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Management Information Systems

Managerial Perspectives

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THIRD EDITION

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To
My Respected Parents

Foreword

I am very glad to write the Foreword for this book authored by Dr Dharam Paul Goyal who had attended a one-month programme for trainers of information analysts conducted by the Indian Institute of Management, Ahmedabad, for Computer Science University faculty from the Commonwealth Countries. Indian organisations are spending large sums of money to understand and use information technology. This investment is growing at the rate of 35 per cent per annum. However, the impact of the investments in IT on efficiency and competitiveness of organisations has been somewhat marginal. This is because organisations do not make a careful choice of the application areas, or are unable to implement the chosen applications successfully. Often data existing in computer files is not used by managers to improve planning and decision-making.

Indian industry needs IT specialists who have a broad perspective on organisational functioning and concepts in designing information systems. Similarly, managers need to be aware of the potential of information technology and the effort that is required to harness this potential. From the contents of this book, I find that the coverage would be useful for providing information system concepts to IT professionals. Managers would also find the contents useful, particularly because a large number of case studies have been included.

IIM, Ahmedabad

S C Bhatnagar

Preface to the Third Edition

Two reasons have primarily contributed in seeing this edition happen. First, the challenges posed by the ever-increasing complexity of business environment coupled with the evolution and advancement of Information Systems and the enhanced capability of ISs to cope with the business challenges. The second reason has been the encouragement received from the overwhelming reception of the earlier editions and the feedback received from the valued readers of this book. I wrote this book to fulfill the needs of a large majority of students, looking for a simple, easy to understand, and comprehensive yet relevant material presented in a logical way on a subject like Management Information Systems. I am more than rewarded when I see the objective of my writing this book being achieved.

In this revised third edition, various concepts have either been revised or updated and a few new chapters like IS for Competitive Advantage; ERP Systems; Business Intelligence and Knowledge Management Systems; Evaluation of IS; IS Security and Control; and Global ISs, have been incorporated. Every effort has been made to keep the language simple and easy to understand. To provide a new and appealing look, the book is being presented in a colorful and larger size.

Acknowledgements

It is difficult to express gratefulness and sentiments in words; it can only be felt. In all humility, I am grateful to a large number of students and professors who contributed in more than one way, either directly or indirectly in this edition. My sincere gratitudes to great visionaries like Professors B S Bhatia and R P Hooda, who have always boosted my morale.

I extend my thanks to all the faculty colleagues at MDI, Gurgaon, especially Professor B S Sahay, for providing me a good academic environment. I am also grateful to a large number of friends and colleagues at various institutes and universities for their confidence in my work and for sending their positive feedback as well as criticism to improve upon this book. My respected parents, who instilled all the good values in me, are a great source of inspiration. Special thanks to my entire family including my wife, Ms Mani Goyal, my son, Ankit and my daughter, Shreya for providing a motivating and congenial environment at home. Many a times, this edition of the book has encroached upon the time of togetherness, which they sacrificed for a greater cause. I also appreciate the untiring efforts of the entire team at Macmillan to make sure that this edition comes out on time. Last but not the least, I am always grateful to the great almighty God for choosing me to disseminate this knowledge.

I shall be happy if you could spare some time to send your valuable feedback to improve upon this edition. I can be reached at dpgoyal23@gmail.com

D P Goyal

Preface to the First Edition

The globalisation of business, widespread technological innovations, social and political changes and an increased awareness in customers are some of the factors that have forced the business world to undergo rapid changes. In view of these ever-increasing complexities of the business environment, a growing need for guidance on concept, issues and strategies for understanding, developing and managing information systems in organisations is being felt all over the world. This is because of the fact that information, which is a vital and necessary input in decision-making, is provided by a Management Information System of the organisation. In other words, any organisation, to survive and grow in this competitive environment, must have an effective and efficient information system.

Based on the feedback received from a large number of practising managers, students and consultants; and from a survey of the available written material on the subject, an effort has been made to cover all the important aspects of MIS. Accordingly, the book has been divided into six parts, each dealing with a major portion of the field of information systems.

Part I deals with an introductory framework of MIS, which traces the growing importance of information systems and presents a general model to understand the concept of MIS, its functions and important characteristics. This part also discusses the structure and categories of MIS.

Part II provides conceptual foundations on decision-making and information; and it also clearly describes a system and system-related concepts.

Part III is dedicated to computer system technology which gives in detail the basics of a computer system and also describes data management and data communication concepts, which are essential to understand computer-based MIS.

Part IV presents models of the system development process, system analysis techniques and system design. This part, basically, educates the user about the various system development phases.

Part V explores some of the challenges involved in managing information systems after these are ready for implementation in users' organisations. It includes topics like implementation, evaluation and maintenance of information systems. This part also provides an insight into understanding information system planning, and information system as an enabler.

Part VI discusses several real-life MIS case studies in organisations. This part is meant to provide an opportunity to the students to correlate theoretical concepts with practical situations. The case studies, it is hoped, will promote discussions among the students.

The subject of MIS has always been difficult to teach and it has been equally difficult to comprehend for students because it has not been well defined. While some authorities focus on computer technology, others devote too much attention to management principles and functional areas.

Nowadays, MIS is considered a combination of two disciplines, namely, management and computer science. In this text, an attempt has been made to balance these disciplines. The book has been divided into six parts, which gives a well-defined form to the study of information systems. The book contains a good balance of theory and practice. For example, in addition to giving a general framework to understand MIS, the text gives a great deal of attention to demonstrating how analysis and design techniques are applied and how one may implement and evaluate a newly developed information system.

Simple and clear language has been used to make the text interesting and understandable. No background of computers is required to follow this text, as the book has been written to satisfy the needs of various kinds of students, business executives, consultants and professors, etc.

Acknowledgements

Many people have helped in making this book a reality. No words can express adequately my gratitude to a large number of persons from whom I sought help and cooperation.

This book might not have seen the light of the day had I not been inspired by Prof. Subhash Bhatnagar of Indian Institute of Management, Ahmedabad; Prof. B.S. Bhatia of Punjabi University; and Prof. O.P. Goyal of M.D. University. I am sincerely indebted to all of them.

My deepest gratitude is due to my teachers, colleagues and friends at the Punjab School of Management Studies, Punjabi University, and my ex-colleagues at Thapar Institute of Engineering and Technology, for boosting my morale and for providing me an encouraging environment. Here I must specially mention the names of Prof. R.K. Sehgal, Prof. Gurdip Singh and Prof. M.S. Bedi for all their help and moral support.

I also cannot forget the contributions made by Prof R.P. Hooda of Kurukshetra University, Prof. D.B. Phatak of IIT, Mumbai, Prof. Ambuj Mohanti of IIM, Calcutta and Prof. (Mrs) Rekha Jain of IIM, Ahmedabad in refining my skills as an academician and an author. I am, indeed, deeply grateful to all these eminent personalities.

My affectionate students, to whom I have taught this course for more than thirteen years, also deserve a special mention for their thought provoking queries and interest in my work. In fact, their difficulty in getting adequate literature matching their requirements motivated me to devote myself to the writing of this book.

I express my gratitude to the anonymous referee for his very useful suggestions for this piece of work.

I must acknowledge with thanks the efforts of M/s Macmillan India Limited for bringing out my work in book form so expeditiously.

My sincere appreciation is also due to Mrs Kamna of IMT for her help in some of the case studies and Mr Prem Pahuja for his efforts in preparing the entire manuscript on a word processor.

Finally, I also wish to thank my wife Mani Kanta Goyal, my eight-year old son Ankit and two-year old daughter Manu for their wholehearted support to this project. Despite my periods of silence and absence because of my involvement with this work, they provided me a motivating and congenial environment at home. No author, perhaps, can ever ask for more from his family.

I shall be grateful to my learned readers if they could bring to my notice any shortcomings in this book and send their valuable suggestions to help improve the next edition.

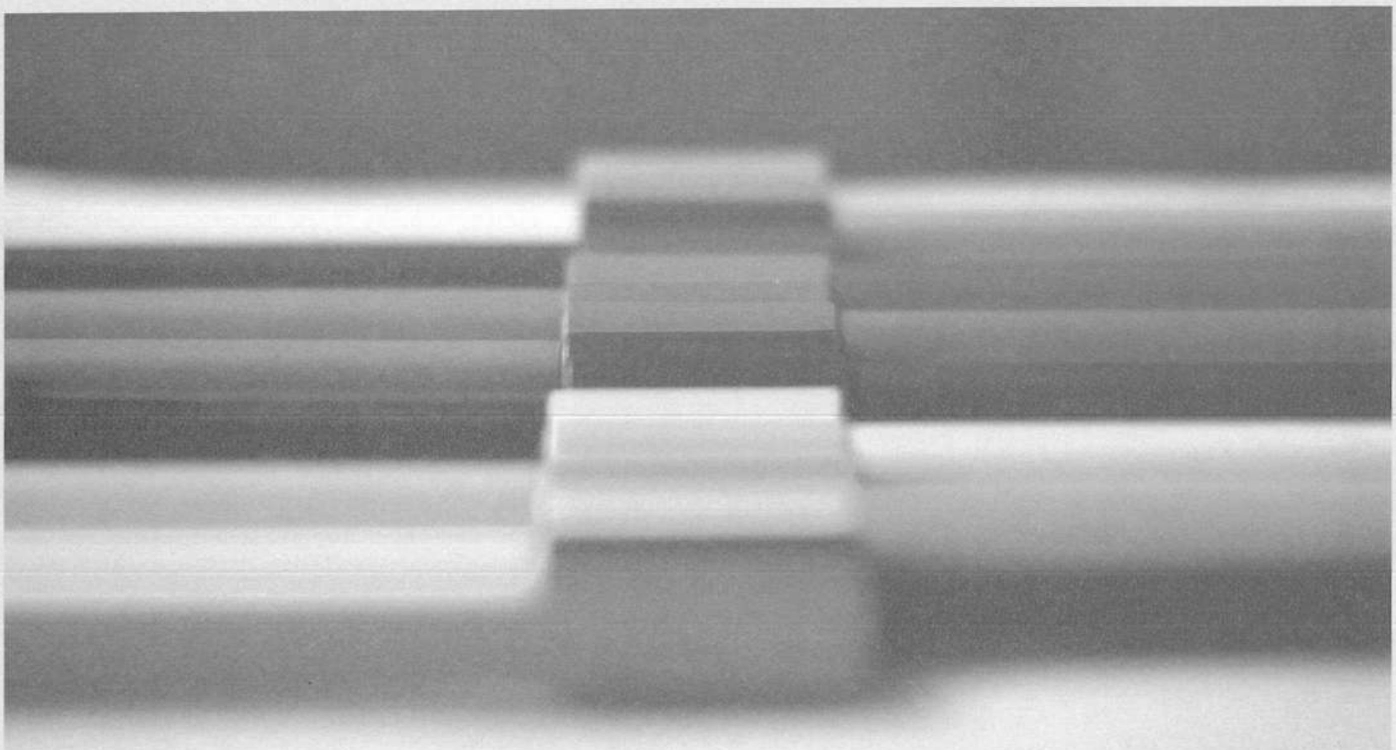
D P Goyal

Contents

Part

1

Conceptual Foundations



Chapter Outline

Management Information Systems: A Framework

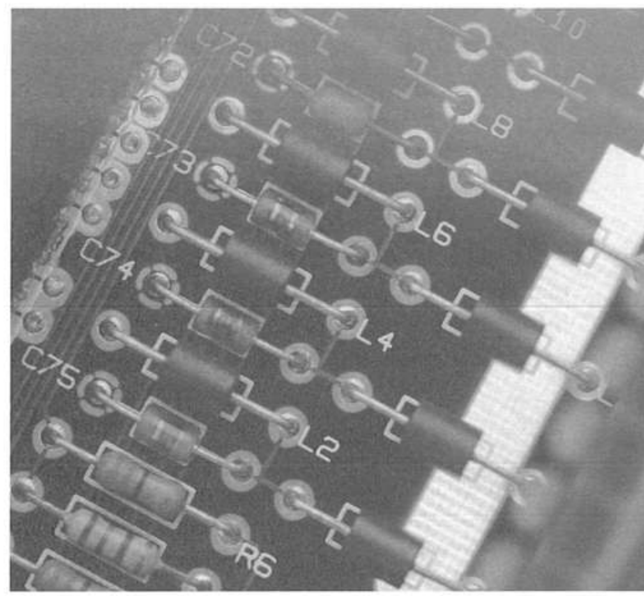
Structure and Classification of MIS

Information and System Concepts

Information Systems for Competitive Advantage

Chapter 1

Management Information Systems: A Framework



Learning Objectives

After going through this chapter, you should be able to:

- Understand why knowledge of information systems is important for business professionals
- Clearly understand the concept of Management Information Systems in terms of its various components and as an integrated system
- Explain the concept of a system
- Know about the nature, scope and characteristics of MIS
- Describe the functions of MIS

1.1 IMPORTANCE OF MIS

It goes without saying that all managerial functions are performed through decision-making; for taking rational decision, timely and reliable information is essential and is procured through a logical and well-structured method of information collecting, processing and disseminating to decision-makers. Such a method in the field of management is widely known as Management Information Systems (MIS).

In today's world of ever-increasing complexities of business as well as management, every business organisation, in order to survive and grow, must have a properly planned, analysed, designed and maintained MIS so that it provides timely, reliable and useful information to enable the management to take speedy and rational decisions.

MIS has assumed all the more important role in today's environment because a manager has to take decisions under two main challenges:

- First, because of the liberalisation and globalisation, in which organisations are required to compete not locally but globally, a manager has to take quick decisions, otherwise his business will be taken away by his competitors. This has further enhanced the necessity for such a system.
- Second, in this information age wherein information is doubling up every two to three years, a manager has to process a large voluminous data; failing which he may end up taking a wrong decision that may prove to be very costly to the company.

In such a situation managers must be equipped with some tool or a system, which can assist them in their challenging role of decision-making. The advances in Information Technology (IT) have come to the rescue of today's manager.

It is because of the above-cited reasons that today MIS is considered to be of paramount importance, sometimes regarded as the nerve centre of an organisation. Such systems assist decision-makers in organisations by providing information at various stages of decision-making and thus greatly help the organisations to achieve their pre-determined goals and objectives. On the other hand, the MIS which is not adequately planned for, analysed, designed, implemented or is poorly maintained, may provide delayed, inaccurate, irrelevant or obsolete information, which may prove costly or even fatal for the organisation. In other words, organisations today just cannot survive and grow without properly planned, designed, implemented and maintained MIS. It has been well understood that MIS enables even small organisations in more than offsetting the economies of scale enjoyed by their bigger competitors and thus helps in providing a competitive edge over other organisations.

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Timely and Reliable information is essential for taking rational decision in managerial functions. Two main challenges of a manager are:
- Taking quick decisions
- Processing a large voluminous data

1.1.1 MIS – Why?

A basic question that comes to one's mind is why should one study MIS? It may be a student aspiring to become a manager, a manager working in some organisation, an entrepreneur or a professional. Nowadays, information systems and information technology have become a vital component of any successful business and every manager is supposed to be equipped with the knowledge of information systems and information technology. Further, information system, nowadays, is regarded as a major functional area just like any other functional areas of a business organisation like marketing, finance, production, and human resources, etc. Also, information technologies including Internet-based information systems, play an increasingly important role in organisations. Today, information systems play three vital roles for a business organisation, namely:

- Support the business processes and operations of an organisation.
- Support the decision-making by employees and managers of an organisation.
- Support the strategies of an organisation for competitive advantage.

Thus, irrespective of your functional area (i.e. finance, human resources, marketing, production); responsibility level in an organisation (i.e. strategic level, middle management, and or *operational* control level); size of the organisation in which you work (small, medium or large), information system is all-pervasive. However, this

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The vital roles of an information system are that they support
- Business processes and operations
- Decision making by employees and manager
- Strategies for competitive advantage

does not mean that you must be an expert in programming or other complex technologies (if you are not going to specialise in information technology); rather you should be well aware of MIS as a system and its applications.

1.1.2 MIS – What you need to know?

Another important question is what one needs to know on this subject to be competent enough to manage the hardware, software, data and network resources of a business and apply that knowledge for the strategic success of the organisation.

The field of information systems encompasses many complex technologies, behavioural concepts and a large number of specialised applications in business and non-business areas. What you need to understand is:

- The basic concepts of information systems and information technology;
- The planning process of information systems;
- The development process of information systems;
- Business applications of information systems for the operations, management, and competitive advantage of a business;
- The challenges in managing IT and other issues in the use of IT.

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It is important to understand:
- Basic concepts of information system and IT
- Basic applications of information systems
- Challenges in managing IT

Figure 1.1 illustrates the major areas that you need to know about information systems.

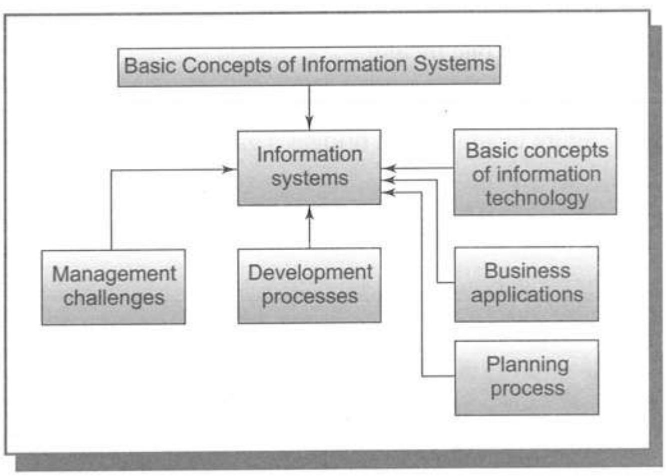

Fig. 1.1 Major Areas of Information System

1.2 MANAGEMENT INFORMATION SYSTEMS: A CONCEPT

The term MIS is of recent origin. But it does not mean that organisations were doing without such a system. In fact, MIS has been in existence since the advent of business organisations. Until recently, MIS occupied the status that oxygen did before Lavoisier's discovery of the gas – it was both vital and unrecognised. However, business as well as management happened to be simple in yesteryears, whereas today both have grown to unprecedented levels of complexity. Also as has already been mentioned, with the advent of computers and communication technology, it has now become possible to transmit large amounts of information across long distances cheaply and without loss of time. Thus, environmental pressures have necessitated that information be considered as a fifth important resource along with the four traditional resources of money, materials, men and machines. In fact, some management researchers have gone as far as to define a manager as a transducer that transfers information to decision. Thus, there is no denying the fact that MIS, though was very much in use

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Though MIS was very much in use since the start of the first business organisation, it remained manual and very simple. Today, it has a refined nomenclature along with a well designed computer based structure, which follows the systems approach.

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Management is about getting things done through and with the people in formally organised groups.

since the start of the first business organisation, it remained manual, very simple and unrecognised, whereas today, it has got a greatly refined nomenclature, along with a well-designed computer-based structure, which follows the systems approach.

Management Information System is an acronym of three words, viz., Management, Information and Systems. In order to fully understand the term MIS, let us try to understand these three words.

1.2.1 Management

Management has been defined variously by different scholars. However, Koontz's definition of management is widely recognised and used, which runs as follows, 'Management is the art of getting things done through and with the people in formally organised groups', (Koontz, 1972). However, a manager in the organisation does not get things done through a magic stick; rather he does it by performing different functions in a systematic way. The basic functions, which a manager performs in an organisation are listed under managerial functions.

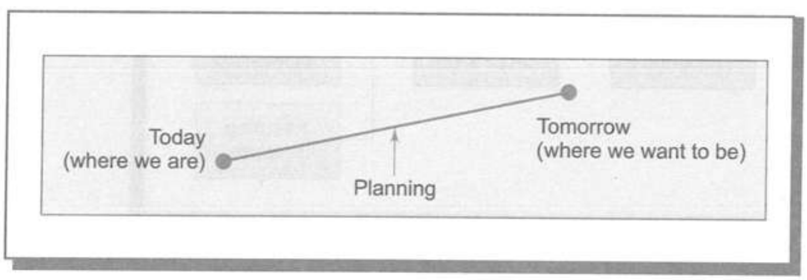
Managerial Functions

(i) Planning,
(ii) Organising,
(iii) Staffing,
(iv) Directing, and
(v) Controlling.

To get an insight into the term Management, it would be fair to briefly discuss these basic functions of management. Let us understand these functions one by one.

Planning

Planning is a process of foreseeing the future in advance. It bridges a gap between where we are and where we want to be.



As planning is to chart the future course of action, it should answer the following questions:

- What to do?
- When to do?
- Who is to do?
- How is it to be done?
- Where is it to be done?
- Why is it to be done?, etc.

Managers plan by setting goals and objectives and lay down policies, procedures, rules, programmes, budgets, strategies and schedules to achieve the plan.

Organising

Organising is the process of identifying the entire job, dividing the job into convenient subjects/tasks, allocating sub-jobs to person/group of persons and delegating authority to each so that the job is carried out as planned. Managers organise tasks by dividing activities, assigning duties and delegating authority for effective operation and achievement of goals.

Staffing

Staffing is the process of putting the right person at the right job. This function involves activities like defining the requirements with regard to the people for the job to be done, selecting suitable persons for these positions and training and developing them to accomplish their tasks as effectively as possible. The two functions, i.e. organising and staffing should not be confused because of their close relationship. Organising focusses attention on the structure and process of allocating jobs so that common objectives can be achieved; whereas staffing pertains to the people in the jobs. Thus, organising is job-oriented, whereas staffing is worker-oriented.

Directing

The function of directing has been identified with command by Henri Fayol. However, modern management philosophers are of the view that directing includes:

(i) Communication,

(ii) Motivation, and

(iii) Leadership.

Directing is important because in order to achieve pre-determined goals and objectives, people manning the organisation have to be guided, motivated and led by the manager.

Controlling

Controlling and planning are the two sides of the same coin. Controlling ensures that activities are being performed as per plans. Controlling is a process which involves:

(i) Fixing standards for measuring work performance,

(ii) Measurement of actual performance,

(iii) Comparing actuals with standards and finding out deviations, if any, and

(iv) Taking corrective actions.

Managers control the performance of work by setting performance standards and avoiding deviations from standards.

Thus, it emanates from the above discussion that in order to get things done through people, a manager performs the above-mentioned functions. Further, to perform these functions, a manager has to take a variety of decisions. In other words, *decision-making* is a fundamental prerequisite for each of the foregoing processes. Peter Drucker has gone to the extent of saying 'Whatever a manager does, he does it through decision-making.' In brief, Decision-Making is the essence of Management.

To further understand the functioning of a business organisation, let us briefly discuss management hierarchy.

Management Hierarchy

There are several ways to describe the various management levels. Although there are no concrete lines of demarcation, one can distinguish between layers within the organisation. Robert B. Anthony described three levels of business activities carried out in operating an organisation. These three levels, viz., Operational Control (operating management); Management Control (middle management); and Strategic Planning (top management) are portrayed in Fig. 1.2.

The strategic planning level determines what markets or businesses the company should be in at present or plan to be in the near future.

The next level, management control, includes processes or functions that facilitate the management of the processes delegated to the operational control level. An example of a management control process is production

Fig. 1.2 Levels of Business Activity

scheduling, where a system is established to schedule products through the various fabrication and assembly points within a factory. The feedback from the production scheduling process enables the management to control the operation.

The bottom level, operational control, indicates processes performed to control the basic product or services produced by the company. It is concerned with individual tasks or transactions, such as procurement of raw material as per the prescribed quantity and quality or selling of products to specific customers. In a bank, operational control activities include physical sorting, recording and posting of cheques.

Jerome Kanter (1996) summarises the interaction amongst the three levels of management. At the strategic planning level, top management establishes the policies, plans and objectives of the company, as well as a general budget framework under which the various departments will operate. These factors are passed down to the middle management, where they are translated into specific revenue, cost, and profit goals. These are reviewed, analysed, and modified in accordance with the overall plans and policies, until agreement is reached. Middle management then issues the specific schedules and measurement yardsticks to the operating management. The latter levels have the job of producing the goods and services required to meet the revenue and profit goals, which in turn will enable the company to reach its overall plans and objectives. The interaction has been shown in Fig. 1.3.

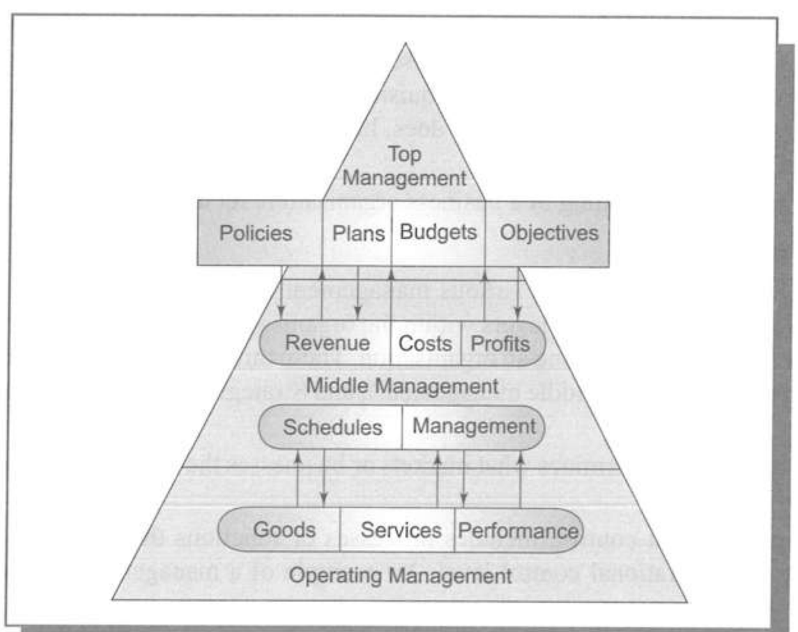


Fig. 1.3 Interaction of the Three Levels of Management

1.2.2 Information

Information, the second component in the term Management Information System, is considered a valuable resource required by the management in order to run a business organisation. Information is data that is processed and is presented in a form which assists decision-makers. It may contain an element of surprise, reduce uncertainty or provoke a manager to initiate an action. Whereas data (the singular being datum) is a term used for raw figures, facts, symbols, etc., that are currently not being used in a decision-making process, data usually take the form of historical records. In contrast to information, raw data may not be able to surprise us, may not be organised and may not add anything to our knowledge.

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Information is data that is processed and is presented in a form that assists decision-makers.

The relation of data to information is that of raw material to finished product, as depicted in the following diagram.

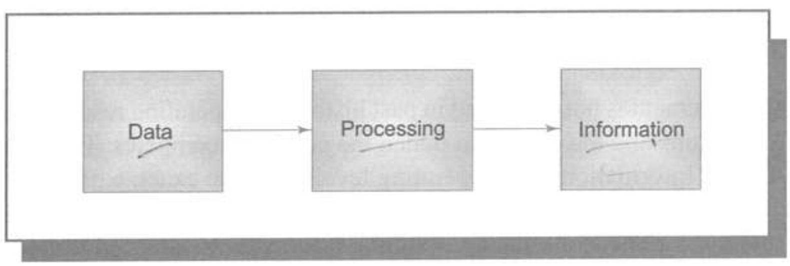

Fig. 1.4 Relation of Data to Information

However, the concept of data and information is a relative one. The analogy of raw material to finished product illustrates further that information for one person may be data for another, just as a finished product from one manufacturing division may be the raw material for another. For example, the withdrawal slip may be information for a cashier or teller of a bank but it is raw data for the branch manager. Similarly, the role may also change over a period of time. Thus, something may be information today but may not be information (may be data) after a certain period of time. Because of this relationship between data and information, the two terms are often used interchangeably.

As discussed earlier, the three levels of management perform different functions in an organisation. Accordingly, they will require different types of information. Kanter, J. (1996) has shown the different needs of information by three levels of management over a continuum, with top management at one end and operating management at the other (Fig. 1.4). Middle management, as always, falls in between, having some elements of both.

The type of information being utilised by each level of management (as shown in Fig. 1.5), is in accordance with the nature of jobs performed by managers at their respective levels. For example, top level management is responsible for formulating strategies, policies and objectives for the entire organisation. This involves predicting the future of the organisation and its environment. The information for such decisions is highly unstructured, i.e. not well-defined. It is because of its unstructured nature that such information becomes difficult to process. For example, it is difficult to determine with accuracy the market share of a company's product or the extent of its penetration in a specific market segment. On the other hand, well-defined information, which may be called structured information, can be easily processed as in the case of operating management. This level of management is given specific jobs to be performed and thus its information needs, which tend to be routine and repetitive, are well-defined and known. For example, a supervisor has the monthly production schedule for a particular product, which indicates that 150 units are scheduled to be produced for each of the next five days. He will want to review the information that indicates the availability of raw material, labour or machines, etc., on a day-to-day basis to see if the schedule is being met and if it is being met efficiently.

