commercial packages should be done by a team that includes users as well as managers and technicians, so that any operational concerns can be raised and clarified. If a system is to be developed in-house (or outsourced), then the users should be consulted about the layout of screens for data capture, and the format of reports. Finally, if the new system will result in changes to existing work procedures, the impact should be discussed and any problems or training needs identified.

User training falls within the ***systems implementation*** stage of the SDLC, and should involve more than just teaching users how to operate the new system. They must also understand what the purpose of the system is, what benefits it is expected to generate for the business, what problems could result if it is incorrectly used, and the importance of their role in its successful implementation.

13.2 Ergonomics

Ergonomics refers to design principles that support safety and efficiency in the workplace. Uncomfortably aligned computer monitors and keyboards, or the incorrect height of chairs and desks, may result in neck or back pain; eye strain can be caused by screen glare or poor display resolution; and repetitive strain injuries (RSI) such as carpal tunnel syndrome, may affect the wrists and hands of data entry personnel. Correct attention to ergonomics will not only reduce health risks, but also improves employee morale and productivity.

Examples of how ergonomic principles can be incorporated in an IS environment include:

- The use of keyboards with built in wrist rests or specially contoured design to reduce RSI.
- Chairs with variable seat height and back support.
- Correct adjustment of the angle of computer monitors.
- In addition to adjusting the brightness and contrast of the computer monitor, an additional transparent screen can be used to reduce glare.

An infrequent but potentially life-threatening new health hazard that has recently been identified by medical practitioners is "e-thrombosis", which may result from sitting immobile for long periods. This is similar to the condition sometimes experienced by travellers on long flights, in which a blood clot forms in the leg veins, and may subsequently break off and travel to the lungs or other vital organs.

13.3 Ethics

The increased use of information systems in business has given rise to new opportunities for behaviour that could negatively affect the organisation, its employees and its customers. The study of ***ethics*** examines the moral quality of a decision or course of action, and is based on what is *right* rather than what is *legal*. Four major areas of ethics that are affected by information technology are privacy, property, accuracy and access, and many businesses have a *code of ethics* determining the expected standard of conduct for their employees.

13.3.1 Privacy

Most companies store information about their customers and staff in corporate databases – not only details like names and addresses, but also transaction histories, payment records, etc. One ethical issue regards the ***privacy*** of that information. By law it may not be passed on to a third party without the consent of the subject of the information. However, within the organisation itself accumulated information may be used, for example through data mining or neural networks, to decide on credit limits or to target customers for promotions, even though the information was not originally supplied with that use in mind. A member of staff who applies for a more senior post, may find that her previous record of sick leave influences the outcome of her application. If you were ill on the day of your final IS exam, you would apply to write a deferred examination: would you think it fair to have your performance in other courses taken into account when deciding whether the deferred exam for IS should be granted? Another cause for concern is the viewing of personal data by employees when this is not actually required for business purposes: if an attractive member of the opposite sex joins your organisation, is it ethical for you to check his/her age and marital status? What about HIV status? And in many countries, governments are now debating the balance between the right to personal privacy of information and the need for national security.

13.3.2 Property

Computer software and data have been the subject of a number of ethical issues related to ***property***. Software piracy (the copying of copyrighted software) is illegal, but what about the copying of software that has not been copyrighted? If you are confident that you can get away with copying your friend's tutorial preparation, do you think that it is acceptable to do so? Copying of other people's ideas without acknowledgement is *plagiarism*, which is generally regarded as unethical even if society does not always consider it to be illegal. Employees who leave an organisation may take with them confidential knowledge about the firm and its business plans, which they gained while they were working for the organisation but which could be useful to a competitor. Even within the organisation itself, employees may be reluctant to volunteer their knowledge for inclusion in an expert system, since this may reduce their own importance. The Internet has facilitated the unauthorised copying of intellectual property across national boundaries, such as the swapping of music files between individuals, which is practically impossible to control without the cooperation of the individuals involved.

13.3.3 Accuracy

Accuracy of information at the transactional level can to some extent be controlled through validation checks within the database and software design. Individuals are entitled by law to check and correct personal information that is stored in corporate databases. Nevertheless, since the users of information systems are human and fallible, the use of technology alone will not prevent the production of inaccurate information, either intentionally or by accident. Again, the growth of the Internet has made the dissemination of incorrect information extremely difficult to control, and raises ethical issues about the responsibility for its consequences. An unresolved problem concerns the retouching, or digital alteration of photographs, where the key issue appears to be whether the intended information content of the image has been changed.

