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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ISBN 0-620-24194-2 (for the printed edition only)

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.

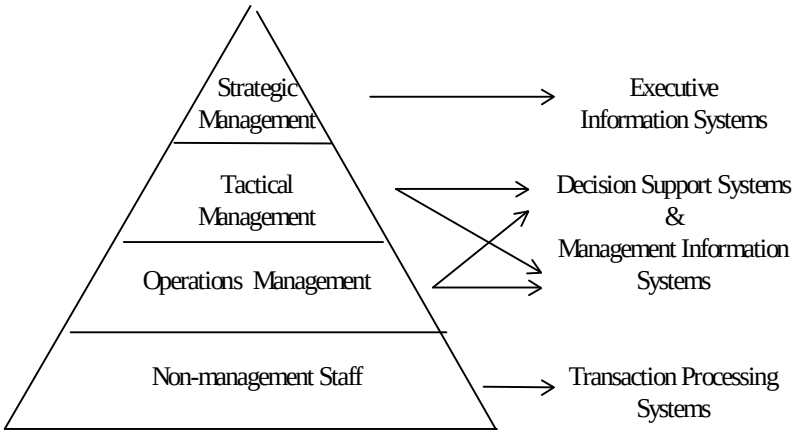

Figure 1-1: Levels of management and types of support systems

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!