Information for planning purposes pertains to the future and thus is approximate when compared to information required at the operating level. For example, a managing director of a company would not require the exact sales figures (say Rs. 534634520.80), rather Rs. 53 crore would suffice. However, from future information requirements,

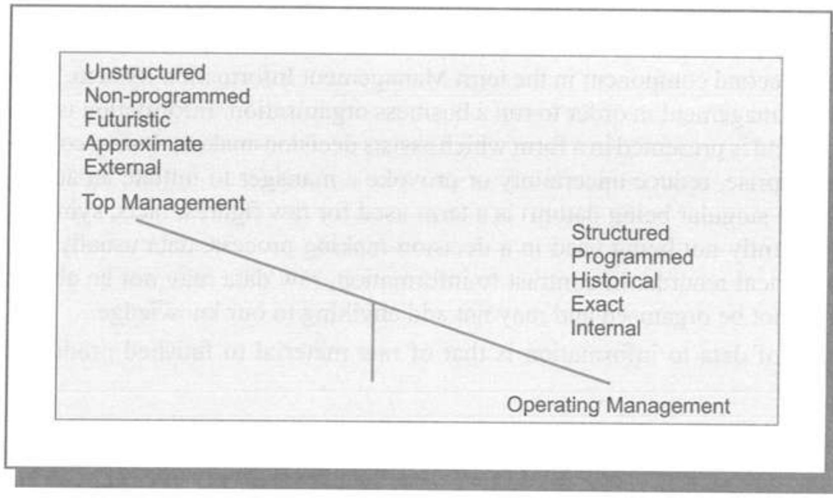

Fig. 1.5 Information Needs of Different Management Levels

one should not understand that the top management is not interested in past history and operating results. Past results must be reviewed in light of external conditions and the market in which the company competes. The focus of top management is on future plans and policies. Information at the operating level has to be exact, e.g. the length of a paper pin to be produced would be 18.2 mm in length and 0.65 mm in diameter and so on. Similarly top management requires mainly external type of information for decision-making. External information is that information whose source is outside the operations of the company. For example, population growth in the market served by a company or the changes in the ethnic make up of the market is external information. Whereas, the operating management needs internal information. The internal information is a by-product of the normal operations of a business. For example, a recording of inventory usage for the past week is typical internal information. Internal information generally is historical or static in nature; it is also called after-the-fact data.

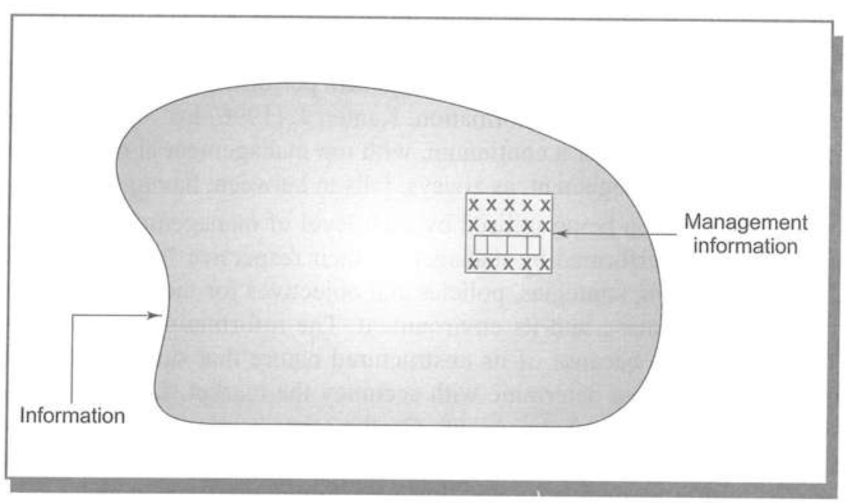

Fig. 1.6 Relation of Information and Management Information

For the sake of simplicity, we have discussed Management and Information components as two different and distinct terms. The latest thinking in the field of MIS has been that MIS is an acronym of two terms, viz., Management Information (MI) and System (S). Thus, MIS must provide the Management Information which is required by the managers in their decision-making. Management Information, in other words, refers to the quality of information in terms of its timeliness, accuracy, completeness, relevance, adequacy, explicitness, etc. The information which observes these quality parameters may be a part of the entire available information, which is generated in the organisation. The relationship of information and Management Information may be depicted as shown in Fig. 1.6.

The characteristics of information which make it Management Information, are discussed in Chapter 3.

1.2.3 System

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A system is a set of interrelated and interdependent elements which are joined together to achieve a common objective.

The term system is the most loosely held term in management literature because of its use in different contexts. However, a system may be defined as a set of elements which are joined together to achieve a common objective. The elements are interrelated and interdependent. Further, every system is said to be composed of sub-systems, which in turn are made up of other sub-systems. This may be illustrated by taking an example of a business organisation, that may be regarded as a system and the parts of the organisation (divisions, departments, units, etc.) are the sub-systems (For details refer to Chapter 3.) The set of elements for a system may be understood as Input, Process and Output. A system has one or multiple input(s); these inputs are processed through a transformation process to convert these input(s) into output(s). For example, in a manufacturing organisation, raw material is input to a system, which is processed by using various organisational processing facilities to convert it into finished products (output). Similarly, in an information system data is input, which is processed to convert it into information. The three elements of a system are portrayed in Fig. 1.7.

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Open System: A system which interacts with its environment and exchanges inputs and outputs.

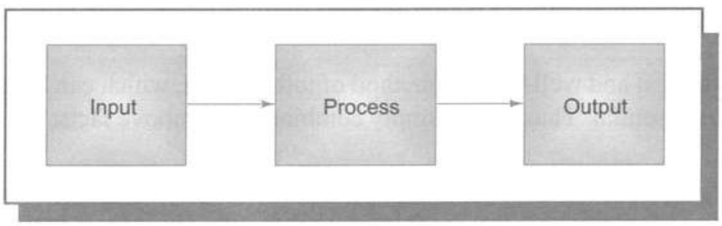

Fig. 1.7 Elements of a System

When feedback and control elements are attached to any system, to make it self-regulating and self-monitoring, it is known as a cybernetic system (see Fig. 1.8). A man-made example of a cybernetic system is that of a Thermostat controlled heating system which automatically monitors and regulates itself to maintain a desired temperature on the basis of feedback it gets from the environment. Automation is introduced in engineering systems by involving the principles of feedback and control.

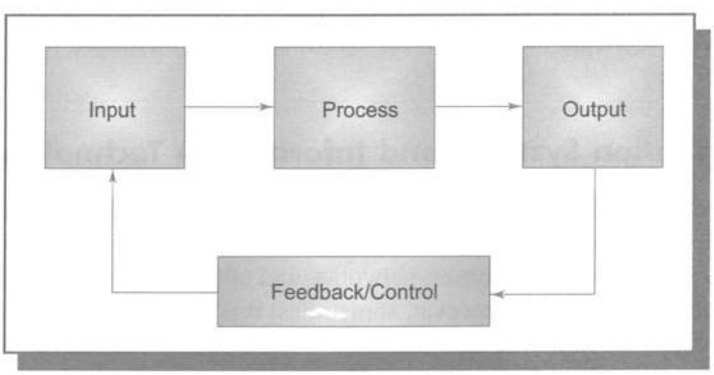

Fig. 1.8 Cybernetic System

A system cannot exist in vacuum; rather, it exists and functions in an environment. However, it is separated from its environment by its boundary as shown in Fig. 1.9.

Several systems may share the same environment. Some of these systems may be connected to one another by means of a shared boundary or Interface. A system which interacts with its environment and exchanges inputs and outputs is known as an open system. A system which does not interact or exchange any of its inputs or outputs with its environment is called a closed system. System concepts have been explained in more detail in Chapter 3.

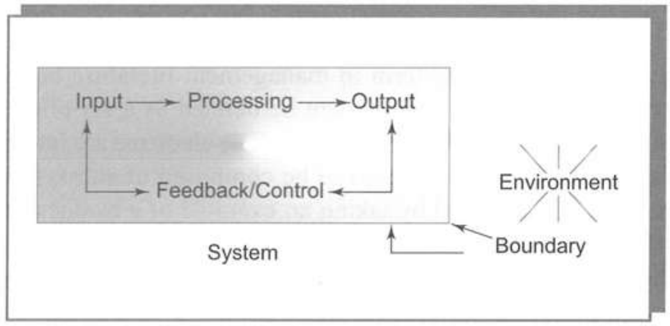

Fig. 1.9 A System with Boundary and Environment

1.3 MIS: A Definition

Having discussed the concepts of the three components of MIS, viz., Management, Information and System, let us now try to understand its definition. While discussing various components, it has been clearly established that decision-making is the essence of management and for taking rational decisions, information is an essential and vital input.

Further, to obtain information, a logical and well-defined method of information, which can be implemented by joining certain interrelated elements is essential. Thus, if we simply combine all the above facts, we may devise our definition of MIS as follows.

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Management Information System is a system consisting of people, machines, procedures, databases and data models, as its elements. The system gathers data from the internal and external sources of an organisation; processes it and supplies information to assist manager in decision making

Management information system is a system consisting of people, machines, procedures, databases and data models, as its elements. The system gathers data from the internal and external sources of an organisation, processes it and supplies information to assist managers in the process of decision-making. Here the word system implies that MIS follows a systems approach which means a holistic approach and is based on the concept of synergy where the output is greater than the sum of its parts. Thus, it clearly indicates that MIS is not a single system, rather it is an integrated system where parts (sub-systems) fit into an overall design.

A diagrammatic representation of the concept of MIS has been shown in Fig. 1.10. The purpose of MIS as understood today, is to raise managing from the level of piecemeal steady information, intuitive guesswork and isolated problem solving to the level of systems insight, system information, sophisticated data processing and systems problem solving.

1.3.1 Management Information Systems and Information Technology

MIS deals with planning, development, applications and management of IT tools to help decision makers in an organisation, whereas, Information Technology (IT), is referred to the technological side of an information system, which is understood to include hardware, software, databases, networks, and other devices. In other words, IT may be viewed as a sub-system of an information system. However, sometimes, it is regarded as a narrow definition of information technology. For the sake of convenience, the term IT is also being used interchangeably with information system. There is another school of thought which advocates that IT should be viewed as a broader concept that describes a combination of all or many of the information systems, users and information management for the entire organisation. However, for the purpose of this book, the term MIS is used in this broader perspective. In this book, technology, has also been covered but not as a sole focus of MIS.

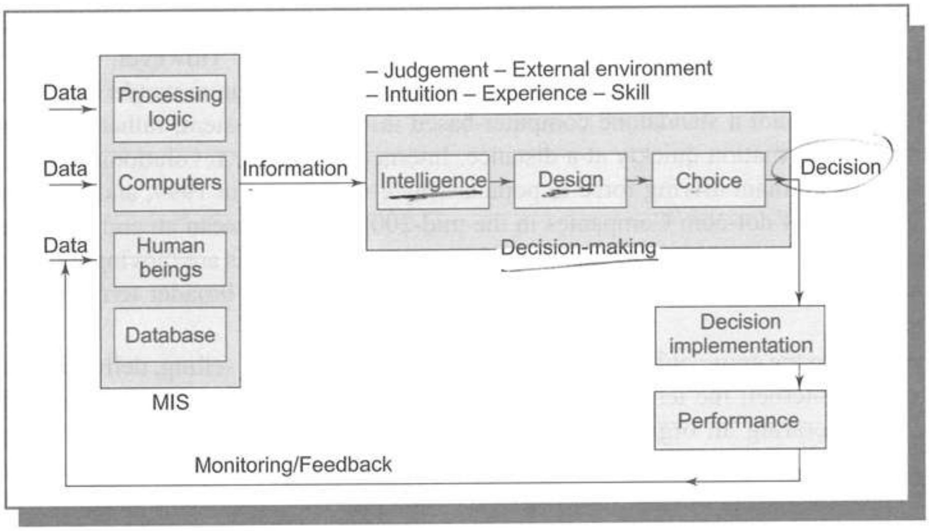

Fig. 1.10 Concept of MIS

1.4 Nature and Scope of MIS

The concept of MIS is interdisciplinary in nature, i.e. it has borrowed its concepts from a large number of disciplines like Accounting, Computers, Organisations, Management, Operations Research and Behavioural Sciences, etc. (see Fig. 1.11).

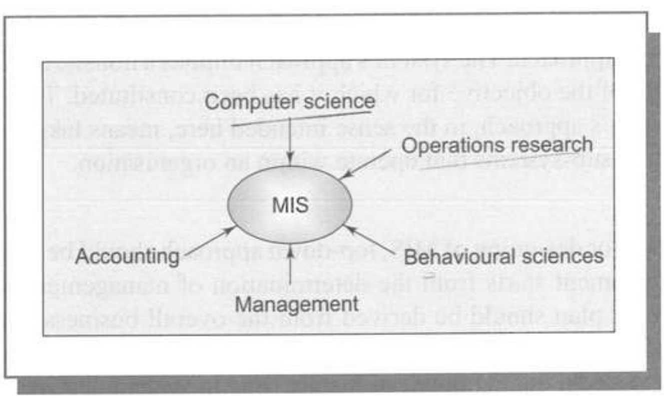

Fig. 1.11 Interdisciplinary Nature of MIS

Because of its interdisciplinary nature, MIS is neither termed as a pure science nor an art; rather it is considered as a combination of both. An *information system* is a logical system, which is concerned with 'how' something is being accomplished and thus may be differentiated from a *physical system*, which is the process itself and is concerned with the content or 'what' is going on. MIS, in fact, encompasses both physical and information systems. There has been a lot of debate on the issue whether MIS is more management-oriented or computer-oriented. Though there are advocates of both the sides, MIS should be considered more of a Management subject than of computers because of the simple logic that computers are just a tool in the hands of managers. Computers are used for their characteristics like accuracy, speed and capacity to handle large amount of data. Nowadays MIS finds application in all functional areas of every type of business organisations at all levels (see Chapter 2). As has already been discussed, MIS caters to information needs of managers in an organisation, thus its scope lies in structured as well as unstructured type of information which could be gathered from internal as well as external sources of the organisation. Further, with the advent of computers and communication technology, the scope of MIS has increased manifold. Though, you will

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Companies have learnt a lot after the failure of dotcom companies in the mid-2000 and nowadays they are moving towards digital organisations where all activities are performed electronically and a much broader term is being used, which is known as e-business.

still find a variety of information systems that exist which may be manual information systems, where managers use tools such as pencils, paper or calculators to convert raw data into information. However, because of high potential of computers and communications technology (CCT), organisations in the future would like to make use of advances of CCT. Today, MIS is not a standalone computer-based information system; rather it is networked where computers can exchange information quickly at a distance. Internet has further revolutionised the business world. In fact, Internet has been the main driving force in popularising e-Commerce in 1999, and the sudden rise of dot-com companies. The failure of dot-com Companies in the mid-2000 does not mean an end of e-Commerce applications; rather companies have learnt a lot in the process. Nowadays organisations are moving towards digital organisations where all business activities are performed electronically and a much broader term is being used, which is known as e-Business.

The term e-Commerce refers to the entire online process of developing, marketing, selling, delivering, servicing and paying for products on the Internet; the term of e-Business is a more general one and it refers to the style of operating an organisation by making extensive use of information technology within critical business processes, such as designing products, obtaining suppliers, manufacturing, selling, fulfilling orders and providing services through the extensive use of computer and communication technologies and computerised data. In other words electronic business covers customer-relationship management, enterprise resource planning, and supply chain management, etc., which also includes e-Commerce. The concepts of e-Commerce and e-Business have been discussed in Chapter 8 and Chapter 9, respectively.

FOCUS

Closed System: A system which does not interact or exchange any of its inputs or outputs with the environment.

1.4.1 MIS Characteristics

A management information system has the following characteristics.

System Approach

The information system follows a System's approach. The system's approach implies a holistic approach to the study of system and its performance in the light of the objective for which it has been constituted. This approach is anti-piecemeal in nature. In other words, system's approach, in the sense intended here, means taking a comprehensive view or a complete look at the interlocking sub-systems that operate within an organisation.

Management Oriented

This is an important characteristic of MIS. For designing of MIS, top-down approach should be followed. Top-down approach suggests that the system development starts from the determination of management needs and overall business objectives. The MIS development plan should be derived from the overall business plan. Management-oriented characteristic of MIS also implies that the management actively directs the system development efforts. In MIS development, a manager should spend a good amount of his/her time in system design. To ensure that the implemented system meets the specifications of the system, continued review and participation of the manager is necessary.

Need Based

MIS design and development should be as per the information needs of managers at different levels, viz., strategic planning level, management control level and operational control level. In other words, MIS should cater to the specific needs of managers in an organisation's hierarchy.

Exception Based

MIS should be developed on the exception-based reporting principle, which means an abnormal situation, i.e. the maximum, minimum or expected values vary beyond tolerance limits. In such situations, there should be exception reporting to the decision-maker at the required level.

Future Oriented

Besides exception-based reporting, MIS should also look at the future. In other words, MIS should not merely provide past or historical information; rather it should provide information on the basis of projections based on which actions may be initiated.

Integrated

Integration is a necessary characteristic of a management information system. Integration is significant because of its ability to produce more meaningful information. For example, in order to develop an effective production scheduling system, it is necessary to balance such factors as:

(i) set-up costs,
(ii) workforce,
(iii) overtime rates,
(iv) production capacity,
(v) inventory level,
(vi) capital requirements,
(vii) customer services, etc.

A system that ignores any one of these elements, for example, inventory levels, is not providing the management with an optimal picture. The cost of carrying excess inventory may more than offset the other benefits of the system. Integration in the sense intended here means taking a comprehensive view or looking at the complete picture of the interlocking sub-systems that operate within the company. One can start developing an MIS by attacking a specific sub-system, but unless its place in the total system is realised and properly reflected, serious shortcomings may result. Thus, an integrated system that blends information from several operational areas is a necessary characteristic of an MIS.

Common Data Flows

Because of the integrated concept of MIS, there is an opportunity to avoid duplication and redundancy in data gathering, storage and dissemination. System designers are aware that a few key source documents account for much of the information flow. For example, customers' orders are the basis for billing the customer for the goods ordered, setting up accounts receivables, initiating production activity, sales analysis, sales forecasting, etc. It is prudent to capture and use this data throughout the functional areas. The common data flow concept supports several of the basic tenets of system analysis. These include avoiding duplication, combining similar functions and simplifying operations wherever possible. The development of common data flow is an economically sound and logical concept, but it must be viewed in a practical light.

Long-Term Planning

MIS is developed over relatively long periods. Such systems do not develop overnight. A heavy element of planning is involved. The MIS designer must have the future objectives and needs of the company in mind. The designer must avoid the possibility of the system going obsolete before its time.

Sub-System Concept

The process of MIS development is quite complex and one is likely to lose insight frequently. Thus, the system, though viewed as a single entity, must be broken down into digestible sub-systems which are more meaningful at the planning stage.

Central Database

A central database is the mortar that holds the functional systems together. Each system requires access to the master file of data, covering inventory, personnel, vendors, customers, etc. If the data is stored efficiently and with common usage in mind, one master file can provide the data needed by any of the functional systems. It seems logical to gather data once, properly validate it and place it on a central storage medium, that can be accessed by any other sub-system.

1.4.2 MIS Functions

MIS is set up by an organisation with the prime objective to obtain management information which is to be used by its managers in decision-making. Thus, MIS must perform the following functions in order to meet its objectives.

(i) Data Capturing

MIS captures data from various internal and external sources of an organisation. Data capturing may be manual or through computer terminals. End users typically record data about transactions on some physical medium, such as a paper form, or enter it directly into a computer system.

(ii) Processing of Data

The captured data is processed to convert it into the required management information. Processing of data is done by such activities as calculating, comparing, sorting, classifying and summarising. These activities organise, analyse and manipulate data using various statistical, mathematical, operations research and/or other business models.

(iii) Storage of Information

MIS stores processed or unprocessed data for future use. If any information is not immediately required, it is saved as an organisational record. In this activity, data and information are retained in an organised manner for later use. Stored data is commonly organised into fields, records, files and databases, all of which will be discussed in detail in later chapters.

(iv) Retrieval of Information

MIS retrieves information from its stores as and when required by various users. As per the requirements of management users, the retrieved information is either disseminated as such or it is processed again to meet the exact MI demands.

(v) Dissemination of Information

Information, which is a finished product of MIS, is disseminated to the users in the organisation. It could be periodic through reports, or on-line through computer terminals. Figure 1.12 depicts various functions performed by MIS.

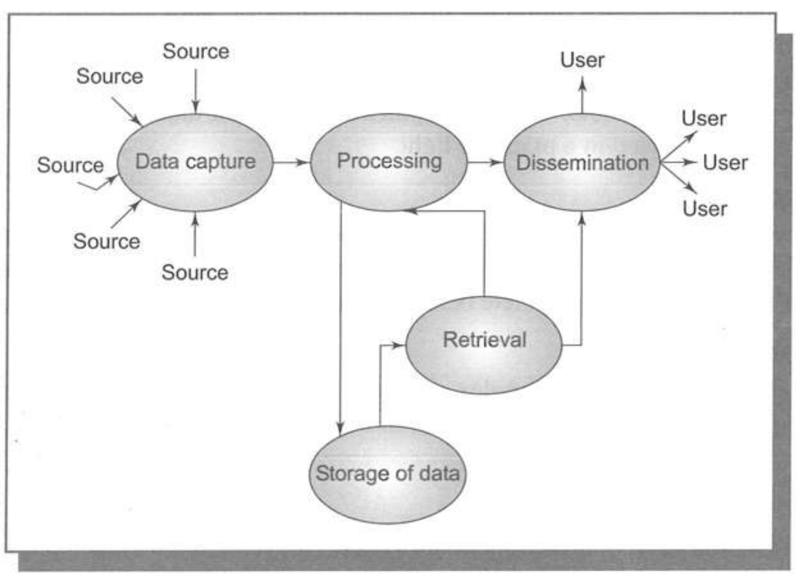

Fig. 1.12 Functions of MIS

SUMMARY

MIS is considered to be of recent origin in management but it had always been in existence in the past as well. Of course, it was not in a refined form then. Thus, what is new in MIS is only its nomenclature and its computerisation, which perhaps has become necessary because of environmental pressures on modern business organisations. MIS is an acronym of three letters, i.e. M (Management); I (Information); and S (System). Management is to plan, organise, staff, direct and control business resources to achieve predetermined objectives; for performing all these functions, a manager has to take an array of decisions. For taking rational decisions, information is an essential input. Information, which is processed data becomes Management Information when it is used in decision-making and follows certain characteristics, viz., it is timely, relevant, accurate, current, adequate without superfluous data, clear in form and non-repetitive.

System is a set of interrelated elements joined together to achieve a common objective and has input, process, output, feedback and control elements. MIS is a man/machine system consisting of people, machines, procedures, databases and data models as its elements. It gathers data from the internal and external sources of an organisation; processes it and supplies Management Information to assist decision-making by managers in an organisation. In other words, MIS captures data from various sources; processes it to convert this data into information and disseminates it to the decision-makers in an organisation. The concept of MIS is interdisciplinary and involves various disciplines of accounting, management, computers, operations research, behavioural sciences, etc. It is neither a pure science nor an art; rather a combination of both. MIS is a good example of physical as well as information system, which finds application in diverse fields of management.

REVIEW QUESTIONS

1. Can't we do without MIS in business organisations? How did business organisations manage to survive and grow without MIS in the past?
2. What is understood by the term MIS? How does it assist managers in their day-to-day functioning?
3. How would you distinguish between data and information? Can data for one person be information for another? How?
4. Discuss a Cybernetic System. Do you think MIS is an example of a Cybernetic System? Illustrate.
5. Discuss various activities performed by MIS in an organisation.
6. Briefly discuss systems approach and MIS as a system. Also discuss its nature and scope in business organisations.
7. Give various characteristics of MIS. Support your answer with suitable examples.
8. Briefly describe the following terms:
   (a) Physical system
   (b) Information system
   (c) Interface
   (d) Boundary and environment
   (e) Cybernetic system
   (f) Management control level
   (g) Synergy
   (h) Decision support
   (i) Central database
   (j) Integrated system
   (k) Management oriented

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ASSIGNMENTS

1. Visit a nearby business organisation and study its MIS.
2. Classify all data items being used in Personnel Information System of your institution.
3. Study a reporting system of any business organisation.
4. List ten information systems in a business organisation.

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Case Study 1

HOTEL STAYCOOL

The opening-up of the economy and the gradual shift in the economy from manufacturing to services has resulted in an intense competition for survival in the hospitality industry.

Hotel Staycool is a well-known hotel situated in the heart of the city. With 15 floors and 280 rooms providing excellent boarding and lodging facilities, it offers deluxe suites, superior single and double rooms along with services like coffee shop, restaurants, saloon, health club, shopping arcades and convention halls. It is one of the most sought-after hotels in the city as reflected by the fact that 1,20,000 guests stayed at the hotel in the financial year 2009-10.

The functional responsibilities of the hotel are divided into various departments, which are shown in Fig. 1.

The front office of the hotel occupies a very important position in ensuring a loyal clientele for the hotel. The job of the front office is to interact with every outsider who steps in the hotel. The front desk takes care of all the needs of the guests. The most important job of the front office includes making all reservations, handling check-ins and check-outs. In short, the

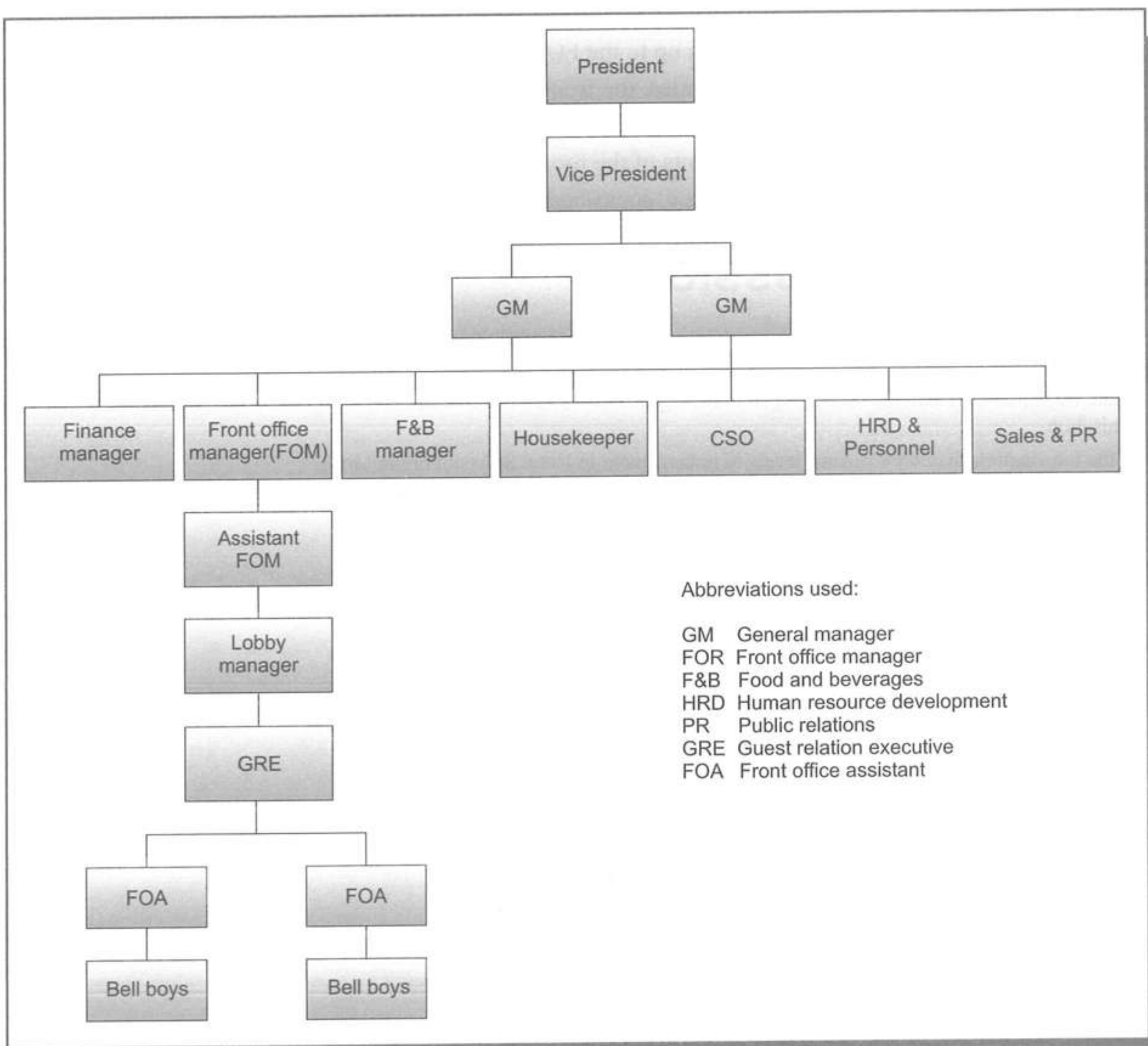

Fig. 1 Organisational Structure of Hotel Staycool

front office or the front desk is the interface between the hotel and the outside world. Behind the scene is a large number of people, who perform a wide variety of functions to keep the front office running smoothly.