13.3.4 Access

Access to information can be protected through the use of technology, such as passwords, electronic and biometric controls. Databases can allow or restrict access for different types of users. But what about equal access to information for those who do not have computers, or who are unable to use them because of physical disabilities? Many people feel that it is unethical for society to condone the lack of access to information for specific groups. On the other hand, employees who have access to organisational computing resources are often guilty of abusing the privilege by using company time and equipment for personal pursuits such as emailing and web surfing.

13.4 Data Processing Controls

An important function in computer auditing is the review and analysis of information systems security. One element of this is physical access control; another is software-based data processing controls that are intended to prevent data errors from occurring, to identify any errors that have occurred, and to assist with recovery from errors. Validation checks may be built into the database structure, or coded as part of a software application, to enforce business rules such as credit limits or minimum and maximum charges. Network and database access may be selectively restricted, and network monitoring software keeps track of which users log on to the system, what files they access, and what changes they make. *Audit trails* provide a transaction history showing where each entry originated and who was responsible, and serve an important function not only in identifying the source of problems but also in determining where staff training is needed. Sequential numbering of transactions and of audit reports ensures that every business activity is recorded. Where financial totals are transferred from subsidiary journals to the general ledger, the corresponding general ledger audit report should cross reference the audit report that reflects the individual transactions, and control totals in both ledgers must be reconciled. *Exception reports* should be produced in the case of transactions or totals exceeding previously specified limits.

Further data processing security for complex transactions can provided by database management systems. A single transaction may result in updates to a number of different files, e.g. a sale will affect both the accounts receivable and inventory files. In this case, all the required updates must be made successfully before the transaction is *committed* to the database; if an error occurs at any stage after the start of processing, then all the updates will be *rolled back* (i.e. undone), to prevent the possibility of inconsistent entries.

Additional *management controls* should be implemented to reduce data processing risk. Employees should be thoroughly trained in the software and procedures that they are expected to use. Regular backups should be made and stored in secure off-site locations. Separation of duties among employees reduces the risk of deliberate fraud, and awareness of ethical standards should be a part of company policy.

13.5 Disaster Recovery

Natural disasters, sabotage, theft, viruses – any of these can result in damage to, or even destruction of, an organisation's information systems. Reliance on corporate databases and powerful servers increases the vulnerability of the system. A disaster recovery plan is needed to document how the business would be able to recover from either the total loss of computing capabilities, or else the interruption of critical services.

Regular ***backup*** of data and programs is the first essential for recovery from mishap. Backups should be kept off-site and in a fireproof container or safe, and should be tested at intervals to ensure that the restore procedures function successfully.

A ***hot site*** provides an alternative computing facility that can be used in the event of a major disaster, such as occurred at the World Trade Centre in New York in September 2001. Backup copies of application programs and corporate data can be run on equipment at the hot site with minimal interruption to business. Because the duplication of computer hardware is expensive, this facility may be shared between a number of firms operating in different geographical locations. (In fact, the internal systems used to manage the twin towers of the World Trade Centre, each had their disaster recovery facilities located in the opposite tower, since the likelihood of both towers being destroyed simultaneously was believed to be remote.)

Some disasters can be minimised through avoidance and early warning systems. An *uninterrupted power supply (UPS)* will prevent data corruption resulting from power spikes, and in the event of a total power failure, can run the system for a limited period before shutting it down in an orderly fashion and without data loss. Temperature control systems, smoke detectors and water sprinklers or gas fire suppression systems should be installed to reduce fire risk, while physical controls such as door locks and alarm systems will protect against unauthorised intruders. Expert systems can be used to monitor the network for faults and to protect against communications threats such as viruses and hackers.

13.6 How IS Affects You

Every department of an organisation uses information technology in some way, and even if you are not an IS major, IS is likely to be an important element of your future career in commerce.

- In *finance* and *accounting*, information systems are used to forecast revenues, plan business activities, manage financial resources and audit the performance of the organisation.
- In *sales* and *marketing*, information systems are used to determine the potential market for new products, to plan advertising campaigns and predict sales revenues, to determine product prices and manage customer relations.
- Many of the processes in an organisation's value chain can be enhanced through the use of computer-based information systems, from procurement to manufacturing to after-sales service. The *operations* manager who has a sound knowledge of information technology will be able to apply it effectively in order to maintain competitive advantage in the market.
- *Human resource* management is no longer focused solely on employee record keeping. The internet has become a powerful employment tool; company intranets empower staff to manage their benefits, leave and training requirements. IT now has an important role to play in the hiring and retention of staff.
- Of course, if you intend becoming an *IS specialist*, then the development and management of information systems will be central to your future career, and this is only the beginning of your studies in the field of IS. Even if you focus on a particular aspect of IS, such as database or network administration, you will need a solid foundation of basic principles that will enable you to integrate your area of responsibility with the goals of the business and the IT architecture that supports them.