From the very moment a guest begins his stay in the hotel, the front office comes into the picture and interacts with the guest on a daily basis till he leaves the hotel. The guests can be individuals or corporate guests. In case of corporate guest, the bill is sent to the organisation sponsoring the stay. The front office comes into contact with the traveller in the following ways.

(i) *While answering queries* about reservations/cancellations/modifications regarding the stay.

(ii) *While making reservations for the traveller.* The traveller can also book the room by paying in advance.

(iii) *By receiving the traveller on his/her arrival.* The guest fills in the detailed personal information form, which includes his identity, estimated duration of stay, room preferences, etc.

(iv) *While making room allotments.* Actual room as per the guest choice is allotted, provided it is notified as ready, by the housekeeping department.

(v) *While handling guest demands or grievances during the stay.*

(vi) *While making arrangements for departure of the traveller.* Return tickets, taxi, payment, clearance, etc., are arranged by the front office.

At Staycool, the basic operations of the front desk are performed by a team of three Front Office Assistants (FOAs), two cashiers per shift (of 8 hours) and a hierarchy that goes up to the FOM.

Apart from performing the above-mentioned activities, the front office also interacts with:

(i) Accounts: Daily-reporting of transaction details.

(ii) Housekeeping: Informing about the requirements of the room, e.g. additional beds, cleaning, etc.

(iii) Management: Statistical data about the guest, e.g. socio-economic profile, nationality, etc.

QUESTIONS FOR DISCUSSION

1. Identify the data involved in the organisational activities mentioned in Hotel Staycool. What possible information can be generated by this set of data?
2. Identify the ways in which activities are grouped in the organisation structure and discuss its impact on the information requirements of the organisation.
3. Identify the information shared by various levels of management in Hotel Staycool organisation.
4. Discuss the possible benefits that the hotel may accrue if it decides to implement a suitable IT/IS.

Case Study 2

MIS AT SUDESH AND COMPANY

Sudesh and Company, with four plants, sixteen assembly departments, eighteen cloth-cutting centres and more than 200 machine centres has installed an integrated information system.

The operations are characterised by a nation-wide distribution network. The project moves through 38 branch offices and 312 authorised distributors all of which maintain some inventory. Authorised distributors generate 37 per cent of the orders but account for only 24 per cent of the sales. Most of the business is done through the branch offices.

The product line is large, products are classified into 176 family groups, representing 12,000 finished goods. Approximately 1,500 new items enter the product line annually and a similar number are discontinued.

The 12,000 finished goods require 25,000 components, of which 6,600 are carried in inventory and 18,400 are made to order. The integrated system has already paid substantial dividends and refinements continue to increase the benefits. In the seventies, Sudesh and Co. was achieving a 60 per cent customer service level (i.e. 60 per cent of the orders were being delivered according to original customer request with no delays or adjusting of dates). The sales/inventory ratio was a respectable 4.2 per cent. However, the production cost variance averaged 16.3 per cent. Clerical expenses ran up to 36 per cent of sales.

This was not good enough in a highly competitive business. Since the primary asset a company has (in addition to high quality reliable products) is customer service, an improvement in customer service was given top priority.

Three areas of cost control were also given high priority. They were:

(i) Production costs, especially those associated with a nationwide disbursement of inventory, must be controlled within reasonable limits, relative to the needs of customer service.

(ii) Distribution costs, especially those associated with a nationwide disbursement of inventory must be controlled within reasonable limits, relative to the needs of customer service,

(iii) Clerical costs in a growing business must be contained and if possible, reduced.

A computerised integrated management information and control system was instituted. By the early eighties, performance in the following four areas of high priority greatly improved.

(i) Customer Service: Up to 72 per cent of orders were now filled as requested, as against the earlier 60 per cent, showing substantial improvement.

(ii) Inventory Turnover: The sales/inventory ratio was 6.2, a 50 per cent increase over the previous performance. More improvement was expected.

(iii) Production Cost Variance: This category had all but disappeared, being controlled with a 1 per cent tolerance. This was possible because timely and accurate information now was available when needed.

(iv) Clerical Expense: The ratio of clerical expenses had dropped to 2.8 per cent, an unusual achievement in a rapidly growing business that had to face increasing rates of clerical labour.

Of late, the company realised that they should enter into custom manufacturing, as its initial mass production techniques had pushed it into standardised products and long product life cycles. Rigid manufacturing emphasised efficiency and low cost, but not true customer satisfaction. Customers want quality, value and products specially tailored to their needs – at the lowest possible price.

Custom-manufacturing uses state-of-the-art information technology to produce and deliver products and services designed to fit the specifications of individual customers. Companies can customise products in quantities as small as one unit with the same speed and low cost as mass production methods. In custom-manufacturing, software and computer networks are used to link the plant floor tightly with orders, design and purchasing to finely control the production machines. The result is a dynamically responsive environment in which products can be turned out in greater variety and easily customised with no added cost for small production runs. Huge manufacturers can be as agile as small firms.

Custom-manufacturing systems take information from the customer and apply it behind the scenes to control the flow of goods.

QUESTIONS FOR DISCUSSION

1. Are you impressed with the improvement in customer service, inventory turnover, production cost variance and clerical expenses? Justify your answer.
2. How could custom-manufacturing change the way the company did its business?
3. Which activity areas were the focus of MIS: operational control, management control or strategic planning? Do you agree with the emphasis?

Chapter 2

Structure and Classification of MIS

Learning Objectives

After going through this chapter, you should be able to:

- Clearly understand the concept of a structure of MIS
- Describe the structure of MIS using multiple approaches
- Explain the classification of MIS and understand the concepts of TPS, MIS, DSS, ESS, OAS and BES
- Understand functional information systems

2.1 STRUCTURE OF MIS

Structure of MIS is a difficult concept to understand because there is no standard or universally accepted framework for describing management information system. Thus, it is not simple to answer a question like what does a management information system look like? How can one describe its conceptual or physical structure? Structure, no doubt, determines the shape of an entity. The question, as to what does an entity look like, should ideally speaking, be answered by giving its outline or structural specifications. However, some entities may have well-defined outlines or other structural specifications, whereas some may not. It is because of this reason that structure of MIS is difficult to delineate. Different approaches may be used while describing an entity. For example, a car may be perceived in a number of different ways; by describing its physical characteristics, i.e. its shape, colour, seating capacity, doors, etc., in terms of the component systems such as chassis, engine, ignition system, etc., and in terms of its major use such as passenger car, sports car, etc. Each of these approaches would provide an understanding to the person about the car. Similarly, a department may be understood in terms of its functions like sales, advertising and market research; or by describing its organisational structure, like marketing department has vice-president at its top, followed by marketing manager at the management control and sales officer at the operational control level of the hierarchy. Thus, multiple approaches help in describing the structure of an entity in a better way.

FOCUS

MIS structure may be described by following a variety of different approaches:
- Physical components
- Information system processing functions
- Decision support
- Level of Management activities
- Organizational functions

MIS structure may be described by following a variety of different approaches, such as:

(i) Physical components,

(ii) Information system processing functions,

(iii) Decision support,

(iv) Levels of management activities, and

(v) Organisational functions.

2.1.1 MIS Structure Based on Physical Components

Structure of MIS may be understood by looking at the physical components of the information system in an organisation. The physical components of an organisational information system may be hardware, software, database, manual procedures and operating persons. A brief description of these components has been outlined in the following paragraphs:

Hardware

Hardware refers to the physical data processing equipment and peripheral devices. For example, Central Processing Unit (CPU), monitor, keyboard, printer, drives, tapes, communication devices, etc.

Software

Software is a broad term given to the instructions or programs that direct the operation of the hardware. Software could be of two types, i.e. system software and application software.

Database

The database consists of all data utilised by application software. Data is stored in files.

Procedures

Formal operating procedures, which are required to operate a system, such as manuals, are also regarded as physical elements.

Operating Personnel

Personnel like Computer Operators, Computer Programmers, System Analysts, System Managers, etc., are the operating people of the information systems.

Input and Output

Various physical inputs and outputs from the information system, existing in the forms like printout, reports, etc.

2.1.2 Information System Processing Functions

Information system structure can also be understood in terms of its processing functions. The functions of an MIS explain what the system does. The main processing functions of information systems are described below.

(i) *To Process Transactions:* Information systems process transactions, where transaction may be defined as an activity taking place in an organisation. For example, making a purchase or a sale or manufacturing a product. It may be within the organisation or may be external in nature.

(ii) *To Maintain Master Files:* Information systems create and maintain master files in an organisation. A master file stores relatively permanent or historical data about organisational entities. For example, data processing to prepare an employee's salary requires data items for the employee' s basic pay, allowances, deductions, etc.

(iii) *To Produce Reports:* Reports are significant products of an information system. Many reports are produced on a regular basis, which are called scheduled reports. An information system also produces reports on ad hoc requests. These are known as special or ad hoc reports.

(iv) *To Process Enquiries:* An information system is used to process enquiries. For processing such queries, the information system uses its database. These may be regular enquiries with a pre-defined format or ad hoc enquiries.

(v) *To Process Interactive Support Applications:* The information system contains applications designed to support systems for planning, analysis, and decision-making. Various types of models are used for processing

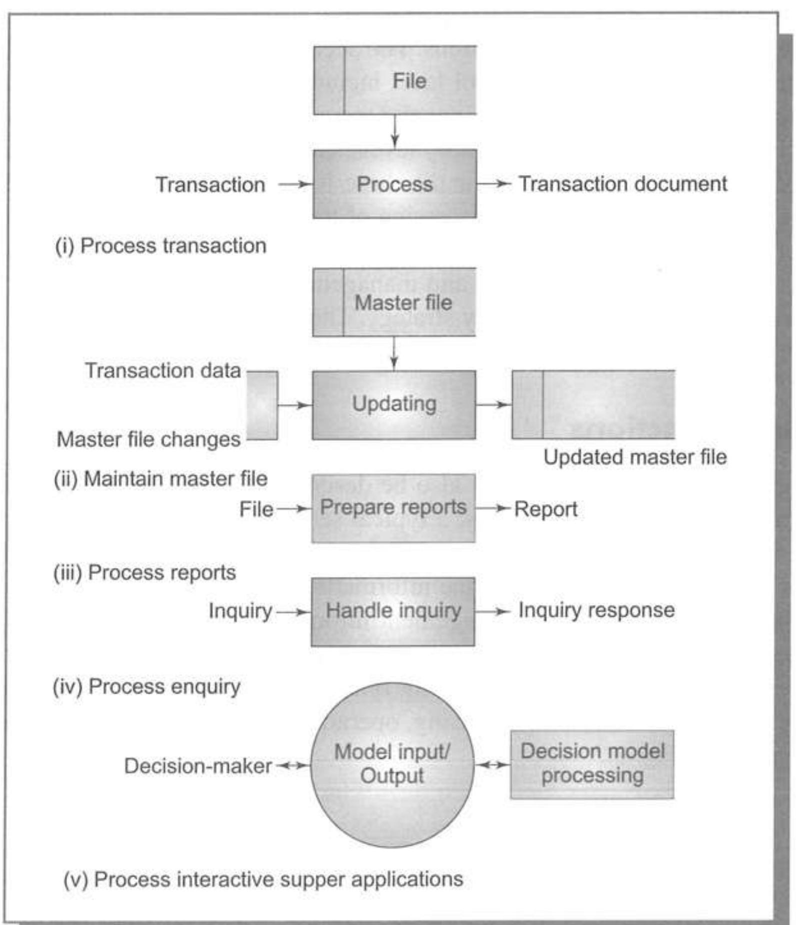

Fig. 2.1 Information System Processing Functions

such applications. The mode of operation, as the name suggests, is interactive, in which the user responds to questions and requests for data and receives results so as to make changes in the inputs until an optimum solution is found. This approach has been depicted in Fig. 2.1.

2.1.3 Decision Support

Structure of MIS can also be described on the basis of its support in decision-making in an organisation. Decisions vary with respect to the structure that can be provided for making them. A highly structured decision can be pre-planned, whereas a highly unstructured decision cannot. A structured decision, because of its well-defined nature can be said to be programmable. However, it should not be taken to necessarily mean that the decision is automated, although many programmable decisions are automated. An unstructured decision is said to be non-programmable. The structured programmable decision tends to be routine and frequently repeated; the unstructured decision tends to occur with less frequency and tends to be irregular (see Chapter 9). Information system support will fit easily into this classification, but some decisions are more or less structured and have some elements that are programmable and some that are not. Such decisions are called semi-structured decisions.

2.1.4 Levels of Management Activities

Management information systems support various management activities in an organisation. This implies that the structure of an information system can be categorised in terms of levels of management activities. Anthony, on the basis of activities, has classified the management hierarchy into three levels. These are:

(i) Strategic Planning Level,
(ii) Management Control Level, and
(iii) Operational Control Level.

Stragetic planning deals with long-range considerations. The decisions include the choice of business directions, market strategy, product mix, etc. Management control level includes acquisition and organisation of resources, structuring of work, and acquisition and training of personnel. Operational control is related to short-term decisions for current operations. Pricing, production levels, inventory levels, etc., are a result of operational control activities. Management activities and information processing for the three levels are interrelated. For example, inventory control at the operational level depends on accurate processing of transactions at the level of management control. Decisions made about safety stock and reorder frequency are dependent on the correct summarisation of results of operations. At the strategic level, results in operations and management control are related to strategic objectives, competitor behaviour and so forth to arrive at inventory strategy. Thus, the information systems would be different for the three levels of management hierarchy.

2.1.5 Organisational Functions

The structure of management information system can also be described in terms of the organisational functions. Though there is no standard classification of functions, a typical set of functions in a manufacturing organisation includes production, sales and marketing, finance and accounting, materials, personnel and information systems. Each of these functions, as already discussed, has unique information needs and each requires information system support designed specifically for it. Moreover, a management information system is essentially an integration of information systems that are designed to support the functional sub-systems of the organisation. Each sub-system requires applications to perform all information processing related to the function. Within each functional sub-system, there will be applications for transaction processing, operational control, management control and strategic planning. This has been depicted in Fig. 2.2.

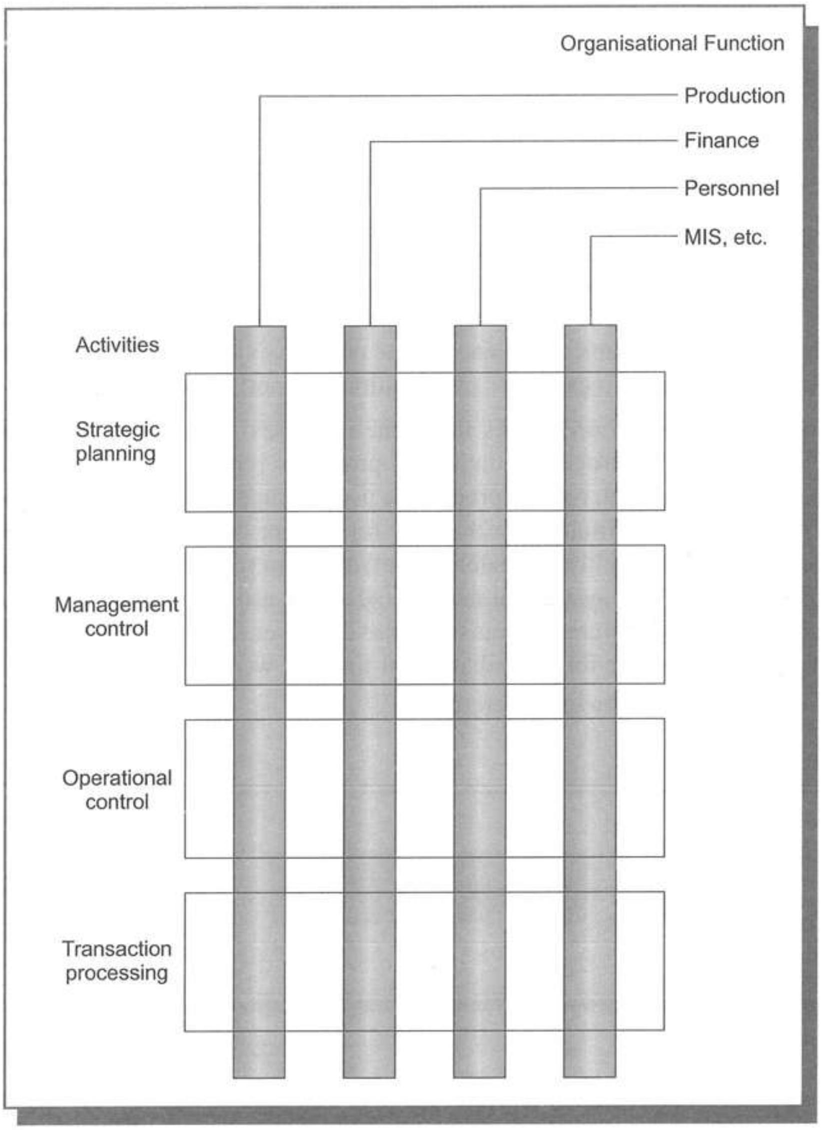

Fig. 2.2 Organisational Functions and Management Activities

2.2 MIS CLASSIFICATION

The discipline of MIS is in its evolutionary stage. MIS is a concept which is a matter of degree rather than an absolute one. In management, there are perhaps few other areas other than MIS which have evoked such a controversy. Over the years, it has evolved from an elementary concept to an advanced discipline of today.

Though it lacks clear lines of demarcation and is classified in several different ways; for the sake of clarity, we have categorised information systems on the basis of their roles in the operations and management of a business. Accordingly information systems have been primarily categorised as under:

(i) Operations Support Systems
(ii) Management Support Systems

Let us understand some of the examples under each information system category.

2.2.1 Operations Support Systems

As and when any transaction takes place in an organisation, data, which is a by-product of a transaction, is generated. Also, business operations are carried out using data. In order to process such data, information systems are required, which are called operations support systems. These systems produce various types of information products for internal and external use. However, such systems do not lay emphasis on producing specific information products that can be used by the managers.

In order to make use of such products, further processing of the output from such systems is required. Such a processing is done by management information systems. The role of operations support system is to efficiently process business transactions, control industrial processes, support organisational communications and update company's databases. Given below is a brief description of various examples of operations support systems.

FOCUS

Operating support systems:
Transaction Processing systems: It records and processes data, and produces reports. It represents the automation of the fundamental, routine processing used to support business operations.
Office automation systems: It refers to the application of computer and communication technology to office functions. By providing secretarial assistance and better communication facilities it improves the productivity of managers.

(i) *Transaction Processing Systems:* As the name indicates, transaction processing system (TPS) records and processes data, and produces reports. It represents the automation of the fundamental, routine processing used to support business operations. It does not provide any information to the user for his/her decision-making. These systems process transactions either in batch processing or in real-time processing. For example, point-of-sale (POS) systems at many retail stores use electronic cash register terminals to electronically capture and transmit sales data over telecommunication links to head office computer centre for immediate (real-time) or weekly (batch) processing.

TPS uses data and produces data as shown in the following diagram.

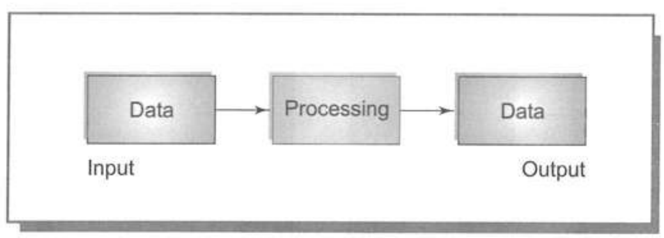

Fig. 2.3 Transaction Processing System

Previously, TPS was known as Management Information System. Prior to computers, data processing was performed manually or with simple machines. However, nowadays, data processing is mainly done with the help of computers. In many organisations, TPS is also known as a Data Processing System. Its domain is obviously at the lowest level of management hierarchy of an organisation. Transactions could be externally generated or from events internal to an organisation. Externally generated transactions are from customers, suppliers, and other groups. Any internal event that is recorded by the information system is considered to be a transaction. For example, transferring work in process from one stage of production to the next, recording depreciation on equipment, making routine file changes such as adding or deleting records or changing an employee's address, and correcting errors in previous input data are all examples of internal transactions. The output of a data processing system or TPS may be in several forms. One type of output is revised data files which have been corrected for errors, have had records added or deleted or have had record status such as employee name or address altered in some fashion.

(ii) *Process Control Systems:* The systems which monitor and control physical processes are known as Process Control Systems. For example, pharmaceutical manufacturing company uses electronic sensors linked to computers to monitor chemical processes and make the required adjustments.

(iii) *Office Automation Systems:* Office automation refers to the application of computer and communication technology to office functions. Office automation systems are meant to improve the productivity of managers at various levels of management by providing secretarial assistance and better communication facilities. Office automation systems are the combination of hardware, software and people in information systems, that process offices transactions and support office activities at all levels of the organisation. These systems include a wide range of support facilities, which include word processing, electronic filing, electronic mail, message switching, data storage, data and voice communications, etc.

Office activities may be grouped under two classes, namely:

(i) activities performed by clerical personnel (clerks, secretaries, typists, etc.), and
(ii) activities performed by the executives (managers, engineers or other professionals like economists, researchers, etc.).

In the first category, the following is a list of activities.

(a) typing,
(b) mailing,
(c) scheduling of meetings and conferences,
(d) calendar keeping, and
(e) retrieving documents.

The following is a list of activities in the second category (managerial category).

(a) conferencing,
(b) production of information (messages, memos, reports, etc.), and
(c) controlling performance.

As already discussed, information technology facilitates both types of activities. A wide variety of office automation devices like fax machines, copiers, phones, etc., are used in offices. However, nowadays, computer-based office automation systems are gaining popularity among managers and office staff, because such systems offer integrated solutions that can be shared automatically. Computer-based office automation systems not only cater to the communication needs of the office managers within the organisation but also help to communicate with external entities such as vendors, investors, customers, etc. Some of the applications of office automation systems are discussed, in brief.

Word Processing

This refers to the computer-assisted preparation of documents (like letters, reports, memos, etc.) from textual data. Text is entered via a keyboard which is displayed on the screen of a visual display unit. Data once entered can be manipulated in various ways. It can be edited, stored on magnetic media and reproduced through simple commands which eliminate the need for redrafting the entire document. Spellings can be checked automatically and pre-defined letters can be generated, addressed to many persons by merging the letter and address through a mail-merge program. Nowadays, these systems can even be trained to understand the dictation of the manager and to convert it to text on the word processor.

Electronic Filing

This facilitates the filing of incoming and outgoing mail/documents on a magnetic media. Information is captured from the documents and is stored for future reference. Computer-based filing systems have the advantage of space saving and permitting easily modifiable cross-reference indexes. These indexes contain pointers to the location of the document itself.

Electronic Mail

It involves the transfer of letters and other documents through telecommunication lines, rather than through physical delivery. An electronic mail system requires a telecommunication network and software. It speeds up mail deliveries and reduces the cost and time taken by paper-mail.

Local Area Networks (LANs) have further facilitated the sharing of data files and software among many different computer terminals. Workstations/terminals can also transfer data/messages to each other. Voice mail, which is another form of e-mail, transmits messages in digitized voice. The receiver can hear the spoken messages in the voice of the sender by dialing a voice-mail service. Advancements in multimedia technologies have also made desk-top teleconferencing systems quite popular.

2.2.2 Management Support Systems

FOCUS

Management Support System (MSS) are the information systems' applications that focus on providing information and decision support for effective decision making by manager

Management Support Systems (MSSs) are the information systems' applications that focus on providing information and decision support for effective decision-making by managers. There are various types of information systems that support a variety of decision-making process. For example, management information systems, decision support systems, and executive support systems.

(i) Management Information Systems

Management Information System (MIS) is an information system which processes data and converts it into information. This has been depicted diagrammatically in Fig. 2.4.

A management information system uses TPS for its data inputs. The information generated by the information system may be used for control of operations, strategic and long-range planning, short-range planning, management control and other managerial problem solving. Exception reports are the first type of information, which may be based directly on transaction files. The domain of MIS is mainly management control level of management hierarchy. In contrast to TPS, a management information system is more comprehensive; it encompasses processing in support of a wide range of organisational functions and management processes. Secondly, MIS is capable of providing analysis, planning and decision-making support.

FOCUS

Management Support System (MSS) are Management Information System is an information system which processes data and converts it into information.

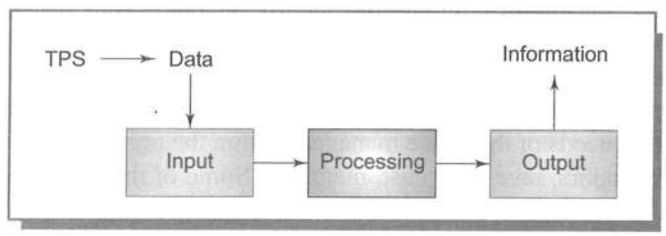

Fig. 2.4 Management Information System

(ii) Decision Support System (DSS)

A decision support system (DSS) is an information system application that assists decision-making. DSS tends to be used in planning, analysing alternatives, and trial and error search for solutions. Such systems are generally operated through terminal-based interactive dialogues with users. They incorporate a variety of decision-models and thus are capable of performing 'What-if' analysis for managers. DSS differs from most traditional information systems in that usually each decision support system is distinct from the other information system and is tailor-made for every manager. Decision Support Systems, although created and used by managers, are nevertheless a part of the organisation's MIS. As decision support system is tailored to a specific managerial task or special problem, its use is limited to that task or problem. Decision support systems tend to be designed primarily to serve at the management control level and strategic planning level managers. The elements of a decision support system include a database, model base and a software providing interactive dialogue facility for the manager. The data in the database typically is a combination of master files (internal corporate data) and data from external sources.

FOCUS

Decision support system is an information system application that assists decision making. DSS tends to be used in planning, analysing alternatives, and trial and error search for solutions.

The second component of the DSS is a library of models to manipulate and analyse the data in the desired ways. The model base might include econometric models to forecast demand by industry and simulation models of the corporation.

A user interface is the third component. Through this, the user can communicate with the DSS. The physical interface generally consists of a terminal, hooked up to the mainframe computer, either directly or by telephone. Micro-computers with modems are being used ever more frequently for this interface. These elements are illustrated in Fig. 2.5.

DSS goes one step further to a management information system as DSS supports decision-making. DSS uses MIS depicted in Fig. 2.6.

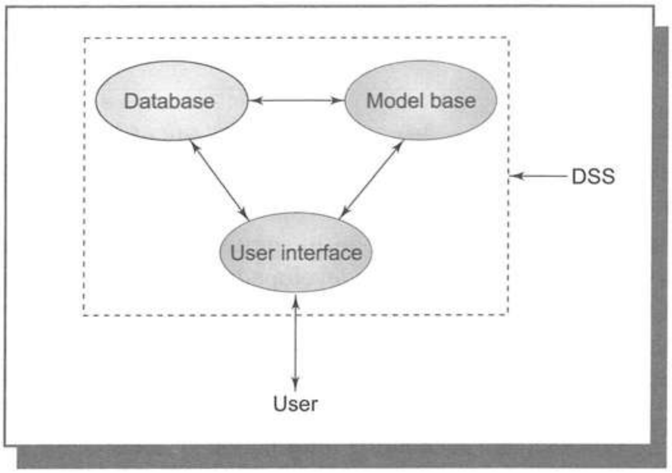

Fig. 2.5 Elements of DSS

DSS can be differentiated from MIS in terms of its processing capabilities. Whereas MIS processes data to convert it into information; DSS processes information to support the decision-making process of a manager. For

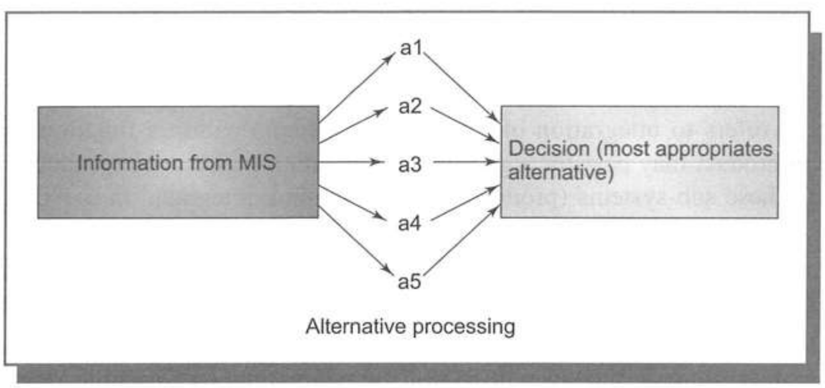

Fig. 2.6 Decision Support System

example, a salary information system provides information to every employee regarding his basic salary, allowances and deductions, if any, etc. However, if an employee wants to make deposits in some schemes for availing income tax rebates, he can make use of DSS. Decision support system helps the user decide in which scheme and how much he should invest in order to get maximum benefits. Secondly, DSS provides an interactive dialogue environment, through which the user can interact with the system to add/alter the data as per his requirements. The main application areas of DSS are production, finance and marketing. For example, DSS supports decision making i ı procurement analysis, production planning and scheduling, inventory planning and control, financial planning and analysis, tax planning, strategic financial planning, financial performance analysis, marketing mix decisions, etc. DSS can nowadays, be developed with the help of special purpose software packages. These language packages usually include several pre-written analysis routines such as interest calculation formulae, discounted cash flow calculation routines, internal rates of return, and time-series analysis routines. These routines can be easily integrated into decision support system requiring that particular calculating function. Interactive Financial Planning Systems (IFPSs) and Simplan are two well-known decision support system software packages in use. Visicalc, Supercalc, Context MBA, MS-Excel, etc., provide similar but less extensive assistance in developing decision support systems.

(iii) Executive Support System

Executive Support System (ESS) is an extension of the management information system, which ia a special kind of DSS and provides critical information from various inter- and intra-sources in easy to use displays. An ESS is specially tailored for the use of the chief executive of an organisaton to support his decision-making. Thus, ESS is a comprehensive information system which includes various types of decision-support systems, but it is more specific and person-oriented. An ESS is designed to cater to the information needs of a chief executive keeping in view not only his requirements but also taking into account his personality and style of functioning, etc.

(iv) Enterprise Systems

Enterprise systems as the name implies are the systems that integrates all facets of an organisation including its planning, manufacturing, sales, human resource management, customer relations, inventory control, customer order tracking, financial management, and marketing, i.e. all aspects of business organisation.

FOCUS

Executive Support system is a special kind of DSS and provides critical information from various inter and intra sources in easy to use displays.

It is, as has already been defined, an integrated system. In business organisations, information systems are generally developed to cater to the information needs of managers of each of the functional areas of the business. The functional areas of a business may be marketing, production, human resource, finance and accounting, etc., and correspondingly the information systems supporting these functions are known as marketing information system, production/manufacturing information system, human resource information system and financial and accounting information systems (see functional information system). Alternatively there may be a common structure useful to each of the business functions. Integration of the information may be:

(i) hierarchical,
(ii) horizontal, and
(iii) cross-functional.

In hierarchical integration, operational control level systems feed data to a higher level system, i.e. to the management control level (middle level) and to the strategic planning level (top level).

Horizontal integration refers to integration of information systems within a functional area or a chain of command. For example, a product may pass through several production processes in production department. The information system of all these sub-systems (production processes) are integrated in a departmental production information system.

Cross-functional information system, as the name indicates, associate with different functional areas. For example, a marketing information system may transmit information regarding loss of sales because of inventory shortage to the inventory control information system.

Nowadays, with the emergence of Business Process Re-engineering (BPR) and advancements in network technology, emphasis is being given to business processes and their integration. The information systems that focus on the business process that a product passes through, integrate all these processes even in different functional areas and thus make the demarcation lines of functional areas weak. Such information systems are more popular in larger organisations having wide geographical coverage and diversified product range because of the problems faced by these organisations mainly in inter-functional communications. Different software vendors have termed such systems differently, but the most commonly used systems are Customer Relations Management (CRM); Supply Chain Management (SCM); and Enterprise Resources Planning (ERP) systems. These systems have been explained in Chapter 9.

FOCUS

Enterprise Systems integrates all facets of the organization including its planning, manufacturing, sales, human resource management, customer relations, inventory control, customer order tracking, financial management and marketing- i.e. all aspects of business organization.

2.2.3 General Support Systems

The above-mentioned categories of information systems have been defined on the basis of their role in operations and management of a business. However, there are many other applications of information systems which fall in both the categories, as they provide support in operations as well as managing of the business. Such information systems may be categorised under general support systems. For example, business expert systems, functional business systems and strategic information systems.

(i) Business Expert Systems

Business expert systems, which are based on artificial intelligence (AI), are advanced information systems. Artificial intelligence may be referred to as the capability that makes computers display intelligent, human-like behaviour. For example, reasoning, drawing inferences, learning and problem-solving are such acts of intelligence.

A Business Expert System (BES) is a knowledge-based information system that uses its knowledge about a specific, complex application area to act as an expert. Thus, expert systems provide decision support to managers in the form of advice from an expert in a specific problem area. Expert systems find application in diverse areas, ranging from medical, engineering and business.

> **FOCUS** Business Expert systems are advanced information systems based on artificial intelligence, which may be referred to as the capability that makes computer display intelligent, human like behaviour.

The main advantages of using expert systems may be outlined as follows.

(i) The knowledge/capabilities of many experts can be used to build a single expert system.

(ii) Decision-making in critical times can be more reliable, as these systems are not affected by emotional factors or fatigue.

(iii) Multiple hypotheses can be considered simultaneously.

The expert system is interactive in nature, which enables it to ask questions of the user. On the basis of these questions, an expert system searches its knowledge base for facts and rules, explains its reasoning process when asked and comes out with expert advice to the end user in the subject area being explored.

The main components of an expert system (see Fig. 2.7) include:

(i) Knowledge base,

(ii) Inference engine, and

(iii) User interface.

Knowledge base contains the facts about the specific expert area and heuristic (rules of thumb) that describe the reasoning procedures of an expert on the subject.

Inference engine contains the logic of reaching an inference from the stored data and rules (knowledge base).

> **FOCUS** Knowledge Management systems support the creation, organisation and dissemination of business knowledge to managers and other employees of the organisation.

Expert systems may be developed by suing either programming languages, such as LISP, PROLOG or C by using expert system packages (expert system shells). Using the expert system packages, which are like application generators, one can design an expert system that combines the features of a DSS and an expert system. This integration makes the application development process easier and faster for end users.

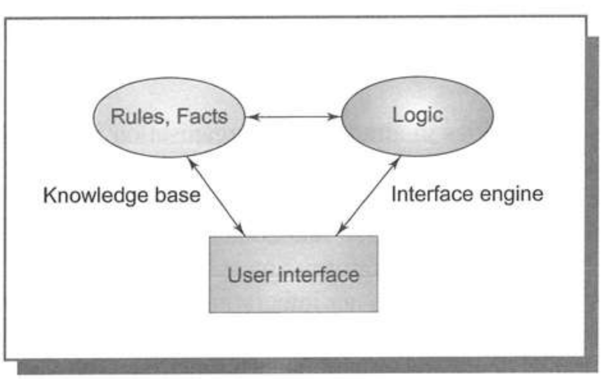

Fig. 2.7 Main Components of an Expert system

(ii) Knowledge Management Systems

Knowledge management systems are information systems that are knowledge based and, thus, support the creation, organisation and dissemination of business knowledge to managers and other employees of the organisation, for example, Intranet access to the best practices and solutions to various business problems. Nowadays many companies are building knowledge management systems to manage organisational learning and business know-how. They are developed to provide quick feedback to knowledge workers, encourage behaviour changes by employees and improve business performance. Figure 2.8 portrays a general structure of knowledge management system.

> **FOCUS** Strategic Information systems apply information technology to products, services or business processes of an organisation to help the organisation gain a strategic advantage over its competitor.
> Functional Business systems are generally developed around the functional areas of a business organisation.

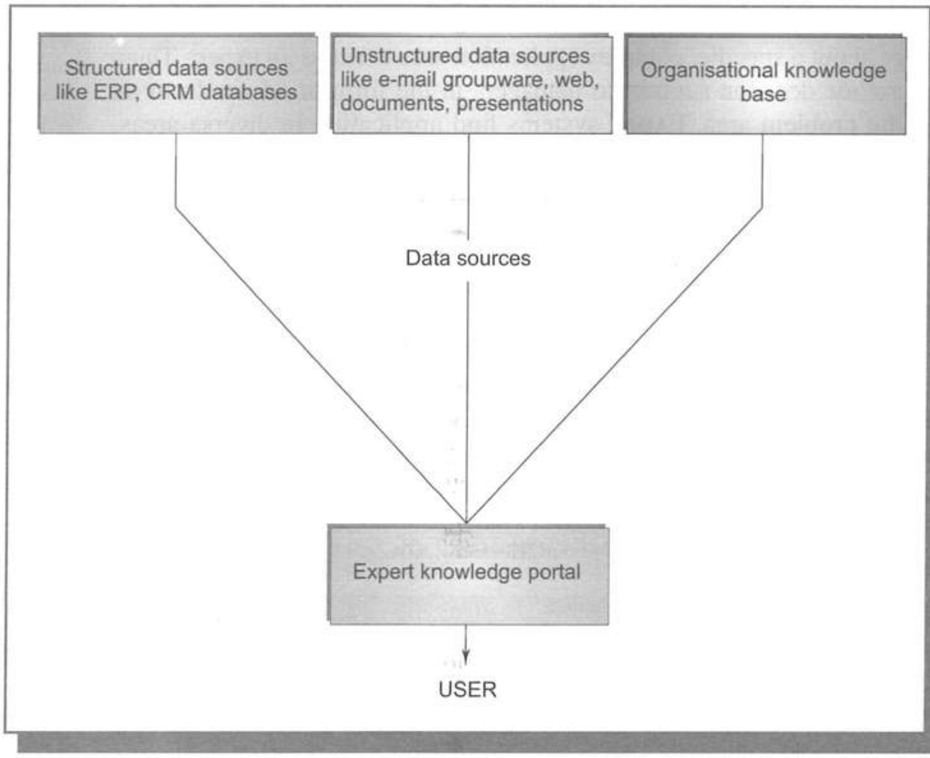

Fig. 2.8 Knowledge Management System

(iii) Strategic Information Systems

Strategic Information Systems apply information technology to the products, services or business processes of an organisation to help the organisation gain a strategic advantage over its competitor. Thus strategic information system can be any kind of information system (TPS, MIS, DSS, ESS, etc.) that uses IT to help an organisation gain a competitive advantage, reduce a competitive disadvantage, or meet other strategic enterprise objectives (Bowles, Jerry, 1997).

(iv) Functional Business Systems

One of the most widely used basis for organising activities in almost every organisation is the business function. Business activities are grouped around functions such as production, marketing, finance and personnel, etc., resulting in the respective department or an area of the business organisation. These departments or functional areas are commonly known as the functional areas of business. Each of these functional areas, as already discussed in the previous chapter, has unique information needs and thus requires information system support designed specifically for it. Moreover, a management information system is essentially an integration of information systems that are designed to support the functional sub-systems of the business. Each sub-system requires applications to perform all information processing related to the function. It may be noted that within each functions, sub-system, there will be applications for transaction processing, operational control, management control and strategic planning. Secondly, different functional systems should not, in any way, be misunderstood as being independent, separate or distinct systems; rather they all are the parts of the organisational system and interact with other sub-systems through the medium of information. Further, there is no standard classification of such sub-systems in an organisation, but typical set of functions in a manufacturing organisation includes:

(i) production,
(ii) marketing,
(iii) finance and accounting,
(iv) materials, and
(v) personnel systems.

Some of the main activities for each functional system have been illustrated in Fig. 2.9.

Information systems are generally developed around the functional areas of a business organisation, popularly known as functional information systems. For example, Financial Information System, Personnel Information System, Marketing Information System, Production Information System and so on. A brief description of these functional information systems is given below.

(a) Financial Information System

Financial information system is a sub-system of organisational management information system. This sub-system supports the decision-making process of financial functions at the level of an organisation. The basic financial decisions, which an organisation usually takes, may include the following.

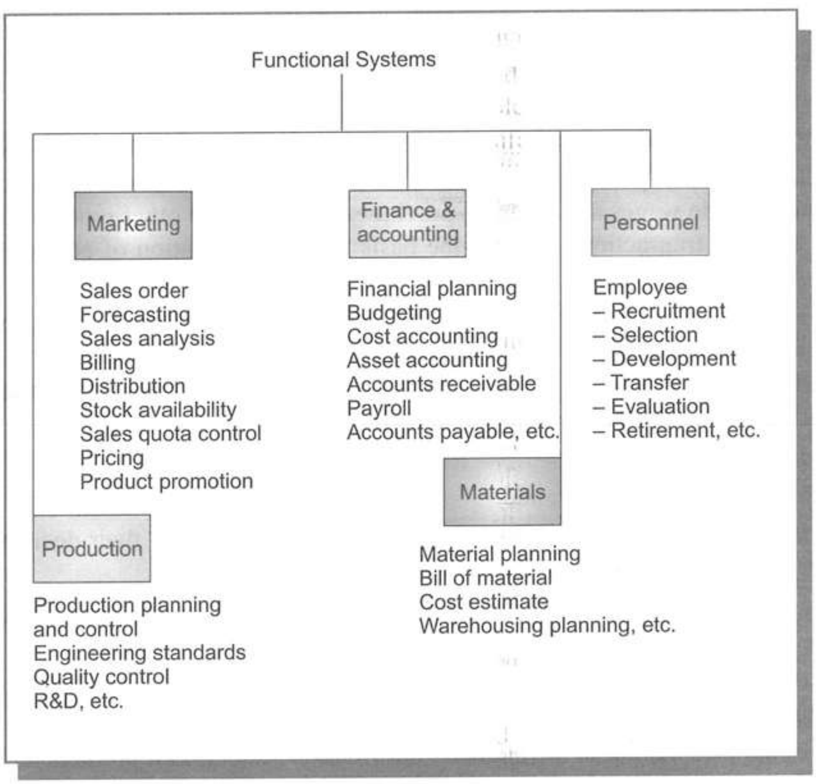

Fig. 2.9 Main Activities of Various Functional System

(i) Where to invest funds and to what extent?

(ii) Where to raise funds and what amount?

(iii) How much to pay in dividends (in case, it is a public company)?

A brief description of each of the financial decisions, that a financial manager has to take, is given below.

Capital Budgeting Decision

In this decision, funds are allocated to long-term assets which would yield benefits/returns in the future. For example, funds allocated for land, building, machinery, etc. Before committing funds, it is very important for the financial manager to evaluate the prospective profitability of the new investment.

Financing Decision

It relates to when, where and how to acquire funds to meet the investment needs of the organisation. The financial manager has to decide about the proportion of equity capital and debt capital. He has to determine areas where the use of debt capital affects the return and poses a risk to shareholders. The return on equity may increase, but so will the risk. Thus, a proper balance will have to be struck between return and risk.

Dividend Decision

This decision relates to the dividend policy of the organisation. A decision whether the organisation should distribute all profits or retain them or distribute a portion and retain the balance, has to be taken by the financial managers.

Current Asset Management

In order to safeguard the organisation against illiquidity or insolvency, current assets of the organisation are also required to be efficiently managed. Investment in current assets affects the organisation's profitability, liquidity and risk. If sufficient funds are not invested in current assets, the organisation may become illiquid. But it would lose profitability as idle current assets would not earn any profits. Thus, a suitable trade off is needed between profitability and liquidity.

Besides the above-mentioned managerial functions, the other functions of financial systems may be summarised as below.

(i) Controlling the receipt and payments,

(ii) Maintaining statutory records, and

(iii) Preparation of periodic reports for statistics, performance and results for internal control and audit.

Financial systems also include accounting systems as these systems are concerned with recording the transactions of business. Such transactions may include wages and salaries, purchases, sales and all other types of income and expenditure. Obviously, records of these transactions become the basis for the preparation of periodic or annual profit and loss accounts, balance sheets, etc.

In order to perform the above activities and functions, financial information, which is accurate, precise and timely, has to be supplied to the financial manager. These systems involve large amounts of data that is concerned primarily with historical and internal information. However, in some areas of financial planning, it is future-oriented also. For example, the exercise of budgeting is wholly futuristic in nature.

Financial information systems are computerised:

(i) to improve the speed and accuracy of reporting, and

(ii) to provide information and analytical support to financial managers to aid them in their decision-making. Figure 2.10 illustrates a financial information system.

Transactional data is the basis of any type of analysis. This data may include credit applications, billing, payment vouchers, stock transfers, cheques, journal and ledger entries, etc.

Financial intelligence data is collected from banks, government, stock markets, etc., which is processed to determine its impact on the organisational economy.

Organisational plan is another important input in the financial information system, as it portrays the objectives of the organisation. This needs to be reflected in the output of the financial information system, which may be in the form of financial plans.

Many software packages on financial accounting are available in the market, which provide complete financial accounting. Tally, BMS, etc., are the more common packages. Financial planning software (e.g. IFPS, etc.) packages are used for managerial decision-making at higher levels.

(b) Marketing Information System

This sub-system of management information system provides information about various functions of the marketing system of an organisation. Marketing is another functional area of the business organisation, engaged in marketing (selling) of its products to its customers.

Philip Kotler has defined marketing as a social and managerial process by which individuals and groups obtain what they need and want through creating, offering and exchanging products of value with others.

Thus, marketing is a comprehensive term and includes many functions. All activities necessary to direct and facilitate the production and usage of goods and services for a society are included in marketing. Nowadays, marketing has assumed a great significance in all societies, irrespective of the degree of industrialisation. The concept of marketing has also undergone a sea change and thus the traditional concept of marketing does not hold true today. Whereas traditional practices of marketing start with production and considered marketing to be of use in selling and promotion to attain sales at a profit, modern marketing focuses its attention on buyers/customers. It

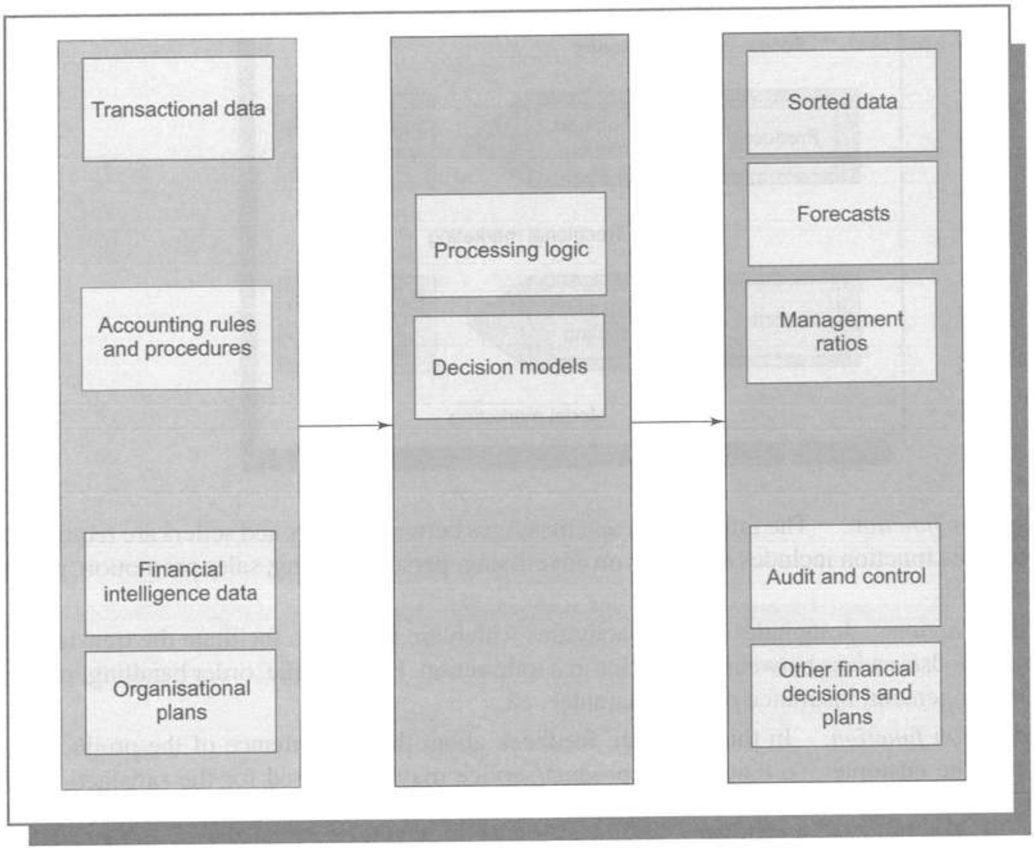

Fig. 2.10 Financial Information System

gets profits through the creation of the buyers' satisfaction and, further seeks to achieve it through an integrated, corporate-wide set of marketing activities. These two views are expressed in Fig. 2.11.

Modern marketing does not simply include activities like selling, advertising or distribution. It involves the interaction of several business activities, whose objective is the satisfaction of the customers' needs and desires. Thus, in this approach, even before the product is produced, marketing comes into operation, i.e. the needs/desires of its potential customers are understood and the product is designed as per the preferences of its customers, whereas in the case of traditional practice, the existing products are sought to be imposed on the market through aggressive selling and promotional pressures.

Some of the important functions of the marketing process include the following.

(i) *The marketing identification function:* The determination of potential buyers and their characteristic is vital in order to satisfy their needs and desires. This enables the marketeer, to know:

  (a) where the buyers are located,
  (b) when do they buy,
  (c) how frequently do they buy, and
  (d) in what quantity do they buy.

(ii) *The purchase motivation function:* In this function, an assessment of various social, economic and psychological forces, which influence the purchase behaviour of the market, is made.

(iii) *The product adjustment function:* This function includes all such activities which are necessary to match the product/services offerings with the market. As the needs/desires of customers keep changing, a corresponding adjustment is required in terms of product planning.

(iv) *The physical distribution function:* The actual movement of goods from points of production to points of consumption is considered in this function. It involves decisions regarding optimum integration of transportation, warehousing and merchandising economics.

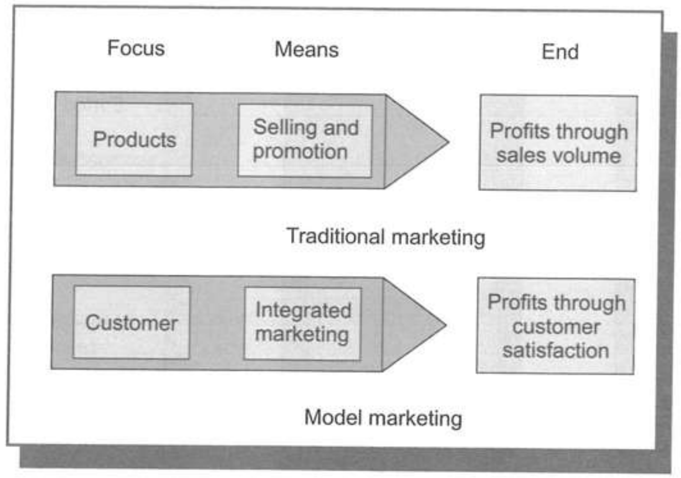

Fig. 2.11 Two Views of Marketing

(v) *The communication function:* The information and messages between buyers and sellers are required to be communicated. This function includes decisions on advertising, personal selling, sales promotion, publicity, packaging issues, etc.

(vi) *The transaction function:* It includes all such activities which are needed to facilitate the transfer of title of ownership of goods/services between the parties in a transaction. For example, order handling, invoicing, billing, credit arrangement, insurance policy, guarantee, etc.

(vii) *The post-transaction function:* In this function, feedback about the performance of the product/service is obtained from the customer, so that quality product/service may be assured for the satisfaction of the customer.

In order to carry out the above-mentioned functions, a marketing manager has to take an array of decisions, for which timely, accurate and relevant information is a must. Thus, every organisation has to organise the flow of marketing information to its marketing managers. The needed information is developed through internal company records, marketing intelligence activities, marketing research and marketing decision support analysis. The concept of marketing information system is illustrated in Fig. 2.12.

Transaction data, which includes reports on orders, sales, prices, inventory levels, receivables, etc., is obtained from the internal records of the organisation. By analysing this information, marketing managers can identify important opportunities and problems. Sometimes, marketing managers need focused studies of specific problems and opportunities, for which they collect *marketing research data.* Such data may be gathered through marketing survey, a product-preference test, a sales forecast by region or an advertising-effectiveness study.

Marketing intelligence data pertains to pertinent developments in the marketing environment. This type of data may be collected by reading books, newspapers, and trade publications, talking to customers, suppliers, distributors, and other outsiders.

To arrive at marketing decisions, a marketing manager needs information on different aspects of marketing. Marketing information system, after collecting various types of data, processes it and disseminates processed data (information) to marketing managers. Marketing managers at higher levels are also being assisted in their decision-making by marketing decision support systems. These systems consist of statistical techniques and decision models to assist in making better analyses and decisions.

(c) Production/Manufacturing Information System

Manufacturing or production information system provides information on production/operation activities of an organisation and thus facilitates the decision-making process of production managers of an organisation.

Manufacturing is another important functional area of an organisation that is engaged in producing goods from raw materials. It is clear that manufacturing is not an activity for every organisation selling goods. Some of these organisations may only be in the business of trading, i.e. buying goods from one organisation and selling it to customers; thus performing the function of either a retailer or a wholesaler. Such organisations are also called

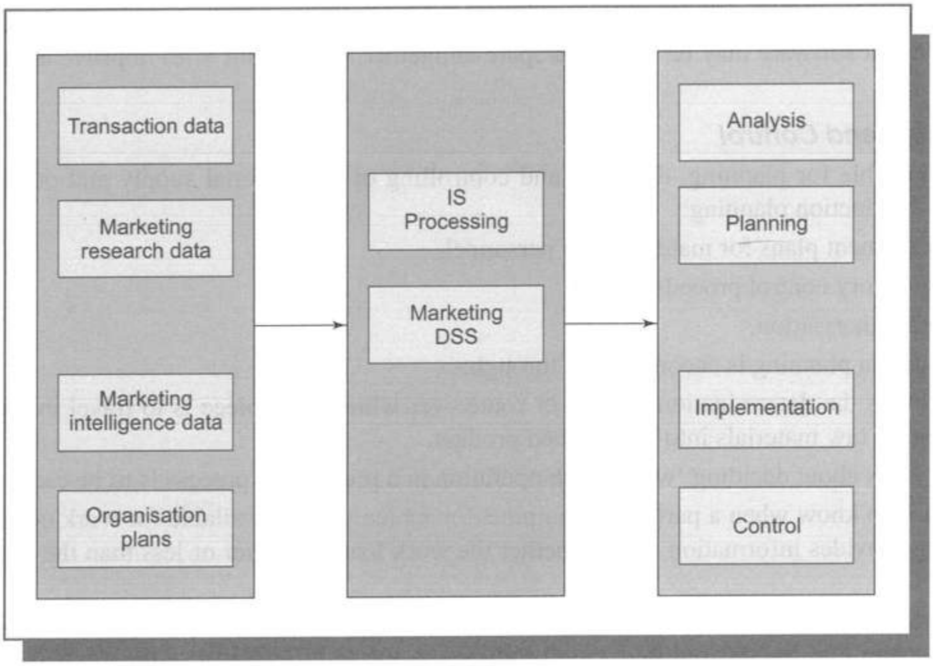

Fig. 2.12 Marketing Information System

merchandising organisations. The concept of production can also be extended to the service organisations, where production is understood as a discharge of some function which has some utility, e.g. repair of an automobile, legal advice to a client, etc. Broadly, we may define production as some act of transformation, i.e. inputs are processed and transformed into outputs. Production management may be understood as an area that deals with decision-making related to the production process, so that the resulting goods and services are produced in accordance with the quantitative specifications and demand schedule with minimum cost. The main decisions to be taken in the manufacturing system are given below.