Whatever your future career, we trust that your introduction to information systems will have opened your eyes to the wide variety of ways in which IS can be used to support the activities of any business.

13.7 South African Perspective

The Computer Society of South Africa (CSSA) has adopted the following code of conduct for its members:

"A professional member of the Computer Society of South Africa:

1. Will behave at all times with integrity. He or she will not knowingly lay claim to a level of competence that he or she does not possess and he or she will at all times exercise competence at least to the level he or she claims.
2. Will act with complete discretion when entrusted with confidential information.
3. Will act with impartiality when purporting to give independent advice and must disclose any relevant interest.
4. Will accept full responsibility for any work which he or she undertakes and will construct and deliver what he or she purports to deliver.
5. Will not seek personal advantage to the detriment of the Society.
6. Will not discriminate on the basis of race, sex, creed or colour."

13.8 Beyond the Basics

When an organisation invests in new technology, four different stages are experienced in its assimilation. If these are understood and supported by management, the introduction and spread of the technology can be facilitated.

Phase 1: Technology identification and investment. A team of technological specialists and business users is needed to explore and *evaluate* new technologies. When the decision is made to acquire a new technology, the initial investment should include staff training and management of the implementation.

Phase 2: Technological learning. Staff must be supported in their efforts to use the new technology, and encouraged to *experiment* in order to gain experience and knowledge of its capabilities. Use of the system should not be restricted only to existing business tasks.

Phase 3. Technological learning. Technical staff and experienced users together define possible applications of the new technology and determine the most cost-effective ways in which it can be *incorporated* within business processes.

Phase 4. Widespread technology transfer. Once the new technology has a base of experienced users and clear plans have been developed for its future use, it can be *transferred* throughout the organisation. At this stage, tighter management control instead of the previous policy of experimentation is needed to achieve the expected return on investment.

13.9 Exercises

13.9.1 Ethics

Would you consider the following scenarios to be ethical or unethical? Explain why you think this.

- A company requires employees to wear name badges that track their whereabouts while they at work.
- The network manager reads an employees e-mail.
- An employee forwards an e-mail to a third party without obtaining permission from the sender of the message.
- An employee uses his computer at work to send personal e-mail to a friend.
- A student uses the university computer labs to send personal e-mail to a friend.
- A student copies text from the Web and incorporates it in an essay without acknowledging the source.
- A student is required to create a Web page for an assignment, so she finds an existing page that she likes and then modifies its contents.

CASE STUDY: CREAM ADVERTISING

Refer back to the Cream Advertising case study that was introduced at the end of Chapter 10.

Jade Smith has come to the conclusion that rather than trying to add new functions to her existing information systems, which are in any case somewhat outdated, new systems should be introduced at all levels of the organisation. This would include applications to provide transaction processing support, management reports, trend analysis and forecasting, and access to information about their market and competitors. Groupware would be an important factor in supporting team work and client communications.

Jade is also is concerned about the growing number of rival advertising companies who have included the internet in their business strategies. She is reluctant to spend money on something that will not necessarily increase business income, but she is aware that her clients feel that Cream is falling behind the times. In her view, the only way that the added expense of e-commerce would be justified, is if they are able to expand their business to cater for a global market and attract new overseas clients.

(a) Explain why it is important to plan for the integration of the different systems, rather than simply acquiring individual software packages and the appropriate hardware from different vendors?

(b) It will probably be necessary to develop software interfaces between the various systems to ensure that data can be transferred between them. Would you advise Jade to employ a technical programmer for this purpose, or should the job be outsourced?

(c) How can Jade best manage the introduction of the new systems to ensure that staff will use them as efficiently as possible? What ongoing support arrangements should be put in place?

(d) The new systems will give all staff access to the internet, as well as to corporate data and applications. What ethical problems might arise and how can they be pre-empted?

(e) In expanding to a web-based global marketplace, are there any cultural or social issues that Jade should be alerted to?

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