(i) Product Design,
(ii) Plant Location and Layout,
(iv) Production Planning and Control, and
(iv) Quality Control.

Let us briefly discuss these functions.

Product Design

Product design, which is also known as Product Engineering, includes the entire development of the product through all initial stages until actual manufacturing starts. Preparation of drawings, specifications, experimental and developmental efforts are the activities involved in product design. Nowadays, Computer Aided Design (CAD) and Computer Aided Engineering (CAE) approaches are used in product design.

Plant Location and Layout

Plant location determines the establishment of an organisation at a particular place. It is an important decision because:

(i) location of plant partially determines operating and capital costs,
(ii) each prospective location implies a new allocation of capacity to the respective market area.

However, it must be borne in mind that the decision of plant location is dynamic in nature and thus location study needs continuous monitoring.

Plant layout is the method of arranging machines, equipment, and other services within a pre-designed building, ensuring steady, smooth and economical flow of material. Just like plant location, plant layout is also a continuous process as there is always scope for making improvements over the existing design.

Plant layout designs can be prepared by using mathematical and simulation models in which computers play an important role. The layout software may be used to prepare altogether a new plant or to improve upon a specified one.

Production Planning and Control

This function is responsible for planning, directing and controlling of the material supply and other production processing activities. Production planning:

(i) prepares procurement plans for materials and personnel,

(ii) establishes inventory control procedures, and

(iii) prepares work authorisation.

The task of production planning is accomplished through:

(i) *Routing:* This is the determination of path or route over which each piece is to travel in the process of transformation of raw materials into the finished product.

(ii) *Scheduling:* It is about deciding 'when' each operation in a production process is to be carried out.

(iii) *Loading:* It is to know when a particular equipment/machine will be available for work on each order or item. Loading provides information about whether the work load is greater or less than the capacity of the equipment.

Production control is a procedure to regulate an orderly flow of material and coordinate various production operations so as to ensure that the desired items are produced in the right quantity of the desired quality at the required time at the optimum cost.

Quality Control

It relates to activities that ensure that the finished product conforms to the standard (pre-set) specifications laid down either by the manufacturer or the customer. Various techniques which are used in controlling the quality of a product include inspection, statistical quality control, and control charts, etc.

Manufacturing information system is shown in Fig. 2.13.

Information needed for manufacturing decisions is processed from data that is gathered from a wide variety of sources as discussed below.

Production Data includes production orders, assembly orders, finished items, scrap, etc.

Inventory Data includes data on inventories of raw materials, goods in process and finished goods.

Supplier Data provides information about the sources of raw materials. Nowadays, maintaining this type of data is the responsibility of materials manager.

Workforce Data includes data about the labour market, performance of workers, etc. This type of data is essential for production scheduling and plant utilisation.

Environment Data includes data on technology trends, raw material prices, labour force economics and dynamics. This helps the production manager in the better planning and control of activities of production processes.

Manufacturing information system gathers different types of data from various sources, processes the data to transform it into meaningful information, which is then provided to the production managers to facilitate decision-making at various levels of management.

(d) Human Resource Information System

This functional information system supports the functions of human resource management of an organisation. The human resource management function, in its narrow sense, is also known as personnel management. The function involves:

(i) manpower planning,

(ii) staffing,

(iii) training and development,

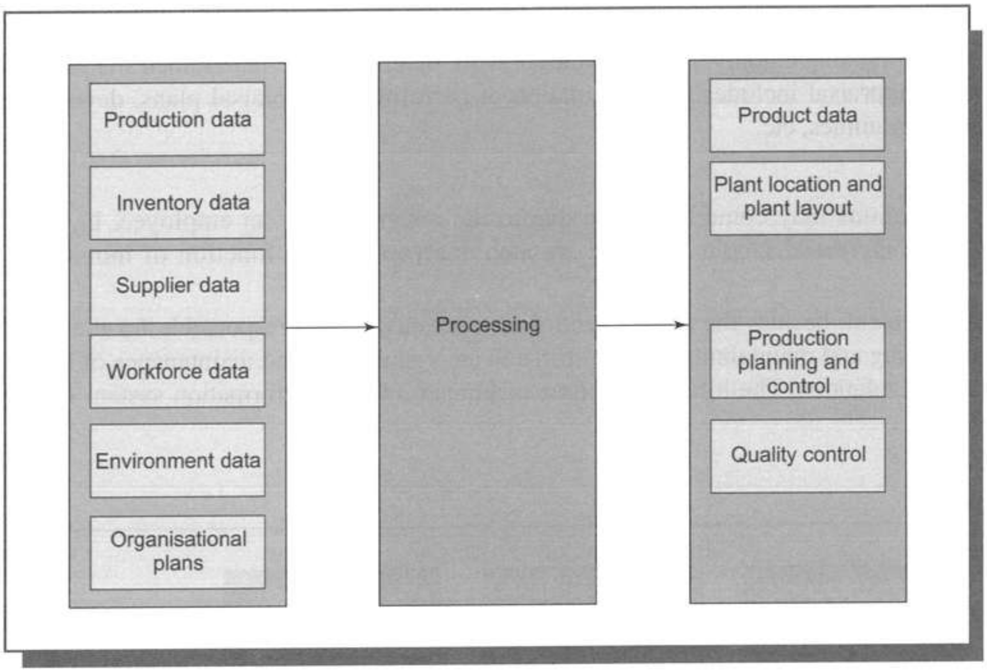

Fig. 2.13 Manufacturing Information System

(iv) performance evaluation, and

(v) separation activities.

It is also concerned with employee compensation, wages and salary administration, employee services and benefits, and labour relations, etc.

To better understand human resource information system, let us briefly review the important functions of the human resource management.

Manpower Planning

It is about deciding the present and future needs of manpower in the organisation.

Staffing

This function includes recruitment, selection and placement of employees. Recruitment refers to attracting qualified and competent people for different jobs. It includes the identification of existing sources of the labour, the development of new sources and the need for attracting a large number of potential applicants. Recruitment is followed by selection that is concerned with selecting the right persons out of a large number of potential candidates. Selection process involves the development of application blanks, valid and reliable tests, interview techniques, employee referral systems, evaluation and selection of personnel in terms of job specifications. Putting the right person at the right job is the responsibility of placement function, which stresses upon the matching of job requirements with the qualification and personality traits of an employee.

Training and Development

The need to train and develop the employees is felt due to:

(a) a gap between the job requirements and competence/ability of the employee.

(b) the need to develop lower level managers to assume higher level responsibilities when required.

As the organisation exists in a dynamic environment and the organisational jobs keep changing, training and development of employees is a continuous activity, it includes:

(a) the identification of training and development needs of personnel at all levels.

(b) development of suitable training programmes and employee development programmes.

Performance Evaluation

This task is concerned with evaluating employee performance at work in terms of pre-determined standards/norms. Evaluation or performance appraisal includes the formulation of performance appraisal plans, development of appraisal techniques and programmes, etc.

Separation Activities

The employee-employer relations may come to an end due to the resignation of an employee, lay-off, death or retirement. Causes of an increased labour turnover are also analysed in this function of human resource management.

Human resource management, besides the above-mentioned functions, is also responsible for the wages and salary administration, sustaining and maintaining the workforce in an organisation and maintenance of healthy and peaceful labour-management relations. The information flow of human resource information system is shown in Fig. 2.14.

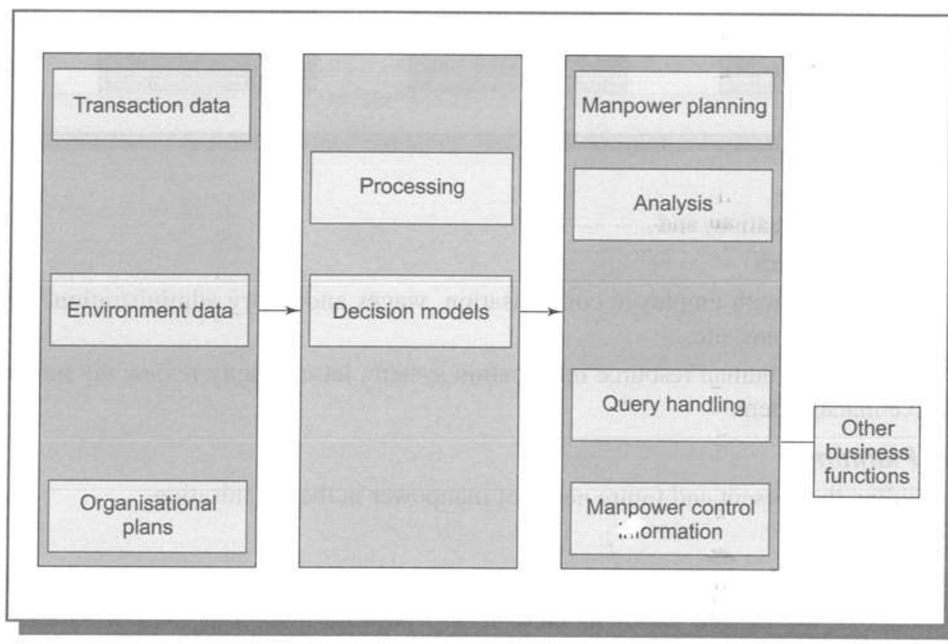

Fig. 2.14 Human Resource Information System

Transaction Data is a basis for various types of output information or analysis. This data includes employee number, name, qualification, experience, joining date, etc., categories and grades of posting and daily performance, etc.

Environmental Data includes data about the availability of personnel, trends in the labour force, competition, market offerings to the employees, government and labour laws, etc. Human resource information system thus gathers such data from journals, news items, research studies, seminars, informal talks of managers, etc.

Organisational Plans also provide an important input in human resource information system, on the basis of which future planning for recruitment, job assignment, etc., is made. Human resource information system processes all these types of data to convert it into information, which supports decision-making of human resource managers. Figure 2.15 illustrates Human Resource Information System support for human resource functions at the three different levels of management hierarchy.

It is worth repeating that all the functional information systems discussed in this section should not be understood as isolated systems. In fact, these systems cannot function in isolation. They are closely associated with each other and interact with the other sub-systems in the organisation by way of information. Thus, from the organisational point of view, integration of all these systems is a major area of thrust.

Management Levels	*Staffing*	*Training and Development*	*Performance Appraisal*	*Employee Compensation*
Strategic planning level	Manpower planning labour force monitoring	Succession planning	Performance evaluation planning	Wages and salary forecasting and plans
Management control level	Budget analysis turnover analysis absenteeism performance	Training effectiveness Career matching	Performance/ training correlation	Compensation effectiveness benefit methods
Operational control level	Recruiting structured interview/ assessment work-force planning scheduling, etc.	Skill assessment	Structured evaluation programs	Compensation equality

Fig. 2.15 Human Resource Information System Support

SUMMARY

If one is interested in knowing as to how an entity looks like, one can estimate it by describing its physical boundary or other structural specifications. Quite often, one can explain the structure of an object, person or a concept by way of adopting multiple approaches. Multiple approaches for explaining or describing an entity help explain the structure of even those entities, which otherwise are difficult to explain (especially abstract entities).

Structure of management information system is difficult to describe by following one approach. It is because of the unstructured nature of MIS. Therefore, multiple strategies are followed in explaining the structure of MIS, which may be physical components, information system processing functions, decision support management activities and organisational functions. Structure of MIS can be understood by looking at the physical components of an information system. The physical components of an MIS may be hardware, software, database, procedure manuals and operating personnel. Processing function may be another approach to explain the structure of MIS. The functions of an MIS explain 'what' the system does. The main processing functions include transaction processing, report generation, enquiry processing, and providing interactive support applications. Decision support can also be taken as a basis to explain the MIS structure. As we know, decisions vary with respect to the structure that can be provided for making them. A highly structured decision can be pre-planned, whereas a highly unstructured decision cannot. Information system support will easily fit into this classification. Similarly, management activities approach is also used to describe the MIS structure, which means that the structure of an information system may be described in terms of a hierarchy of management activities. Strategic planning level, management control level and operational control level are the three levels, which have been classified on the basis of activities. The management activities and information processing for the three levels are interrelated, which implies that MIS would be different for the three levels of management hierarchy.

MIS is in an evolutionary stage. Over the years, it has evolved from an elementary concept to a much advanced discipline of today. It is classified in six classes, namely, transaction processing system, management information system, decision support system, executive support system, office automation systems and business expert systems. As the name indicates, transaction processing system processes transactions and produces reports, whereas MIS processes data and converts it into information. Decision support system is an extension of MIS, which tends to be used in planning, analysing alternatives and searching for solutions by trial and error. Such a system is interactive in nature and incorporates a variety of decision-models. Executive support system is a special kind of decision support system which is specially designed and developed for the chief executive. In this system, the behavioural aspects of the individual (chief executive) are also considered for designing the system. Office automation systems include a wide range of support facilities, which include word processing, electronic filing, electronic mail, data storage, etc. Business expert systems are knowledge-based information systems.

Organisational functions like finance, marketing, production, personnel, MIS, etc., can also explain the structure of MIS in an organisation. As each of these functions has unique information needs, therefore each requires information system support designed specifically for it.

REVIEW QUESTIONS

1. How can the structure of MIS be understood? Discuss various approaches to understand its structure.
2. Illustrate different categories of MIS. Which is the most advanced category? Discuss.
3. Differentiate between TPS and MIS. With the help of a suitable example, explain the concept of DSS.
4. Briefly describe the following:
   (a) Multiple approach to understand the structure of MIS
   (b) Database
   (c) Executive support system
   (d) Decision support system.
5. 'Office automation systems (OAS) have gained greater importance in recent years.' Justify the statement and identify different types of OAS.
6. Briefly discuss Business Expert Systems. How are they different from Decision Support Systems? Give business applications of expert systems.

ASSIGNMENTS

1. Assume an old man visits your organisation and asks you to show him the MIS of your organisation. How would you make him understand the structure of MIS?
2. Suppose you have implemented a newly-developed salary information system in your organisation. Identify its activities and categorise it in the suitable category of MIS.

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CASE STUDY 1

MIS AT NARAYANA LABS. LIMITED

Narayana Laboratories Limited was incorporated under the Company's Act in 1965. It is one of the largest private sector drug and pharmaceutical enterprises in India with a paid-up capital of approximately Rs. 150 million. The turnover of the company in 2009 was Rs. 9850 million. The Board of Directors of the company consists of the Chairman and managing director, four executive directors and two non-executive directors. The company' s head office is situated at New Delhi. The main business of the company is to manufacture drugs, medicines, cosmetics and chemical products. The company also markets a wide range of products, including life-saving antibiotics. The company employs nearly 500 managers and has a workforce of approximately 5500. Compensation packages of the employees are comparable to those of similar companies of repute in the country. The company markets its products under its own trade names and has earned a reputation as market leader for some of its products.

In order to tap the big hospital and nursing home market in India, the company started a new division known as Generics and Hospital Products Division (GHPD) in 1991.

GENERICS AND HOSPITAL PRODUCTS DIVISION (GHPD)

Generics and hospital products division was created mainly to cater to the needs of big hospitals and nursing homes in India, which require medicines in bulk quantities and prefer medicines in the generic names instead of trade names. The division markets about 55 different products of eight different categories like tablets, capsules, liquids, drops, syrups/dry powder, ampoules, vials and ointments. These products are distributed from the head office of the company through its distribution network of 250 distributors throughout the country.

Operational Activities of GHPD

After receiving an order from the distributor, the division processes it and prepares invoices to be sent along with the supply. The distributors are allowed one-month credit period from the date of supply. Maximum limits of credit for different distributors have been prescribed by the division. In addition to order processing and dispatching of supply, the division is also performing the following functions.

(i) Forecasting of sales
(ii) Merchandising planning
(iii) Pricing of products
(iv) Effective physical distribution planning
(v) Cost-effective travel route planning for sales force
(vi) Promotional campaigns
(vii) Analysing various business aspects/opportunities.

Management Information Report (MIR)

GHPD prepares a quarterly report, known as Management Information Report (MIR) to be discussed in a quarterly meeting of all the area managers of the division. This report includes the following information.

(i) Report on total sales for the quarter
(ii) Report on estimated sales for the quarter
(iii) Report on calls made by the sales force for the quarter
(iv) Report on calls to be made by sales force for the quarter
(v) Report on outstanding amount during the quarter

(vi) Report on total outstanding amount for the quarter
(vii) Report on potential areas
(viii) Report on complaints received from distributors and the number of complaints attended to during the quarter.

The formats for reports are given in Exhibit 1.

Exhibit 1 Report on Total Sales for the Quarter Jan-March ______

(Rs in lakhs)

Sl. No.	*Product Name*	*Budgeted Sales*	*Actual Sales*	*Variance*
1	Cap Ampicillin	10	7.0	– 3.0
2	Cap Tetracycline	8	6.1	– 1.9
3	Tab Diazepam	2	1.3	– 0.7
4	Tab Chloroquine	2	1.5	– 0.5

Report on Estimated Sales for the Quarter October-December ______

(Rs in lakhs)

Sl. No.	*Product Name*	*Budgeted Sales*
1	Cap Ampicillin	12
2	Cap Tetracycline	7
3	Tab Diazepam	2.5
4	Tab Chloroquine	2.5

Report on Calls made by the Sales Force for the Quarter ______

Sl. No.	*Product Name*	*Budgeted Calls*	*Actual Calls*	*Variance Remarks*

Report on Calls to be Made by the Sales Force for the Quarter ______

Sl. No.	*Area Name*	*Budgeted Calls*

Report on Outstanding Amount during the Quarter ______

Sl. No.	*Area Name*	*Outstanding Amount*

Report on Outstanding Amount during the Quarter ______

Sl. No.	*Area Name*	*Outstanding Amount in Previous Qr*	*Amount Collected*	*Balance Amount*	*Outstanding Amount in Present Qr*

Report on the Area Tapped (Area-wise)

Sl. No.	*Name of Area*	*Areas Tapped*	*Remarks*

Report on Complaints Received from Distributors and Complaints Attended to during the Quarter ______

Sl. No.	*Distributor Name*	*Complaint*	*Action Taken*	*Remarks*

GHPD'S PERFORMANCE IN THE RECENT PAST

The performance of the division for three years has been shown in Exhibit 2. The effect of the priority given by the government hospitals to procure supplies from the public sector has continued to adversely affect the performance of the division. Over the years, competition has also become stiffer as many small-scale companies have also entered the market of generic products.

Exhibit 2

(Rs in crores)

	2007	2008	2009
Sales	65.10	85.40	94.70
Net profit/(loss)	18.05	28.05	29.45

Computerisation at GHPD

To increase the effectiveness of management information systems at GHPD, the division acquired ten personal computers which were networked with the regional offices. The services of a computer professional was hired to develop the MIS for the division. The division was overburdened with the work of processing the supply orders and it took about 5-7 days to despatch a supply after the receipt of an order. However, sometimes the despatch of supply took more time as the division found that the material could not be despatched to the distributor because of an outstanding amount beyond his prescribed limits.

The newly-developed computerised MIS was implemented in January 2009 and it started providing information to all the managers of GHPD. However, within a period of six months, the Vice President (GHPD) got frustrated with the system and ultimately discarded it. When he couldn't get any help from the developers of the system, he decided to invite a consultant from a leading management institution in India to suggest a solution to the problem.

QUESTION FOR DISCUSSION

1. Why did the Vice President (GHPD) get frustrated with the newly-developed information system? Discuss possible reasons and suggest appropriate measures.
2. What is the root cause of the problem? How could have this problem been avoided?
3. How should the consultant start his analysis?

ASSIGNMENTS

1. Assume you are the consultant invited by Narayana Labs Ltd. How differently would you have tackled the problem?
2. Discuss the inputs, outputs and processes of GHPD of Narayana Labs Ltd.

CASE STUDY 2

SIBA INTERNATIONAL AND FUNCTIONAL INFORMATION SYSTEMS

Siba International is a medium-sized company in India with about 1,500 employees. The company manufactures special machines for the agro-based industry, both for farms and food processing plants. The company buys material and components from about 200 vendors located in India, Japan and Germany. Products are sold either to wholesalers or directly to clients (from a mailing list of about 1,500 customers). The business is quite competitive.

The company has the following information systems in place: marketing, financial accounting, engineering, research and development and manufacturing (CAM). These systems are independent of each other and only the financial accounting systems is on a LAN.

The company is having profitability problems. Cash is in high demand and short supply. It is proposed that the company explores the possibility of using information technology to improve the situation. However, the vice-president of finance objects to the idea, claiming that most of the tangible benefits of information technology are already being realised.

QUESTIONS FOR DISCUSSION

Assume you are hired as a consultant to the president of Siba International.

1. Prepare a list of potential applications of information technologies that you think could help the company.
2. Suggest a suitable design of information systems. Would you recommend any telecommunication arrangements? Justify such design.

CASE STUDY 3

SIGMA INDUSTRIES LIMITED (SIL)—A CASE STUDY

Sigma Industries Limited (SIL) is a diversified company consisting of the following divisions:

1. *Paper Division:* Producing paper and coating plants.
2. *Chemical Division:* Involved in the production of caustic soda, chlorine, phosphoric acid, bromine, etc.
3. *Edible Oils Division:* Engaged in extraction of edible oils.
4. *Shipping Division:* Providing sea-transport.
5. *Glass Division:* Involved in glass container project.
6. *Building Materials Division:* Involved in auto claved aerated concrete project.

Its units are situated at several places all over the country, namely Mumbai, Chennai, Goa, Patiala and Puducherry (the name and other information of the actual organisation have been changed).

The head office of SIL is situated at Delhi and its regional offices operate from Bangalore, Mumbai, Calcutta and Chennai.

All strategic planning is done at the head-office, which houses the managing director, board of directors and vice presidents of various divisions. Management control and operational level control is carried out at the unit level.

UNIT RAJ SHREE

Unit Raj Shree is one of the oldest paper producing units in India. This unit initially started producing plain paper and gradually diversified into production of speciality paper, caustic soda/chlorine, edible oils, etc.

This unit has its own research and development facilities, the efforts of which have led to the creation of new value-added papers alongwith improvement in the quality of the existing products. The production of substitutes for imported paper saves foreign exchange for the country.

The company has always been marching ahead on the path of excellence and growth. The company has ventured into exports of its product range, e.g. speciality paper. The company has gained an edge over international competitors through strict quality control.

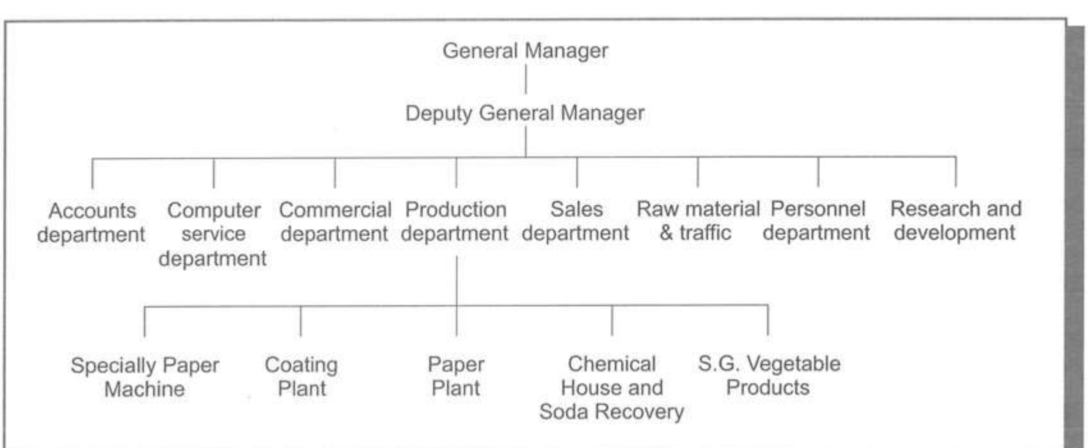


Fig. 1 Organisation Chart of the Unit Raj Shree

Organisation Chart of the Unit

Organisation chart of the Unit Raj Shree has been depicted in Fig. 1.

Objectives of Personnel Management

Organisation success, survival and strength revolve around the effective management of personnel at all managerial levels. The objectives are:

(i) Effective development and utilisation of the human potential within the organisation.

(ii) Establishing mutually satisfying working relationships among all members of the organisation.

Organisation Chart of the Personnel Department

Figure 2 exhibits the organisation chart of the personnel department.

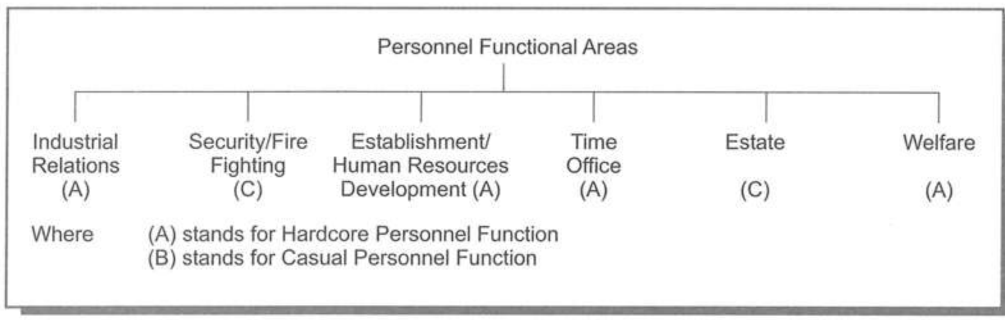


Fig. 2 Organisation Chart of the Personnel Department

Personnel Strength of the Unit

The personnel strength of unit Raj Shree is as follows.

Total permanent workers	=	4892
Clerical staff	=	554
Management staff	=	513
Casual workers	=	800
Contractors	=	650
Temporary workers	=	35
Total		7444

Industrial Relations: Management Hierarchy

The hierarchy of the management staff in this subsystem of the personnel department is shown in Fig. 3.

Labour Social Welfare Counselling: Information Flow

Figure 4 depicts the information flow for labour social welfare counselling.

Computerisation of Personnel Department

There exists a computerised transaction proces-sing system for payroll, records of personal files, medical reimbursement ledger, etc. At the same time, parallel to the computerised dadabase of personal files, manual records of personal files are

Fig. 3 Management Hierarchy for Industrial Relations

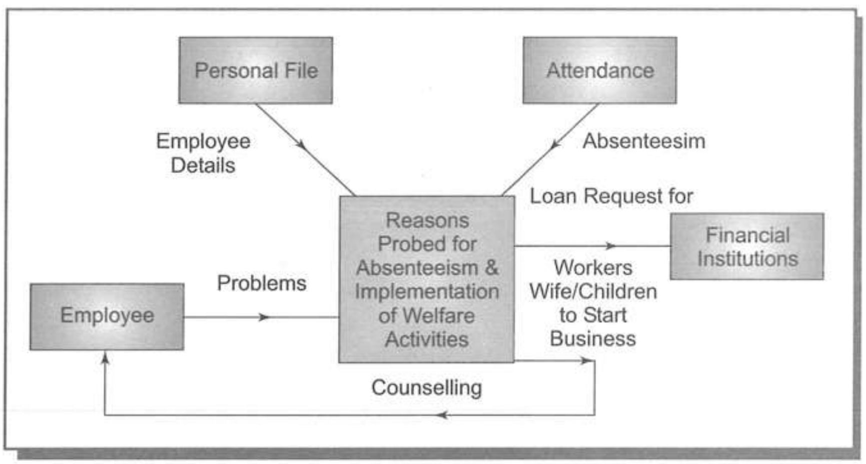


Fig. 4 Information Flow for Labour Social Welfare Counselling

also kept. At present, personnel database consists mainly of financial data like various allowances an employee is entitled to, provident fund, accumulation and withdrawal, income tax assessment, etc.

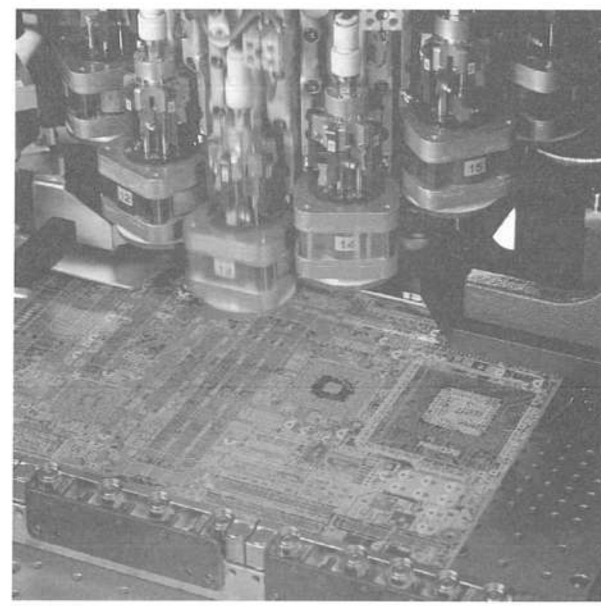
The managers at the organisation have to ask for information, such as qualifications, exper-ience, categories and grades of posting, places of transfer, experience gained, new qualifications acquired, training undertaken, disciplinary action, merit, rewards and performance apprai-sals, etc., to aid them in decision-making. Such information is either supplied through the manual system or from the existing computerised data-base in the organisation.

ASSIGNMENTS

1. On the basis of information from the case study, design an MIS for the personnel department of the organisation.
2. Identify the weaknesses of the existing personnel information system. Suggest measures to overcome these weaknesses.

Chapter 3

Information and System Concepts



Learning Objectives

After going through this chapter, you should be able to:

- Understand the concept and types of information
- Discuss concepts like quality and dimensions of information
- Understand the meaning, definition and elements of a 'system'
- Describe different kinds of systems
- Know system-related concepts like boundary, interface, black box, system decomposition and integration of sub-systems, etc.
- Understand human information processing system and implications for information system design

3.1 INFORMATION: A DEFINITION

Information is a necessary and vital input in any decision-making process in an organisation. However, it is not available in ready form; rather it has to be generated from data which acts as a raw material that needs some processing. Figure 3.l depicts the process of generating information.

FOCUS

Information is a necessary and vital input in any decision-making process in an organisation, and it has to be generated from by processing data

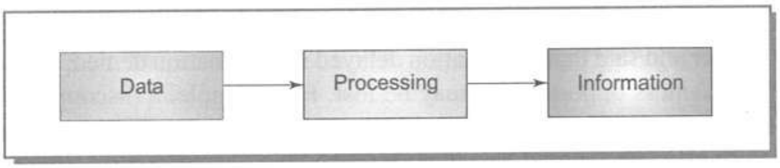


Fig. 3.1 Information Generation

Thus, information in its unprocessed form is called data, which is generated as a by-product of transactions taking place in the organisation. Information, on the other hand, is a processed data and has an element of surprise. Information reduces uncertainty and triggers action. Davis and Olson have defined information as data that has been processed into a form that is meaningful to the recipient and is of real or perceived value in current or prospective actions or decisions.

3.2 TYPES OF INFORMATION

Broadly speaking, information could be classified on the basis of the purpose for which it is utilised, into three main categories; namely:

(i) Strategic information
(ii) Tactical information
(iii) Operational information

3.2.1 Strategic Information

Strategic information is required by the managers at the strategic level of management for the formulation of organisational strategies. This relates to long-term planning policies of the organisation as a whole. For example, information pertaining to new technologies, new products, competitors, etc.

3.2.2 Tactical Information

Information in this category is used in short-term planning and is of use at management control level, for example, for sales analyses and forecasts, production resource requirements, annual financial statements, etc. This type of information is generally based on data arising from current activities of the organisation. However, some of the tactical information, such as competitor information, may arise from sources external to the organisation.

3.2.3 Operational Information

Operational information applies to short periods which may vary from an hour to a few days. It is generally used by decision makers at the operational level. It is often required for taking immediate action. Examples of operational information may include current stocks-in-hand, work-in-progress levels, outstanding orders from customers, etc. The source of such an information is usually current activity data.

3.3 INFORMATION QUALITY

Quality of information refers to its fitness for use, or its reliability. Some of the attributes of information, which influence the quality of information are discussed as follows.

Timeliness

Timeliness means that information must reach the recipients within the prescribed timeframe. For effective decision-making, information must reach the decision maker at the right time, i.e. recipients must get information when they need it. Delays, of whatever nature, destroy the value of information. Timely information can ensure correct executive action at an early stage. The expected losses could be eliminated/minimised and gains maximised by proper management of operations. The report which is required by an executive on the sixth of every month, if presented later, is considered to be of doubtful value and decisions taken on its basis would not be as effective as might have been otherwise. B.K. Chatterjee (1974) has gone one step further and said that information delayed is information denied. Similarly, many short-term business opportunities may be lost. For example, a discount on bulk purchases offered by a supplier may be lost because of late reports. The characteristic of timeliness, to be effective, should also include up-to-date, i.e. current information. In other words, timely information does not mean intime information only rather it means timely as well as up-to-date information.

FOCUS

Quality of information refers to its fitness for use, or its reliability. Few attributes which influence the quality of information are: timeliness, accuracy, relevance, adequacy, completeness, explicitness, exception-based.

Accuracy

Accuracy is another key-attribute of management information. As per John G. Burch and Gary Grudnitski (1986), accuracy means more than just one plus one equals two. It means that information is free from mistakes and errors, is clear and accurately reflects the meaning of data on which it is based. It conveys an accurate picture to the recipient, who may require a presentation in graphical rather than tabular form. Accuracy also means that the information is free from bias. H.C. Advani (1975), has advocated the importance of accuracy by stating that wrong information given to management would result in wrong decisions. However, at the same time, he has cautioned that accuracy should be within limits, or as desired, and should not be achieved by sacrificing promptitude. As managers' decisions are based on the information supplied in MIS reports, all managers need accurate information. If MIS supplies accurate information, the confidence of the managers will be strengthened and as a result, system implementation will be a success.

Relevance

Relevance is yet another key attribute of management information: Information is said to be relevant if it answers specifically for the recipient what, why, where, when, who and why? In other words, the MIS should serve reports to managers which are useful and the information helps them make decisions.

However, what is relevant information for one recipient is not necessarily relevant for another. The relevance of information from a specific customer order, for example, will vary among the employees of the company. The individuals most directly responsible for processing customer orders will regard the detailed contents of a specific order as necessary information to perform their respective jobs. Individual sales persons will most likely be interested only in orders pertaining to their customers and perhaps, in the aggregate of all the orders received in a given commission period. The sales manager may be interested in all customer orders but finds the data relevant only when it is reported or presented in reference to quotas, forecasts or budgets. Accountants view customer orders as data until such time as they represent, or are processed into, billable shipments, accounts receivables, monthly revenues and so forth. Personnel in employee relations, research, and engineering routinely do not regard customer orders as relevant to performing their jobs.

Adequacy

Adequacy means information must be sufficient in quantity, i.e. MIS must provide reports containing information which is required in the deciding processes of decision-making. The report should not give inadequate or for that matter, more than adequate information, which may create a difficult situation for the decision-maker. Whereas inadequacy of information leads to a crisis, information overload results in chaos. Therefore, adequacy is a vital attribute of information which underscores that a report should cover all related aspects about a particular event or situation which the report is reporting.

Completeness

The information which is provided to a manager must be complete and should meet all his needs. Incomplete information may result in wrong decisions and thus may prove costly to the organisation. In extraordinary situations, where providing complete information is not feasible for one reason or the other, the manager must be informed of this fact, so that due care in this regard may be taken.

Explicitness

A report is said to be of good quality if it does not require further analysis by the recipient for decision-making. On the other hand, a poor quality report requires further analysis or processing of its contents. Therefore, explicitness is a prominent attribute of management information procured through the MIS of an organisation; Thus, the reports should be such that a manager does not waste any time on the processing of the report, rather he should be able to extract the required information directly.

Exception-based

Today, more and more organisations are being run on the principle of management by exception. Top managers need only exception reports regarding the performance of the organisation. Exception reporting principle states that only those items of information which will be of particular interest to a manager are reported. Usually, these items indicate that normal operations have gone awry. This approach results in saving precious time of the top management and enables the managers to devote more time in pursuit of alternatives for the growth of the organisation. If reports do not follow the exception reporting principle, these will provide even those details which are not required by managers and thus a lot of their time would be wasted in sifting useful information, and as a result, they will not be able to spend much time on other important activities of the organisation.

Quality, however, is not an absolute concept, rather it is defined within a context. Roman R. Andrus has suggested a utility approach to determine the quality of information. In this regard, he discusses four types of utilities of information, which may facilitate or retard its use.

(i) *Form utility:* In order to be of greater value, the form of information should closely match the requirements of the user.
(ii) *Time utility:* Information, if available when needed, has a greater value.
(iii) *Place utility:* The value of information will be more if it can be accessed or delivered easily,
(iv) *Possession utility:* The person who had the information influences its value by controlling its dissemination to others in the organisation.

3.4 DIMENSIONS OF INFORMATION

Information may be understood to have various dimensions. However, for our purpose, the following three dimensions of information will be of interest.

(i) Economic dimension
(ii) Business dimension
(iii) Technical dimension.

3.4.1 Economic Dimension

This dimension of information refers to the cost of information and its benefits. Generation of information costs money. To decide about the money to be spent on information generation in an organisation, a costbenefit analysis should be undertaken. Measuring costs and benefits of information is difficult because of intangible characteristics of information. However, the following aspects of information may be useful.

Cost of Information

It may include

(a) cost of acquiring data,
(b) cost of maintaining data,
(c) cost of generating information, and
(d) cost of communicating information.

The cost is related to the response time required to generate information and communicate it. Thus, for systems with low response time, the cost is high. Similarly, cost also depends on the required accuracy, speed of generation, etc. For more reliable and accurate systems, costs are higher as compared to the systems with relatively low accuracy.

Value of Information

As mentioned earlier, information has a cost for its acquisition and maintenance. Thus, before a particular piece of information is acquired, decision makers must know its value. In decision theory, the value of information is the value of the change in decision behaviour because of the information. The change in the behaviour due to new information is measured to determine the benefits from its use. To arrive at the value of new information, the cost incurred to get this information is deducted from the benefits.

For example, if there are two products, A and B, to be developed with known pay-offs, as shown in Fig. 3.2. The decision maker will select the product which has got the maximum pay-off, i.e. product B.

A	25
B	35

(a)

Decision = B
(with existing information)

A	40
B	30

(b)

Decision = A
(with new information)

Fig. 3.2 Pay-off Matrix

However, if some additional information is made available to the decision maker, according to which the pay-off distribution changes, as given in matrix (b), the decision maker will opt for product A. The additional or new information causes the decision maker to choose product A, thereby increasing his gain from 30 to 40.

Thus, the value of additional information is (40 – 30) = 10 units. However, if the new information has some cost, the net value gained would be 10 units minus the cost of getting this new information.

3.4.2 Business Dimension

Information can also be understood from its business dimension. Different types of information are required by managers at different levels of the management hierarchy. The information needs of managers at strategic planning level are altogether different than those of operational control managers. It is because managers at different levels are required to perform different functions in an organisation. This has been discussed in Chapter 1.

3.4.3 Technical Dimension

This dimension of information refers to the technical aspects of the database. Various aspects of the database, which are considered under this dimension, include the capacity of database, response time, security, validity, data interrelationship, etc. Technical dimension is covered under design of information systems and under the topic of database management system.

3.5 SYSTEM: A DEFINITION

The word 'System' is used quite often in our everyday life. We talk about an educational system, political system, economic system, circulatory system, solar system, computer system, and so on.

The common feature, which all these systems share, is that they are a collection of elements integrated to achieve the required goals. To be more specific and precise, a system may be defined as a set of elements, joined together to achieve a common objective. For example, a business organisation can be considered as a system, in which the parts (divisions, departments, sections, units, etc.) are joined together for a common goal. In such an organisation, it is clear that a system is not a randomly assembled set of elements; rather it consists of elements which can be identified as related to each other because of a common purpose or a goal.

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A System may be defined as a set of elements, joined together to achieve a common objective. For example, a business organization is like a system, in which parts (divisions, departments, sections, and units etc.) are joined together for a common goal.

3.5.1 Multiple Meaning of the Word 'System'

The above definition of a system is in generalised terms. In actual practice, this term finds its usage and meaning in many diverse ways. The word 'system' means different things to different people in different situations. If an office supervisor in a chairman's office is asked 'what is your system?', it just means 'How do you keep your files in such a way as to take one when wanted by your boss?'. His reply would be: 'I keep the files year-wise and then activity-wise in alphabetical order.' If a similar question is posed to a production manager in an organisation, the reply would be in a different context, pertaining to his system. Similarly, when asked about a computer system, a systems analyst in a computer centre would reply in terms of the name of the computer, hardware manufacturer and a model number like IBM 360, Supermicro-32 or Pentium I, II, III, IV, etc.

In the discipline of systems analysis and design, the term 'system' stands for the kind of a system we deal with.

In management information system, we are usually concerned with man-made systems involving input, processes and output, as represented in Fig. 3.3.

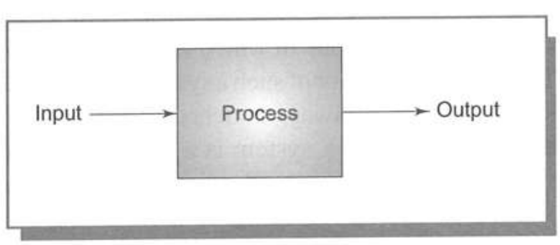

Fig. 3.3 A Model of a System

Thus, a system may be regarded as a set of entities or elements interacting among themselves in a certain manner to process certain inputs to produce certain outputs (objectives) in a definite time period. The concept of multiple inputs and outputs may be represented as shown in Fig. 3.4.

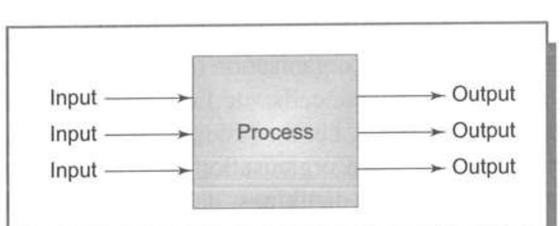

Fig. 3.4 System with Multiple Inputs and Outputs

3.6 KINDS OF SYSTEMS

Different kinds of systems may be understood as:

(i) abstract and physical systems,
(ii) deterministic and probabilistic systems,
(iii) open and closed systems, and
(iv) user-machine systems.

3.6.1 Abstract and Physical Systems

Systems can be categorised as abstract systems and physical systems. There can be misunderstandings if one person talks about an information system as a set of concepts, ideas, or characteristics (abstract) and his listener perceives it as an operational system of people, equipment and reports (physical). An abstract or conceptual system is an orderly arrangement of interdependent ideas or constructs, which may or may not have any counterpart in the real world. For example, a system of theology is an example of abstract system, which is an orderly arrangement of ideas about God and the relationship of humans to God.

On the other hand, physical systems are generally concrete operational systems made up of people, materials, machines, energy and other physical things. Physical systems are more than conceptual constructs; they display some activity or behaviour. The elements in such a system interact to achieve a common objective. For example, the circulatory system, transportation system, computer system and others.

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An Abstract or Conceptual system is an orderly arrangement of interdependent ideas or constructs which may or may not have any counterpart in the real world.

Physical systems are concrete operational systems made of people, materials, machines, energy and other physical things.

3.6.2 Deterministic and Probabilistic Systems

A deterministic system is one in which the occurrence of all events is known with certainty. In such a system, given a description of the system state at a particular point of time of its operation, the next state can be perfectly predicted. An example of such a system is a correct computer program which performs exactly according to a set of instructions.

A probabilistic system is one in which the occurrence of events cannot be perfectly predicted. Though the behaviour of such a system can be described in terms of probability, a certain degree of error is always attached to the prediction of the behaviour of the system. An example of such a system is a set of instructions given to a person who may not follow the instructions exactly as given. Another example is a warehouse and its contents. Given a description of the contents at a given point of time, the average demand, the length of time taken to process orders, etc., the contents at the next point in time could not be perfectly predicted. In our daily life, we usually have to deal with such probabilistic systems.

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A beterministic system is one in which the occurrence of all events is known with certainty.

A Probabilistic system is one in which the occurrence of events cannot be perfectly predicted.

3.6.3 Open and Closed Systems

An open system is one that interacts with its environment and thus exchanges information, material, or energy with the environment, including random and undefined inputs. Open systems are adaptive in nature as they tend to react with the environment in such a way, so as to favour their continued existence. Such systems are 'self-organising', in the sense that they change their organisation in response to changing conditions. All living systems (e.g. humans, plants, cells, etc.) are open systems. They attempt to maintain equilibrium by homeostasis, i.e. the process of adjusting to keep the system operating within prescribed limits. An organisation, which is sensitive to changes in customer tastes, preferences, likings, dislikings, demands, etc., and in consequence adjusts its prices, changes its product mix or looks for new markets, is an open organisation. All organisations essentially are open systems as they cannot work in isolation. Thus, the systems analyst usually deals with adaptive, open systems.

FOCUS

An Open system is one that interacts with its environment and thus exchanges information, material or energy with the environment, including random and undefined inputs.

A Closed system is one which does not interact with its environment. Though relatively can man, such systems are rare in business world.

A closed system is one which does not interact with its environment. Such systems in business world, are rare, but otherwise closed systems are relatively common. Thus, the systems that are relatively isolated from the environment but not completely closed, are termed closed systems (which actually means a relatively closed system). For example, a computer program is a relatively closed system because it accepts and processes previously defined inputs and provides outputs too in a previously defined way. In other words, we may say that a relatively closed system is one which controls its inputs, and outputs and is protected from the environmental disturbances.

3.6.4 User-Machine Systems

Most of the physical systems are user-machine (or human-machine) systems. It is difficult to think of a system composed only of people who do not utilise equipment of some kind to achieve their goals. In user-machine systems, both, i.e. human as well as machine, perform some activities in the accomplishment of a goal (e.g. decision-making). The machine elements (may be computer hardware and software) are relatively closed and deterministic, whereas the human elements of the system are open and probabilistic. No doubt, some small systems that are purely mechanical, do exist, but they are usually a part of a larger system involving people. Various combinations of human and machine are possible. For instance in a system, the computer plays a major role and human simply monitors the machine operation. At the other extreme, the machine performs a supporting role while the human performs the significant work. The division between human and machine will thus vary from system to system.

3.7 SYSTEM RELATED CONCEPTS

3.7.1 Boundary, Interface and Black Box

Boundary

In order to focus on a particular system, users need to define or describe the system under study. This is done with the help of a boundary. The boundary of a system may exist either physically or conceptually. In other words, the boundary is a feature of the system which defines and delineates it. The system is inside the boundary, while its environment is outside the boundary. It is often difficult to specify in detail the boundaries of a system. In that case, a person who studies a system arbitrarily, defines the boundaries for the system. For example, while studying the production system, one may include raw materials and finished goods as within the boundaries; whereas another similar study may exclude either raw materials or finished goods; or both from such a study of the production system. The use of a boundary concept enables a systems analyst to define any on-going process as a system. It further enables him to look at the problem as a whole and to set up the framework to look at its various sub-systems. The boundary concept has been depicted in Fig. 3.5.

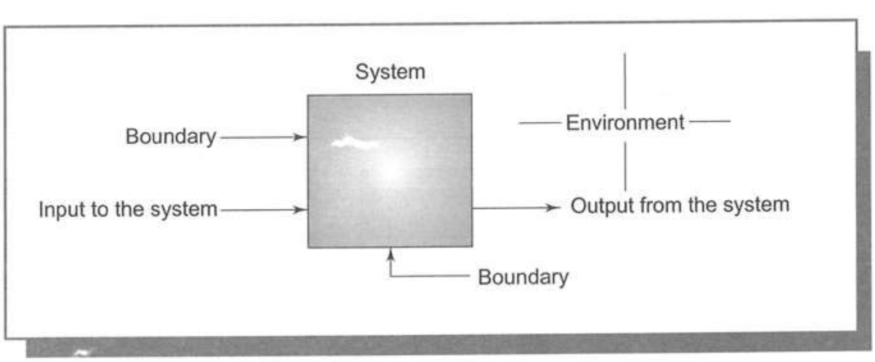

Fig. 3.5 The Concept of Boundaries

Interface

Each system can have sub-systems which, in turn, are made up of units. The interconnections and interactions among the sub-systems are called interfaces. This is shown in Fig. 3.6.

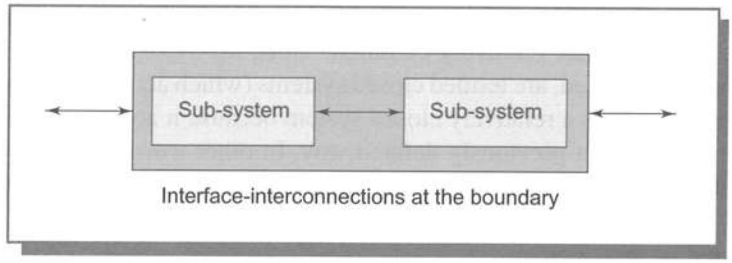

Fig. 3.6 Interface

Black Box

The transformation process in certain sub-systems, especially at the lowest level may not be defined. However, the inputs and outputs are known. Such a sub-system whose processes are not defined, is called a black box system. The concepts of black box has been illustrated in Fig. 3.7.

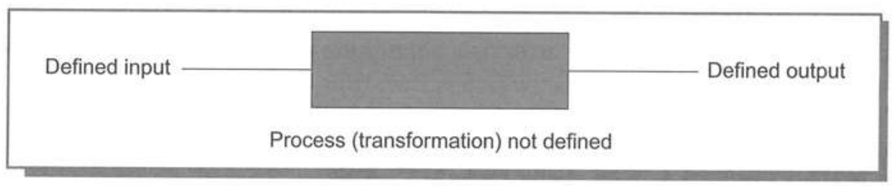

Fig. 3.7 Black Box

3.7.2 System Decomposition

Any system can be divided into smaller systems known as sub-systems and a sub-system can further be divided into still smaller systems called sub-sub-systems, which, in turn, can be divided into still smaller systems. This process continues until the smallest sub-systems are of manageable size. The concept of sub-systems is an important aspect and is basic to the analysis and design of information systems, because it is difficult to comprehend a complex system when considered as a whole. Therefore, for convenience and clarity, a system is divided into smaller systems. The process of dividing or factoring a system into smaller systems is known as decomposition. The sub-systems resulting from this process usually form hierarchical structures. In the hierarchy, a sub-system is one element of supra-system (the system above it). This is shown in Fig. 3.8. A typical example of a system decomposition is depicted in Fig. 3.9.

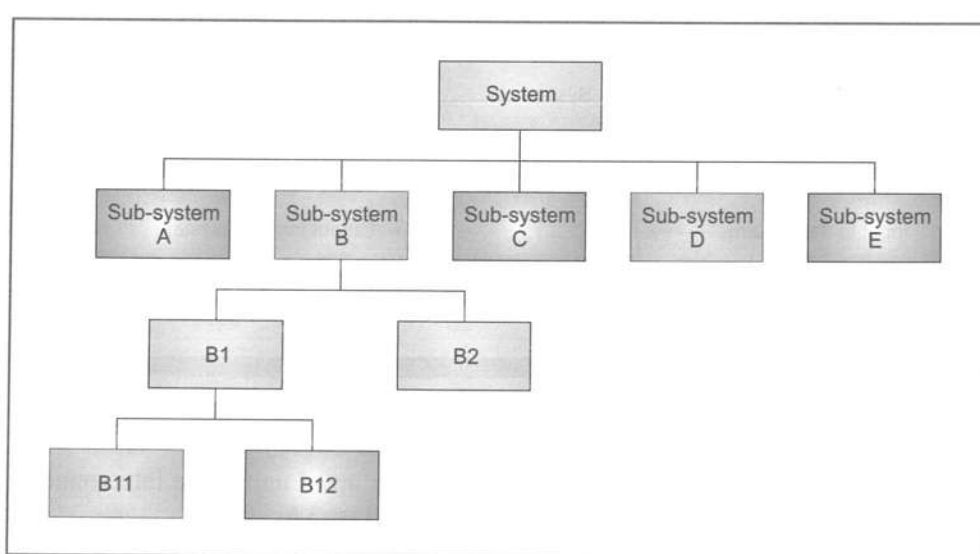

Fig. 3.8 Hierarchical Relations of Sub-systems

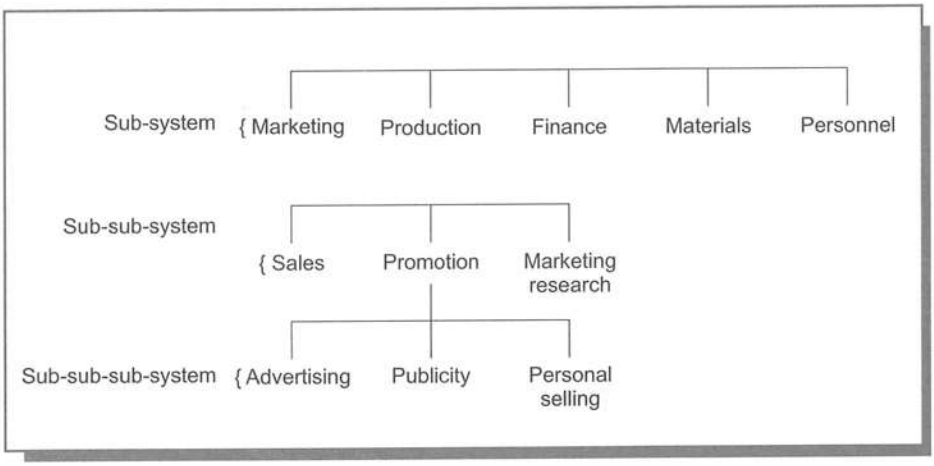

Fig. 3.9 System Decomposition

The process of decomposition into smaller systems is used both to analyse an existing system and to design and implement a new system. On the basis of an objective, the system analyst has to draw the boundaries and define the interfaces so that the sum of the sub-systems constitutes the entire system.

3.7.3 Integration of Sub-Systems

A system is divided into smaller systems only for the sake of clarity. However, it is the whole which dictates the role of the sub-system.

The concept of integration draws attention to the primary importance of the whole system. The whole system is a system, which behaves as if it is a single entity. Thus, one should not get lost amongst the smaller systems. Rather, the sub-systems and their relationships among each other should evolve from the concept of the whole system. In other words, the whole should not be overlooked while trying to understand it through its parts. The integration of the sub-systems has been portrayed in Fig. 3.10.

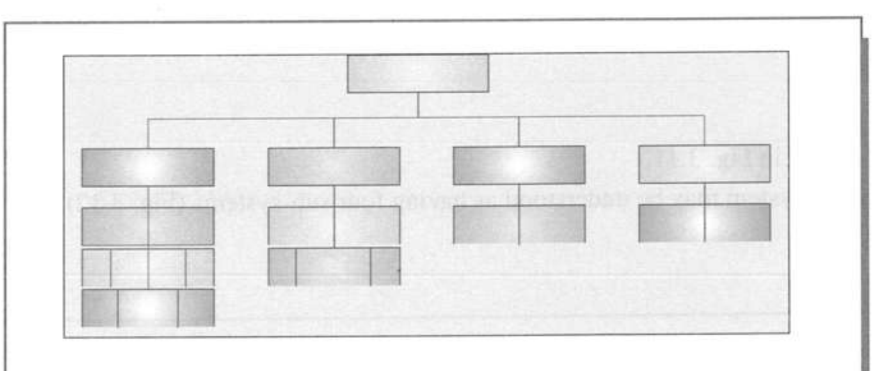

Fig. 3.10 System as a Whole (Integration of Sub-systems)

3.8 ELEMENTS OF A SYSTEM

To understand a general system, let us take an example of a system in which certain data is processed with the objective of converting it into information for decision-making. Its elements can be shown in Fig. 3.11.

Figure 3.11 Illustrates a typical system having input, processor and output as its elements.

Input may be defined as the start-up component on which the system operates. Input, as specified in the above system, is certain data about something (may be customers, sales, inventory, etc.). Data is defined as symbols, facts, figures or relationships to be introduced into, or to be the result of, a system's operation.

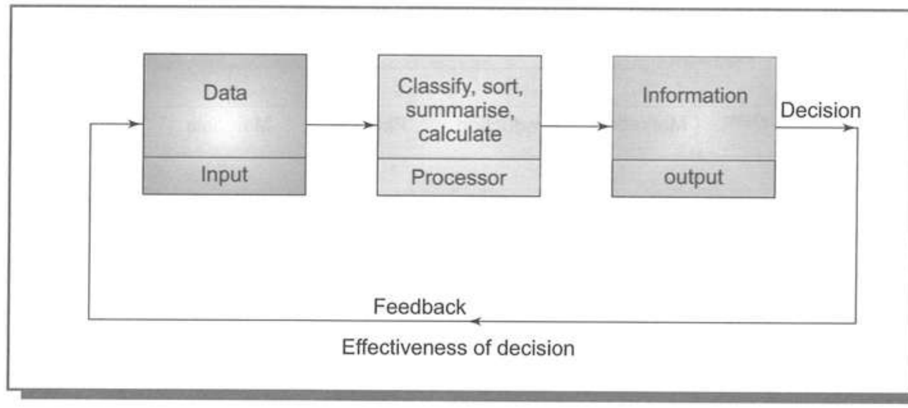

Fig. 3.11 Data Conversion – A System

Output is defined as the result of an operation. Output is the end result of a system, and thus it represents the purpose or objective of a system. 'Information' is the output in the given example. The purpose or objective of the system (i.e. classifying, sorting, summarising and calculating data) is to obtain information (about the number of customers, total sales, inventory status) so as to aid decision-making.

The process is the transformation activity that converts input into output. The actual classification of the data, its sorting, summarising and calculating by people by themselves or through some other means (e.g. through computers) represents processing of the data. People, machines, functions, operations, organisations, and combinations of these act as processors.

These elements, i.e. input, processor, and output are common to all systems and are the terms by which all systems are described. We may define any system in terms of these elements and their properties. While describing the elements of a system, an attempt has been made to explain the processor in a simple and in a general way. However, it should not be concluded from this description that operations within the processor are as simple as depicted. In fact, it is because of the complexity of the processor that it is also known as a block box. This complexity can be illustrated in a simple way by considering our earlier example of a data processing system. The black box or processor of this system describes the following operations:

(i) Classification
(ii) Sorting
(iii) Summarising
(iv) Calculation.

The process has been shown in Fig. 3.11.

In simpler terms, the same system may be understood as having four sub-systems (Fig. 3.12).

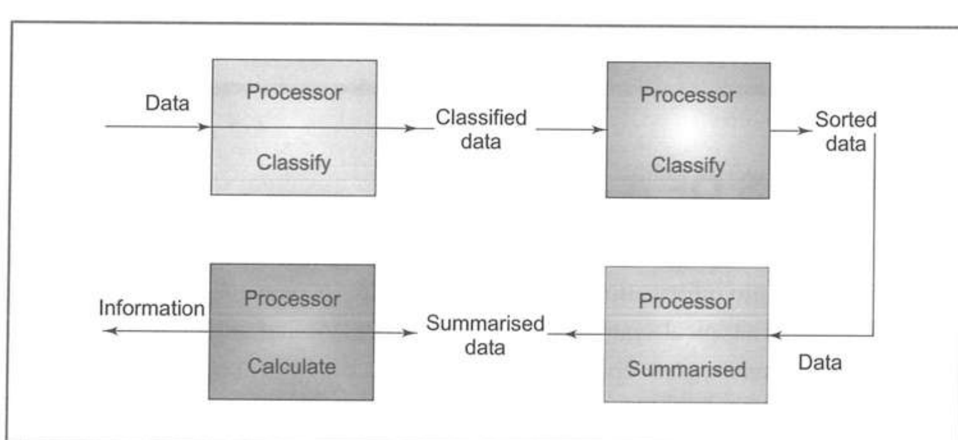

Fig. 3.12 Data Processing and Sub-Systems

Thus, most of the system processors, which at first glance appear to be simple, become extremely complex when they are studied in detail.

Inability to define the constraints or boundaries accurately and precisely also leads to complexity in the processor. For example, it is difficult to decide the boundaries for a personnel information system. One may find it difficult to answer questions, on whether it should include the sub-systems of training, recruiting, placement, safety, discipline, payroll, labour relations and scheduling. No doubt top management' s view of the system differs from that of a personnel officer, whose concept of the system may include only personnel records, recruitment and selection. Neither of these views is incorrect; they only indicate the alternative ways of defining the processor. This complexity of the processor can be overcome if a system analyst or designer defines the boundaries of the system as specifically as possible, so that limits may be placed on the sub-systems to be studied.

The relationship of input, process and output have been shown in Fig. 3.12. Input, process and output are also called system parameters. A parameter is defined as a constant to which properties and values are ascribed.

Though, input, processor and output are defined as system parameters, systems are not static. They are rather dynamic and changes occur inevitably. It becomes all the more important in a dynamic system to review on a continuous basis, the state of the output to make necessary changes. In a business organisation, we need to know whether the product output is profitable and acceptable to the customer, otherwise the business organisation would ultimately fail to survive. The system elements that permit the system to remain in equilibrium or in a balanced state are feedback and control.

These two system parameters, i.e. feedback and control occur together and are discussed as one because of their very definition, which states that the purpose of feedback is control. Feedback control is defined as the system function that compares output with a model or standard. More specifically, feedback is the function that provides information on the deviation between output and the prescribed standards (for control purposes) and delivers this information as input into the process from which the output was obtained. Where control is defined as the system function that compares output, to a pre-determined standard. Control is achieved by correcting the deviation between output and standard. The feedback and control elements are illustrated in Fig. 3.13.

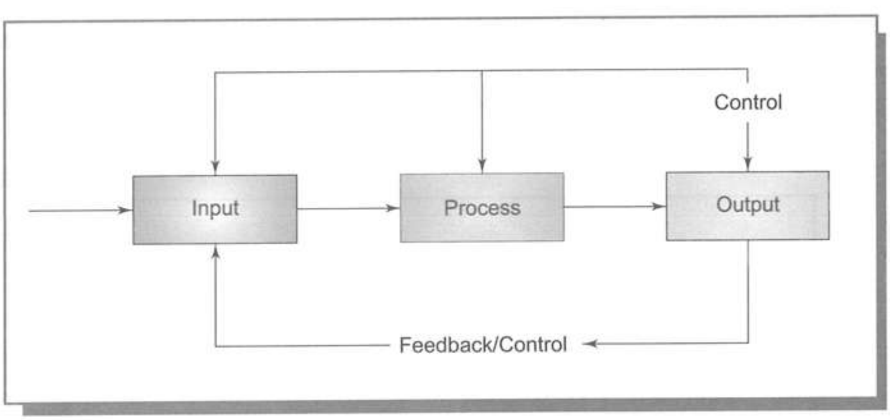

Fig. 3.13 A Complete System

3.9 HUMAN AS AN INFORMATION PROCESSING SYSTEM

Human as an information processing system can be understood with the help of a simple model, which consists of the following components:

(i) Sensory receptors (inputs)
(ii) Processing unit
(iii) Response output.

Sensory receptors include eyes, ears, skin, etc. These receptor capture stimuli, which may be visual, auditory, tactile and others, from the environment and transmit them to the processing unit i.e. the brain. The processing unit

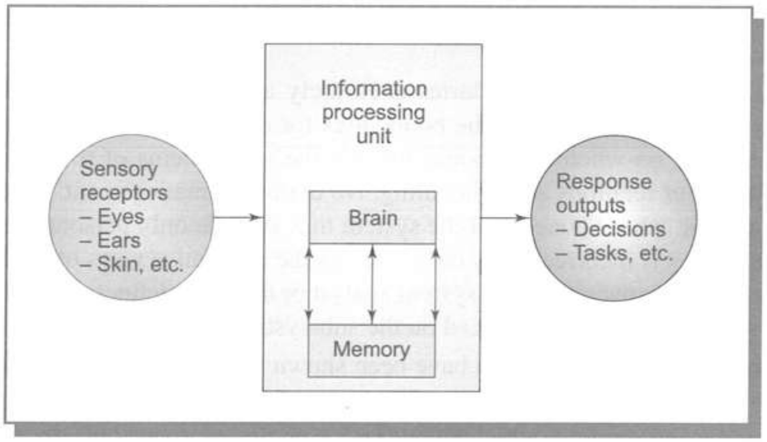

Fig. 3.14 Model of a Human Brain as an Information Processor

(the brain) uses a variety of specialised processing centres and memory units to handle different types of processing and memory functions. The results of the processing of stimuli by brain are response outputs, such as decisions taken and tasks performed. These results may also be in the form of physical movements, speech and other responses. The model is depicted in Fig. 3.14.

The model which has been discussed in the preceding paragraph, is a simplified version of the Newell-Simon model of human information processing system. Allen Newell and Herbert A. Simon (1972) proposed a model (see Fig. 3.15) of the human information processing system which consists of a processor, sensory input, motor output and three different memories: long-term memory (LTM), short-term memory (STM), and external memory (EM). STM is a part of the processor and is very small. It can store only a few (five to seven) units or chunks of information. A chunk is a unit of stored information, which can be a digit, a word or an image. The long-term memory is believed to have an unlimited capacity to store information. Storage is in compressed form and requires only a fraction of a second to recall from long-term memory but the write time (to memorise) is longer (say, 5 k to 10 k seconds for k symbols). This means long-term memory will take an average of 50–100 seconds to memorise a 10-digit member. However, after its storage, one can recall it in a few hundred milliseconds. The external memory in the human processing system may be represented by an external media such as a notebook, chalkboard, etc.

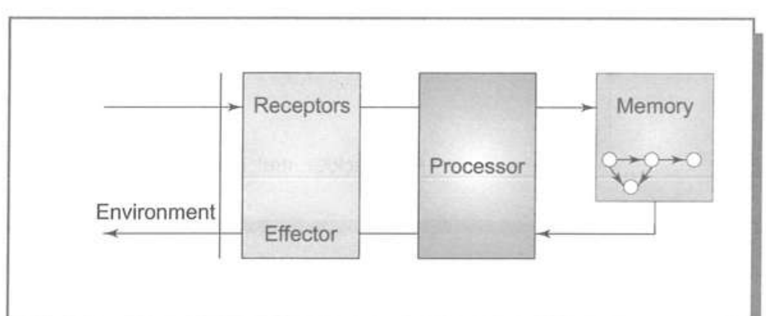

Fig. 3.15 General Structure of a Human Information Processing System

3.9.1 Information Filtering

Humans have a limited capacity to accept input for producing meaningful output. However, the environment provides more input than a human is able to accept. Thus, in order to avoid information overload, the human information processing system filters out the inputs to a manageable quantity (see Fig. 3.16).

This information filtering may be based on a number of factors which may be inborn or have been acquired from past experience, knowledge and cultural background.

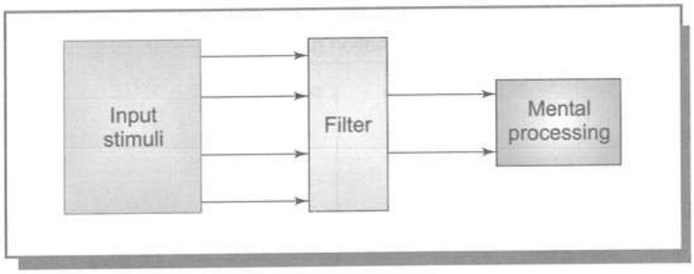

Fig. 3.16 Filtering of Information

Selective Frameworks

To selectively process information, a large variety of conceptual frameworks are used by humans. There have been empirical evidence which show that humans develop frames of reference or intuitive patterns of information capture and processing, when confronted with a task. This problem space, conceptually a 'workspace', is used to structure and limit input and recalling of information and processing methods. This may lead to use of a number of intuitive rules or heuristics to help an individual reduce the number of alternatives to be considered. Humans may also exhibit a trait of *bounded rationality* to limit the alternatives an individual has to consider. Decision rules also help providing filters to screen factors which are unnecessary to decision-making. Similarly, when a decision is to be made under stress, filtering is increased to concentrate only on the most important problem.

Cognitive Biases and Limitations

Bias or limitations in human's cognitive process is another source of information filtering. For example, Miller (1956) has suggested that short-term memory in humans cannot effectively process more than nine units of information (seven plus or minus two 7 ± 2). There is a tendency in humans to overlook small changes in a value, even though they may be statistically significant. Humans also tend to be biased because of many biasing factors, for example, humans tend to give higher weightage or probabilities to outcomes which they like or prefer. Similarly, easily remembered or imagined events may be assigned a higher probability.

3.9.2 Human Differences in Information Processing

Humans differ in handling the same information and solving the same problems. It may be attributed to their different cognitive styles. A cognitive style may be referred to the process through which humans organise and change information during the decision-making process. McKenney and Keen (1974) have suggested a model of cognitive style, which categorises human styles along two continuum as indicated in Fig. 3.17.

In this figure, the horizontal dimension, *information evaluation*, relates to how a human evaluates information. At one extreme, *systematic* humans are inclined to deal with a problem by structuring it in terms of a definite and systematic solution approach, which, if followed through, leads to an acceptable solution. Intuitive (or heuristic) humans are likely to use trial and error method to test various solutions. They are able to approach ill-structured problems, act spontaneously on the basis of new information, and find reasonable solutions on the basis of judgement developed through past experience.

The vertical dimension, information gathering, in Fig. 3,17 relates to the perceptual processes by which the processor organises verbal and visual stimuli. Some humans become deeply immersed in the details of data during an analysis and reach a solution based on extensive use of detailed information. Such humans are persons with *receptive* brain. They are often criticised because they 'cannot see the forest for the trees'. At the other extreme of this dimension, are the humans with *perceptive* minds who focus on relationships among data items as they gather and process information. They are likely to quickly examine any detail captured to find the most relevant way to establish relationships among data items. Humans with perceptive brains do not know what kind of trees there are in the forest.

What determines a human's cognitive style is not well-understood. What is clear is that it differs considerably between different humans. Each human receiving a piece of information will perceive the content of the message

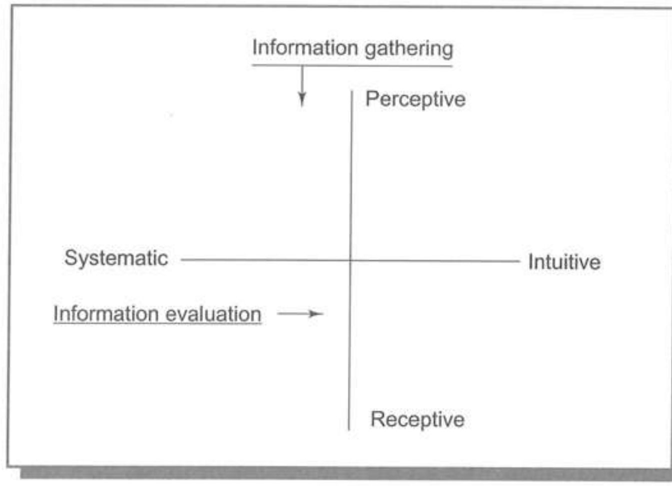

Fig. 3.17 A Model of Congnitive Styles

through a cognitive filter, which may select, amplify, reject or distort portions of the information. As a result, even quite simple messages or information may be interpreted differently by different humans.

Another explanation of human differences in cognitive style is biological (1982). This explanation has focused on the specialisation of the various parts of the human brain (see Fig. 3.18). Research reveals that the left side of the brain favours rational style of information processing. The right side of the brain, however, uses intuitive processing. Many factors like genetics, education, experience and cultural background lead to favour more of one type of processing than the other when a human gathers and evaluates information.

This model explains that humans with an intuitive style tend to take decisions on a 'hunch' without having to know all of the facts, whereas the humans with a rational style, review the facts about a situation and make a decision on the basis of a thorough analysis.

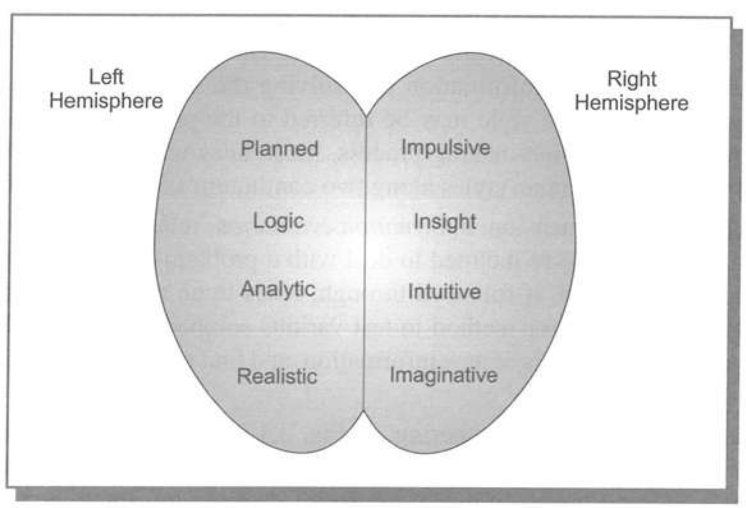

Fig. 3.18 Hemispheric Specialisation of the Brain

3.9.3 Implications for Information Systems

Human information processing system is quite useful in providing insights into the designing of information systems. The concept of information filtering because of selective frameworks and cognitive limitations and other biases in humans are required to be directly addressed in systems design. A brief description of these concepts and their respective implications for information system design are as follows.

Information Filtering

Systems should be so designed that they should attempt to override undesirable frames of reference filters by reinforced display of most relevant data. However, information systems should be able to filter out all irrelevant data.

Newell Simon model suggests that the information format should act in increasing the limits of bounded rationality.

The implications of Magical Number Seven plus or minus two for information system design are that codes for frequent human use should not exceed five to seven symbols or be divided into segments of five or less.

Information system should prominently highlight the differences in the values, especially when the differences are small but significant.

Human Differences in Information Processing

For a human being with a systematic mind, the information system should anticipate the solution method that will be used and should provide the information in the required form for that method. While humans with intuitive minds will have less need for specific decision models, and thus the information systems may not have specific solution algorithms for such humans. Similarly, the different approaches adopted by perceptive and receptive humans should be reflected in the information systems designed for them.

The concept of hemispheric specification of brain suggests that information systems should be designed to take advantage of the more intuitive right-brain functions.

SUMMARY

Information is a necessary and vital input in decision-making by managers in an organisation. Information in its unprocessed form is called data, which is generated as a by-product of transactions taking place in the organisation. Information on the other hand is a processed data and has an element of surprise. Information reduces uncertainty and triggers off action.

Information could be classified on the basis of the purpose for which it is utilised, into following three main categories:

(i) Strategic information,
(ii) Tactical information
(iii) Operational information.

Quality of information refers to its fitness for use, or its reliability. Some of the attributes of information, which influence the quality of information may be:

Timeliness
Accuracy
Relevance
Adequacy
Completeness
Explicitness
Exception-based.

Quality, however, is not an absolute concept. Rather it is defined within a context. A system has quality relative to its primary users.

Information may be understood as having various dimensions. However, for our purpose, the following three dimensions of information will be of interest:

(i) Economic dimension
(ii) Business dimension
(iii) Technical dimension.

In our daily life, the word 'system' is used quite often, but it is the most misunderstood word because it conveys a different meaning to different people. In general, a system is a set of elements which are joined together to achieve a pre-determined objective. However, these elements should be interdependent and interrelated. A system could be termed as an abstract or a physical system. An abstract system may be a logical system, i.e. an orderly arrangement of interdependent ideas or constructs, which may or may not have any counterpart in the real world. Whereas a physical system is a concrete operational system made up of people, materials, machines, energy and other physical things. A system may be called a deterministic system if the occurrence of all events is known with certainty in contrast to a probabilistic system in which the occurrence of the events cannot be perfectly predicted. A system may also be categorised as open and closed system. An open system is one that interacts with its environment, whereas a closed system does not interact with its environment and thus does not exchange information, energy or any material with

the environment. Information systems may be classified as user-machine system because in a user-machine system, both, i.e. human as well as machine perform some activities in the accomplishment of a common goal.

In order to define an area for the purpose of our study, a wall around that area needs to be constructed (not necessarily physically, it may be conceptual or logical one), which is termed as the boundary of the system. In the boundary, certain system constraints are identified and thus the area of study is delineated. The interaction among sub-systems is called system interface. A black box is a concept used for those sub-systems whose processes are not defined. In order to properly understand and design a system, it is divided into sub-systems and this process could be performed, till one feels the sub-system is of manageable size. The repeated process of dividing systems into sub-systems is known as system decomposition. The reverse of system decomposition is called system integration, in which sub-systems are joined to have a whole system.

A general model of a system can be understood in terms of its various parts, namely, Input, Output, Processor and Feedback.

The dynamics of a human as an information processing system can be understood with the help of a simple model consisting of sensory receptors, processing unit, and response output. Human brain resorts to information filtering because of limited capacity to accept input for processing. This information filtering may be based on a number of factors which may be inborn or acquired from past experience, knowledge and cultural background. There also exist human differences in information processing, which may be attributed to the different cognitive styles of humans. All these concepts provide a useful insight to the users and designers of information systems.

REVIEW QUESTIONS

1. Discuss various types of information. Elaborate on their uses.
2. Comment on the quality of information. Discuss various characteristics of information.
3. Elaborate on various dimensions of information.
4. What is meant by the word 'system'? Discuss different kinds of systems.
5. What are the common elements of any system?
6. Briefly discuss the concept of Boundary, Interface and Black Box.
7. How would you distinguish between decomposition of a system and integration of sub-systems? Discuss.
8. Elaborate on the human information processing system. Discuss its implications for IS design.

ASSIGNMENT

1. Assume you are working on the development of a computer-based information system. What importance do the following general system concepts have for you? Give examples of each as they apply to information systems:
   (i) System boundary
   (ii) Feedback
   (iii) System environment
   (iv) Open system
   (v) Sub-system
   (vi) Interface.

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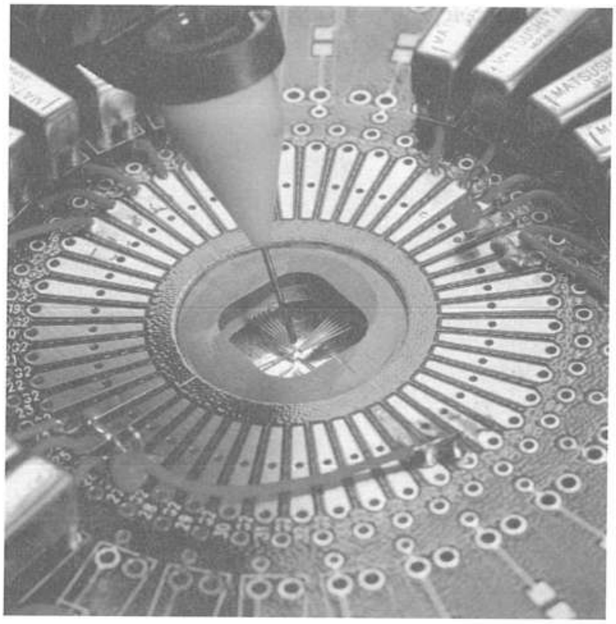
Chapter 4

Information Systems for Competitive Advantage



Learning Objectives

After going through this chapter, you should be able to:

- Clearly undersand the changing concepts of IS
- Explain what is business strategy and what are strategic moves
- Identify and describe the enablement role of IS in competitive advantage
- Understand the concept of strategic information systems and its role in competitive advantage

4.1 INTRODUCTION

There is no denying the fact that information systems contribute to organisational efficiency and effectiveness. However, until recently, information systems have not played a major role in the production, marketing and services. It is in the last few decades that there has been a revolutionary change in the use of information and information systems in organisations. Today, many organisations are using information and information systems as tools for gaining and sustaining competitive advantage.

FOCUS

Information and Information systems in organizations faced a revolutionary change in the last few decades.Today, many organizations are using information and information systems as a tool for gaining competitive advantage.

The growing uses of information systems may largely be attributed to the changing concept of the roles of information in the organisations. Information is regarded as a resource, just like other traditional 'four Ms' – men, money, materials and machines of an organisation. Let us have a look at the changing concepts of information systems.

4.2 CHANGING CONCEPTS OF IS

The concept of IS has passed through several stages. In 1950, information was considered a necessary evil, whereas today information is regarded as an important strategic resource. The changing concept of IS has been briefly discussed as below:

4.2.1 Information as a Necessary Evil

Information was regarded as a necessary evil, associated with the development, production and marketing of products or services. Information was thus merely considered as a by-product of transactions in the organisations. As a result, information systems of 1950s were primarily designed with the aim to reduce the cost of routine paper processing in accounting areas. The term Electronic Data Processing (EDP) was coined during this period.

4.2.2 Information for General Management Support

By mid 1960s, organisations began recognising information as an important tool which could support general management tasks. The information systems corresponding to this period were known as management information systems (MIS) and were thought of as systems processing data into information.

4.2.3 Information for Decision-Making

In the early 1980s, information was regarded as providing special-purpose, tailor-made management controls over the organisation. Decision Support Systems and Executive Support Systems were important advancements, which took place during this period. The purpose of such information systems was to improve and speed-up the decision-making process of top-level managers.

4.2.4 Information as a Strategic Resource

In the revolutionary change pattern, the concept of information changed again by the mid-eighties and information has since then been considered as a strategic resource, capable of providing competitive advantage or a strategic weapon to fight the competition. Latest information systems which, are known as strategic systems, support this concept of information. Table 4.1 portrays the changing concepts of information and information systems in organisations.

4.3 COMPETITIVE ADVANTAGE

FOCUS

Competitive Advantage is an advantage over competitors in some measure such as cost, quality, or speed. A Competitive Strategy is a broad-based formula for how a business is going to compete.

Information and information systems, can be used to gain and sustain competitive advantage in organisations.

Table 4.1 Changing Concepts of Information Systems

Time Period	*Concept of Information*	*Information Information*	*Aims of Information Systems*
1950–65	Necessary evil; A by-product	Electronic Data A by-product	Fast paper processing
1966–70	General purpose support	Management Reporting System	Speedy general report requirement
1971-85	Specific management control Support Systems	Decision Support Systems, Executive	Improvement, tailor made decision-making
1986	Strategic resource; Competitive weapon	Strategic Information Systems	Promote survival and growth of organisation

Competitive advantage is an advantage over competitors in some measure such as cost, quality, or speed and is at the core of a firm's success or failure (Porter and Millar, 1985). An organisation seeks to gain competitive advantage through its *competitive strategy* in an industry. A Competitive Strategy is a broad-based formula for how a business is going to compete, what its goals should be, and what plans and policies will be required to carry out these goals (Porter, 1985).

An organization that performs better than others is said to have a competitive advantage over others. The organizations having a competitive advantage perform better in terms of revenue, profitability, or productivity. For example, google.com is a leader in web search; Amazon.com is a leader in online retail; Apple's itune is regarded as a leader in online music; HDFC bank is considered as a leader in IT applications etc. But the basic question is why do some organizations perform better than others and how do they achieve competitive advantage? Their superior performance may be because of their access to special resources that others do not have, or their ability to use resources more efficiently. The challenging task before you is to understand how to analyze a business organisation and identify its strategic advantage? Also how can you achieve a competitive advantage for your organisation and how do IS/IT contributes to strategic advantage.

The well-known framework for analysing competitiveness is *Michael Porter's competitive forces model* (Porter, 1985). This model helps the organisation in understanding a general view of the organisation, its competitors and the firm's environment. On the basis of this understanding, organisations can formulate their strategies to increase their competitive edge and would also know the role of IS/IT in enhancing their competitveness. Porter's five forces model is discussed as follows:

4.3.1 Porter's Five Forces Model

Porter has suggested five major forces that could pose a threat to a given industry. In other words, these five forces shape the strategy of competition in an industry. Though the details of the model may differ from one industry to another, its general structure remains the same and is universal. The five forces can be generalised as follows:

1. The threat of entry of new competitors
2. The bargaining power of suppliers
3. The bargaining power of customers (buyers)
4. The threat of substitute products or services
5. The rivalry among existing competitors (firms)

Figure 4.1 illustrates the Porter's five forces model. These five forces explain the general business environment of an organisation. The following sections briefly discuss how these forces shape the competitive position of an organisation.

New Market Entrants

Because of free economy, new companies are always entering in the marketplace. The entry of these organizations is difficult in some of the industries, whereas it is easy in some other industries. For example, it is easy to start a new

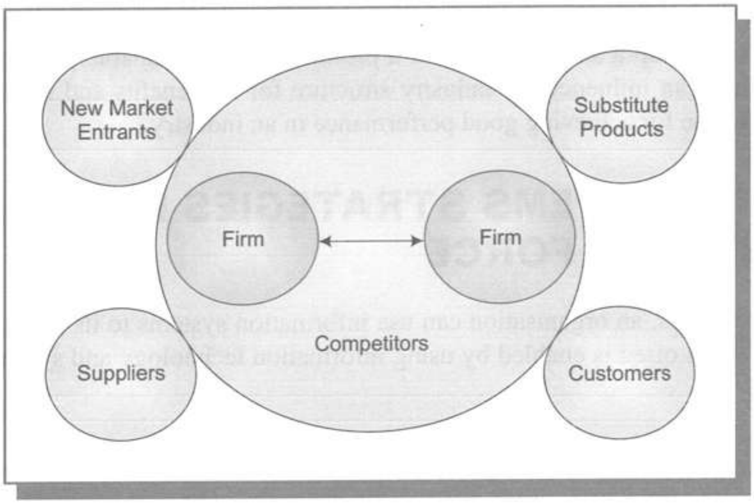


Fig. 4.1 Porter's Competitive Forces Model

retail shop: but quite difficult to start a new university, which requires high capital cost and a professional expertise. The new companies have many advantages like they start with latest technology/infrastructure; recruit young and motivated people; and not have a legacy system to unlearn and relearn the experiences. But these advantages, many a times become disadvantages. The new technology/infrastructure needs relearn huge funding; young people are less experienced; and need good time to create a brand.

Substitute Products and Services

There are substitutes for almost every product, which might be used in the case of high prices or non availability of the products. New researches produce substitutes for the existing products which may be more efficient , less costly or ecofriendly. For example, ethanol can be used as a substitute for gasoline in cars; vegetable oil for diesel fuel in trucks; and wind, solar, coal, and hydropower for industrial electricity generation. The availability of more substitute products in an industry would mean lowering of pricing and thus an impact on the profit margins.

Customers

The bargaining power of customers increases if they can easily switch to a competitor's products and services. For example, the online purchases have increased the bargaining power of the customers as they can know all the available products/services offered by different suppliers and they also know the prices of these products. For example, online booking of an air ticket offers a number of facilities to its customers and thus online customers have a great advantage over offline air ticket firms.

Suppliers

The supplier's power can also influence the company in a big way, especially when the firm can not increase prices as fast as its supplier can.If the number of suppliers for a given industry is large, the organisation can have a greater control over its suppliers and can negotiate in a better way in terms of price, quality and delivery schedules. For example, automotive company generally has multiple competing suppliers of key components.

Traditional Competitors

In order to attract new and to retain the existing customers, the competitors are always finding new ways of doing business which are more efficient. They are also improving their products/services and try to increase the loyalty of their customers to their organisations.

The strength of each force is determined by several factors of the industry structure, which are also shown in Figure 4.1. Organizations need to develop a strategy to attain a profitable and sustainable position against these forces. Porter explained how a firm can influence the industry structure for its benefits and recommended three strategies that organisations should use for achieving good performance in an industry.

4.4 INFORMATION SYSTEMS STRATEGIES FOR DEALING WITH COMPETITIVE FORCE

To counteract various competitive forces, an organisation can use information systems to its advantage. There are three generic strategies, each of which often is enabled by using information technology and systems. These three strategies are:

(a) low-cost leadership;
(b) product differentiation; and
(c) focus on market niche.

Low-Cost Leadership

To get a competitive advantge, an organization wants to achieve the lowest operational cost. Information systems can help an organization in achieving this goal. For example Wal-Mart was able to become the leading retail business in the United States because of its legendary inventory replenishment system which enabled the company to keep its prices low. Wal-Mart's continuous replenishment system sends orders for new merchandise directly to suppliers as soon as consumers pay for their purchases at the cash register. Point-of-sale terminals record the bar code of each item passing the checkout counter and send a purchase transaction directly to a central computer at Wal-Mart headquarters. The computer collects the orders from all Wal-Mart stores and transmits them to suppliers. Suppliers can also access Wal-Mart's sales and inventory data using Web-enabled information system. Besides managing with small inventory, the system also enables Wal-Mart to adjust purchases of store items to meet customer demands.

FOCUS

To counteract various competitive forces, an organization can use information systems to its advantage.

Product Differentiation

Another strategy to gain competitive advantage is product differentiation. Information systems are used to enable new products and services, or greatly change the customer convenience in the existing products and services. A new and unique search service on its website by Google is a good example of product differentiation. Apple is another example of continuous innovation which has recently introduced a portable iPod video player.

Similarly, Dell Computer Corporation is following a product defferentiation strategy, which sells directly to customers using assemble-to-order manufacturing. Customers can buy computers directly from Dell, customised with the exact features and components number or through Dell's website. Once Dell's production control receives an order, it directs an assembly plant to assemble the computer using components from an on-site warehouse based on the configuration specified by the customer.

Focus on Market Niche

An organisation can focus on a small market niche so as to serve this narrow target market better than its competitors. Information systems can support this strategy by analysing data and providing information for sales and marketing activities with the help of information systems companies. These can analyse customer buying patterns, tastes, and preferences so and thus focus on smaller and smaller target markets for their advertising and other marketing related activities.

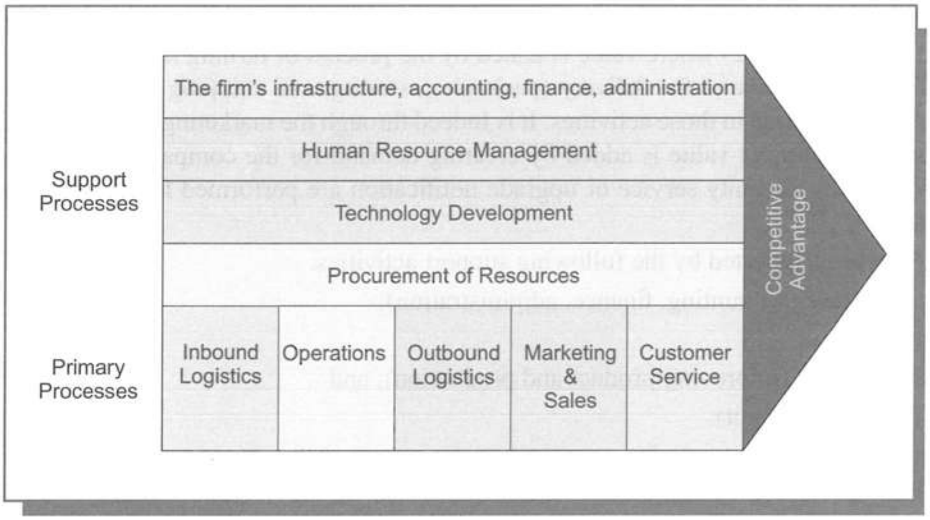


Fig. 4.2 The Value Chain of an Organisation

For example, of customer relationship management (CRM) system has a large number of analytical capabilities for this type of support.

Besides the above-mentioned strategies, information systems are also being used to strengthen linkages with suppliers and customers. Amazon.com keeps track of user preferences for book and CD purchases, and can recommend titles purchased by others to its customers.

No doubt the Porter's five forces model helps identifying competitive forces and suggesting generic strategies, it is not very specific about what exactly to do. The model is also silent on the methodiology to be followed for achieving competitive advantages. For example, if one wants to achieve operational excellence, the model does not guide from where to start? To overcome the limitations of five forces model, Michael Porter (1985) has suggested another model, which is popularly known as the business value chain model or Porter's value chain model.

4.5 PORTER'S VALUE CHAIN MODEL

The value chain model, which was developed by Michael Porter in 1985, highlights specific activities in the business where competitive strategies can best be applied and where information systems are most likely to have a strategic impact. The model (see Fig. 4.2) views an organisation as a series, chain or network of basic activities that add value to its products or services and thus add a margin of value both to the organisation and its customers. Thus, this model can be used to identify specific, critical-leverage points where a firm can use information technology most effectively to enhance its competitive position.

According to the model, the activities conducted in a typical manufacturing organisation can be categorised into two main categories:

(a) Primary activities

(b) Support activites

The primary activities as the name suggests, include the activities in which materials are purchased, processed into products and delivered to customers. These activities are:

1. Inbound logistics (inputs)
2. Operational (manufacturing)
3. Outbound logistics (storage and distribution)
4. Marketing and sales
5. Services.

According to this model the primary activities are assumed to take place in the above sequence and value is added to the product or service in each activity. To be more specific, the incoming materials (1) are processed (in receiving, storage, etc.), and this processing value is added to them in activities known as inbound logistics. Then the materials are used in operations (2) where value is added by the process of turning raw material into products. the products are required to be prepared for delivery (packaging, storing, and shipping in the outbound logistics activities (3) and more value is added in those activities. It is Indeed through the marketing and sales that the product is sold to customer, and thus product value is added by creating demand for the company's products. Lastly, the after-sales services (5) such as warranty service or upgrade notification are performed for the customer, and thus further value is added.

The primary activities are supported by the following support activities:

1. the firm's infrastructure (accounting, finance, administration);
2. human resources;
3. technology development (improving product and production); and
4. procurement (purchasing input).

It may be noted that each support activity can support any or all of the primary activities, and the support activities may also support each other. This model can be used to do company analysis in which, one can systematically evaluate a company's key processes and core competencies. In this analysis, one can first determine strengths and weaknesses of performing the activities and the value added by each activity. Some of the activities may add more value and might provide strategic advantage. This will help the organisations critically examine the value-adding activities at each stage and thus suggests whether to improve the business processes or drop the business processes. Then one investigates whether by adding IT, the company can get even greater added value and where in the chain the use of information system is most appropriate. One can also begin to ask how information systems can be used to improve the relationship with customers and with suppliers who lie outside the firm value chain but belong to the firm's extended value chain where they are absolutely critical to the success of the organisation. The concept of extended value chain is discussed under value web.

The Value Web

Since the performance of an organisation depends not only on what goes on inside an organisation but also on how well the organisation coordinates with direct and indirect suppliers, delivery firms, and customers. Thus the value chain of its suppliers, distributors, and customers, Internet technology has made it possible to create highly synchronized industry value chains called value webs. A value web is a collection of various organisations that use information technology to coordinate their value chains to produce a product or service. It is more customers-driven and operates in a less linear fashion than the traditional value chain. Information systems can be used to achieve strategic advantage at the industry level.

FOCUS

A value web is a collection of various organizations that use information technology to coordinate their value chains to produce a product or service.

An information system which is used to get an edge over the competitors of the organisation is known as Strategic Information System (SIS). Let us have a brief look at the concept of strategic information systems.

4.5 STRATEGIC INFORMATION SYSTEMS (SIS)

Strategic Information Systems (SIS) are a specialised type of information systems. These systems change the goals, operations, products, services or environmental relations of an organisation to help it gain an edge over the competitors. Strategic information systems may even change the business of an organisation. These changes in the business force organisations to adopt new behaviour patterns. As a result, organisations may often need to change their internal operations, require new managers, a new workforce and a much closer relationship with customers and suppliers.

FOCUS

These systems change the goals, operations, products, services or environmental relations of an organisation to help it gain an edge over the competitors. It can be used at all level of an organisation.

Strategic information systems should not be confused with strategic level systems. Where strategic level systems are meant for top-level managers that focus on decisions relating to strategy formulation, the strategic information systems can be used at all levels of the organisation and are more far-reaching and deep-rooted than the other types of information systems. Strategic information systems fundamentally change the way an organisation runs its business.

Strategic Information Systems for Competitive Advantage

Today, organisations use their strategic information systems for gaining competitive advantage. An SIS can offer competitive advantage to an organisation in the following ways.

(i) creating barriers to competitors' entry into the market,

(ii) generating databases to improve marketing techniques,

(iii) 'locking in' customers and suppliers,

(iv) lowering the costs of the products, and

(v) leveraging technology in the value chain.

A brief discussion of these strategies is given in the following text.

(i) *Creating barriers to competitors' entry:* In this strategy, an organisation uses information systems to provide products or services that are difficult to duplicate or that are used to serve highly specialised markets. This prevents the entry of competitors as they find the cost for adopting a similar strategy very high. The organisation gets a competitive advantage as with differentiated products and services, they no longer have to compete on the basis of cost. For example, banks are taking a lead in developing specialised information systems. Citibank developed automatic teller machines (ATM) to facilitate deposits or money withdrawals by the customer which helped the bank in becoming, at one point of time, the largest bank in the United States. Similarly, some banks develop new kinds of banking services using information technology.

(ii) *Generating databases to improve marketing:* An information system also provides companies an edge over their competition by generating databases to improve their sales and marketing strategies. Such systems treat existing information as a resource. For example, an organisation may use its database to monitor the purchases made by its customers, to identify different segments of the market, etc. This helps framing the marketing strategies to serve the customers better and thus helps retaining the existing customers. The cost of retaining an existing customer has been estimated as one fifth that of acquiring a new one.

(iii) *'Locking in' customers and suppliers:* Another way of gaining competitive advantage by using strategic information systems is by 'locking in' customers and suppliers. In this concept, information systems are used to provide such advantages to a customer or a supplier, that it becomes very difficult for them to switch-over to a competitor. For example, an organisation may develop its information system and give many benefits to its customers, like reliable order filling, reduced transaction costs, increased management support and faster delivery service. Such information systems also provide benefits to suppliers, who can monitor product requirements, factory scheduling, and commitments of their customers against their own schedule to ensure that the required inventory will be available. The efficiency and convenience will help discourage the customers and suppliers from switching to competitors.

(iv) *Lowering the costs of the products:* Strategic information systems may also help organisations lower their internal costs, allowing them to deliver products and services at a lower price than their competitors can provide. Thus, such information systems can contribute to the survival and growth of the organisation. For example, airlines use information systems strategically to lower costs so that they may counter competitors' discount fares.

(v) *Leveraging technology in the value chain:* This approach, popularly known as Porter's value chain model, pinpoints specific activities in the business where competitive strategies can be best applied, and where information systems are likely to have a greater strategic impact. This model advocates that information technology can best be used to gain competitive advantage by identifying specific, critical leverage points.

An information system will have a strategic impact if it enables the organisation in providing products or services at a lower cost or with a greater value than that of the product or service offered by the competitors. Figure 4.1 illustrates the activities of the value chain and representative technologies with strategic information systems.

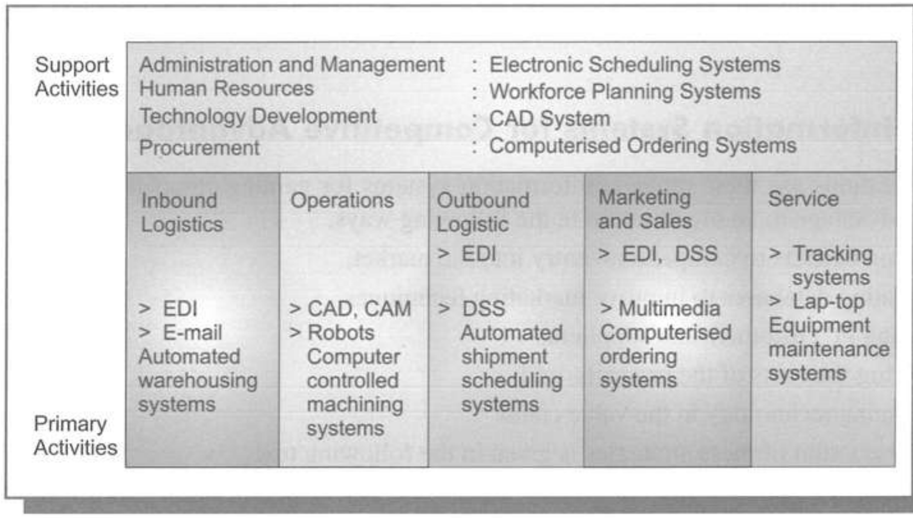


Fig. 4.3 Activities of the Value Chain and Representative Technologies

For example, an organisation can save money in the inbound logistics activity by receiving materials on daily basis from the suppliers and thus lowering the costs of warehousing and inventory. For this, strategic information links have to be established between the organisation and the supplier. Similarly, computer controlled machining systems would support the operations activity, reducing costs and enhancing quality. These systems enable a manufacturing organisation to have a competitive advantage. Systems like electronic scheduling and communication systems will have a strategic impact on a consultancy firm.

It is beyond doubt that strategic information system can be used for competitive adnavtage and there might be many opportunities to accomplish a competitive edge with SIS. The use of latest technologies by many organisations has been one of the major reasons for their great competitive advantage.

The organisations can implement some of the strategic initiatives, as discussed in the previous section of this chapter, by using information systems. An SIS can be developed afresh, developed by modifying an existing system, or 'found' by realising that a system already in place can be need as a SIS. That is why a SIS can be any small information system and even at the lowest level of management. While developing an SIS, one needs to keep in mind that it should satisfy two important conditions. First, the information system should serve an organisational goal rather than simply provide information; and second; the organisation's IS unit should work with managers of all other functional units like marketing finance, human resource, manufacturing, etc., to achieve the organisational goal.

Developing an SIS

In order to develop an effective SIS, the organisation should ensure the commitment as well as involvement of top management. The SIS must be a part of the overall organisational strategic plan. All the managers, who would be using the system must be involved in its development. There must a 'high' readiness for SIS of the organisation; for which the top management must ask a set of question, which include the following;

(1) What is the mission of our organisation?
(2) What are the goals to be achieved by our organisation?
(3) How can we gain competitive advantage?
(4) Can information system get us a significant advantage?
(5) Will the development of SIS be feasible in term of technical financial, Legal operational terms?
(6) What is the risk of not developing such a system?
(7) Are there any alternative means of acheving the same goals, if so, how do they compare with the advantages and disadvantages of a new SIS?

While determining the feasibility of SIS, one should not be carried away by the economic justification. The purpose of these systems is not only to reduce costs or increase revenues; rather as the name implies the benefits are strategic in mature; which are very critical in achieving the goals of the organisation. These systems may create an altogether new service or prodict; or may even change the way an organisation does business.

For the implementation of SIS, the organisations are required to undertake Business Process Reengineering (BPR). This process would let the organisations to understand their business processes and thus helps eliminating the redundant processes.

Business Process Re-engineering

Business Process Re-engineering is redesigning the business processes which becomes a prerequisite for implementing an SIS. The organisation, while taking a decision to implement an SIS, should ask a basic question that if they are to establish their business unit again, from scratch,what processes named they implement and how? The answer often leads to redesigning the business process and thus to eliminate some of the existing activities or operations and build others from the ground up. Such changes are called re-engineering of the business processes which might include adoption of new machinery and elimination of management layers. IT plays an important role in this process. Such a re-engineering effort leads to efficiency and improvements thus leading to competitive advantage.

Sustainable Competitive Advantage

It is often seen that competitve advantage cannot be sustained innovatively for long. Competitors would copy the new information system soon and as a reult the advantage diminishes For example, ATM and online banking used by the few banks had a good strategic advangage but now almost every bank has to provide these services. Thus innovative strategies have to be formulated on continuous basis and organisations find new ways to use information systems to their advantage. For example, Amazon adds new features to its website on continuous basis to maintain competitive advantage. The company has moved from merely selling books through, web to providing best-seller lists, readers reviews, author's inteviews; product reviews by customers, and so on. The constant improvement helps the company maintain its dominant position in online retailing.

SUMMARY

Until recently, information was considered as a by-product of transactions in the organisations and thus was regarded as a necessary evil. Today, concept and thinking about information have undergone a tremendous change and now organisations view information as a weapon against competition and a strategic resource. Competitive advantage is an advantage over competitors in some measure such as cost, quality, or speed. Competitive advantage is at the core of a firm's success or failure. An Organisation seeks to gain competitive advantage through its competitive strategy in an industry. A Competitive Strategy is a broad-based formula for how a business is going to Compete, what its goals should be, and what plans and policies will be required to carry out these goals. The well-known framework for analysing competitiveness is Michael Porter's competitive forces model. This model helps the organisation in understanding a general view of the organisation, its competitors and the firm's environment. On the basis of this understanding, organisations can formulate their strategies to increase their competitive edge and would pose a threat to a given industry. In other words, these five forces shape the strategy of competition in an industry. Through the details of the model may differ from one industry to another, its gerneral structure remains the same and is universal. The five forces can be generalised namely, the threat of entry of new competitors; the bargaining power of suppliers; the bargaining power of customers (buyers); the threat of substitute products or services; and the rivalry among existing competitors (firms).

To counteract various competitive forces, an organization can use information systems to its advantage. There are three generic strategies, each of which oftern is enabled by using information technology and systems. These three strategies are: low-cost leadership;product differentiation; and focus on market niche. Strategic information systems change goals, operations, products, services and environmental relationships of organisations to help them gain an edge over their competitors. Value chain model can help identify areas of a business organisation where IS can get a strategic advantage. The value chain model views the

organisation as a series or 'chain' of basic activities and add a margin of value to an organisation's products or services. Information systems can have strategic impact on activities that add the maximum value to the organisation. To gain competitive advantages, organisations use strategic information systems in the following ways:

(i) creating barriers to competitors' entry
(ii) generating databases;
(iii) 'locking in' customers;
(iv) lowering the product/service cost; and
(v) leveraging technology in the value chain.

REVIEW QUESTIONS

1. Give four different concepts of the role of information systems in organisations. Do you think information systems have changed to match these differing views of information?
2. Discuss five forces competitive model. How would you apply this model in industry.
3. Discuss value chain model. Give its applications.
4. Discuss the concept of strategic information systems. Differentiate strategic information system and a strategic-level system.
5. Discuss the four basic competitive strategies. How can SIS help rganisations pursue each of these strategies?
6. An SIS offers an organisation shortlived advantage. Why is it so?
7. What is re-engineering? What does it have to do with IT?

ASSIGNMENTS

1. Visit a nearby organisation. Study its business. Based on the study, suggest an appropriate strategic information system for the organisation.
2. Take an example of one organisation each from a) automotive sector b) Air travel sector; and apply Porter's five forces competitive model and value chain model. Analyse the following:
   (i) How are the two organisations different?
   (ii) What kind of SIS should be implemented in each organisation?

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CASE STUDY 1

VEHICLE BOOKING INFORMATION SYSTEM

A transport company, having 120 vehicles provides private car-taxi, carriers and buses on hire basis. The major activities of the company include:

(i) monitoring of vehicles engaged,
(ii) booking of vehicles for trips,
(iii) deciding the route of vehicles,
(iv) reimbursement to drivers,
(v) testing and maintenance of vehicles before each trip,
(vi) billing of clients,
(vii) analysis of damages caused, and
(viii) analysis of driver's performance, though this is the main neglected task.

The owner of the company has recently tied up with a manufacturing company to provide trucks for despatch of goods. The client company has a very strict monitoring system of despatch. Any delay in reaching the destination will imply a penalty at the rate of Rs 300 per day. Also, the transporter can enjoy an award of Rs 300 if its truck reaches before time. A list of all possible destinations of the client-product has been given to the transporter which reflects the norm days to reach the location. Now, the owner has to carefully plan out his information system. He has enough money to spend on MIS analysis and implementation of the proposed solution, but does not know how to manage his time for making new strategies.

FOCUS

An information system will have a strategic impact if it helps the organization in providing products or services at a lower cost or with a greater value than that offered by the competitors.

QUESTIONS FOR DISCUSSION

1. What kind of strategic information system you would propose for such a company?
2. How can you help him in managing his time for making new strategies?

CASE STUDY 2

MANAGEMENT INFORMATION SYSTEM AT HIRA & COMPANY

INTRODUCTION

Hira & Co. is engaged in the business of automobile manufacturing. It manufactures a wide range of two-wheelers, catering to various segments of the market. It has a plant with a capacity of 500 vehicles daily. These vehicles, after production and quality testing are sent to the warehouse for stock maintenance. The company recorded the annual turnover of Rs 600 crore in the year 1997–98. It has further plans to grow by adding another plant with similar capacity.

Sales and Distribution

The marketing department of the company operates from the head office which is 100 km away from the plant. This department has developed a network of 170 dealers all over the country and in the neighbouring countries. All sales of vehicles are done only through the dealers. The company assigns annual sales targets to all dealers after consultation with the concerned dealer. These targets generally vary from region to region, depending on the demand of the product in the state or the city. The annual target is then distributed over the year to derive the monthly sales targets. The dealers place their orders with the marketing department. No sales are made without a corresponding demand by the dealer. A control is kept on the sale with respect to the monthly/annual sales targets achieved/remaining. The marketing department keeps one copy of all orders with it and sends another to the despatch department. The marketing manager ties up with the despatch in-charge to allocate priorities to the orders for despatch.

Despatch Plan

The despatch department, located in the factory premises, gets the order details from the marketing department. The person in-charge of despatch consults the marketing manager to identify key orders in order to assign them a high priority for despatch. It then arranges the re-quired despatches, according to the geographical locations. Thus, all orders pertaining to one city or cities on the same route are selected for loading on one truck. The plan also considers the vehicle number of the truck which will be routed for a despatch. The despatch plan, after finalisation, is sent to the marketing department for information and necessary tie-ups with the dealers.

The Mode of DEspatch

The company has enrolled trucks for all despatches. For this, it has entered into annual contracts with various transporters. The transporters register their trucks with the company for the period of the contract. They have to specify the truck number, permit details and details of the driver. Every truck must have a valid permit number which signifies the government permission given to the truck to ply on the routes specified in the permit. The despatch department has to keep an eye on the trucks whose permit validity is about to expire. All trucks have special fittings as per the company specification to suit the transportation of the vehicles to be despatched. As soon as the truck comes back from the tour, it reports back to the despatch section. These trucks are loaded on a first-come first-served basis.

Process of Delivery and Acknowledgement

As the despatch department plans the despatch, the details are sent to the EDP department, which generates five copies of invoice for every order. The invoice contains the actual number of items delivered and the total amount in rupees, in addition to the customer identity details. The truck details are entered as the material gets loaded physically at the gate. One copy each goes to the warehouse, accounts, marketing, truck driver and the concerned dealer. The copies of the accounts and marketing department are sent via regular company vans which ply between the factory and HO twice every day. The truck driver takes his and the dealer's copy along with the material to be delivered. On return, the driver gets the dealer's acknowledgement on his own copy and submits this back to the despatch section. The despatch department later sends this back to the marketing.

Process of Payments

The dealers have a special system of payments. Most of the dealers send a letter of credit (LC) to the company given by its bankers for a specific time period and amount. The time is generally one year. The company interacts with a branch of the dealer's banker in town. As soon as the despatch is made to the dealer, the accounts person goes to the bank, shows the invoice to the bank so that the bank realises the LC and the payment is given to the company in a day. Next, it is the task of the bank to follow-up with its dealer for actual realisation of money.

In some cases, the dealer directly sends in a demand draft for the payment. The drafts can be sent in advance also. It is possible to get a payment partly by LC and partly by draft. Marketing and finance departments maintain separate details for the outstandings on their respective personal computers.

Information Flow

The EDP at factory processes the invoices on a minicomputer that runs a proprietary language. Though, a new RISC-based machine has been installed with UNIX SVR4.0 and Sybase system 10, it will take at least two years to convert this system to new formats, as per the priorities of the company.

The marketing department gets a copy of the invoice the same day when the product is to be despatched. This data is entered on a local personal computer running on Windows and Foxpro. Every morning before 10.00 A.M., a report goes to the director of the company giving the despatch status of the previous day for all the dealers with their targets achieved and remaining. The despatches are indicated separately for each model. The report also indicates the dealers' outstandings. The management is somewhat rigid about the length of the report not exceeding two pages. The marketing department keeps track of the payments due on part of the dealers. Dealers also continue to ringup the marketing department to know about the status of their orders and payments. Practically, one person is meant exclusively for attending to phone calls.

Problems in the Existing Information Flow

There is generally a long waiting list of trucks standing idle in wait for loading. This is generally so because the despatch section does not know exactly how many trucks would be available on a given day. The real problem arises when the despatch section plans a despatch for a dealer whose LC validity period has expired, i.e. the material is sent to a dealer whose payment status is not clear. At times, the data maintained by marketing and finance departments does not reconcile, thus adding to ambiguities. The finance department normally lags behind as the payment details first come to the marketing department.

Future Plans

The marketing manager wants to increase the reliability of despatch. For this, he has proposed to include the dealer's detailed feedback on delivery of goods, including the departure details and date and time of arrival of the truck at the dealer's premises. The number of trucks that will be available during the following weekdays is required to be known in advance. The truck performance can also be monitored on the basis of its time delays and the dealer's feedback on delivery. Special schemes are being worked out to motivate/penalise the transporters for their performance. A policy decision is also required to be taken regarding despatching material whose payment status is not clear.

Future Plans: Information Technology

The management is fast realising the need to move towards automation for better control over its despatch system. The inhouse software development team has already made one application to monitor the payment status of dealers but this has not been implemented as the operational staff is not willing to add to its load. It seems, the management does not want to employ more manpower for this work but the existing staff feels that this new task would add to the workload, making it beyond their capacity.

The marketing manager has seen many of its competing organisations changing their ways to tie-in with customers and suppliers with the help of IT. However, the ideas are not very mature in his mind. He wants a solution that increases the business as well as dealer satisfaction but at the same time the cost of which can be justified to the top management.

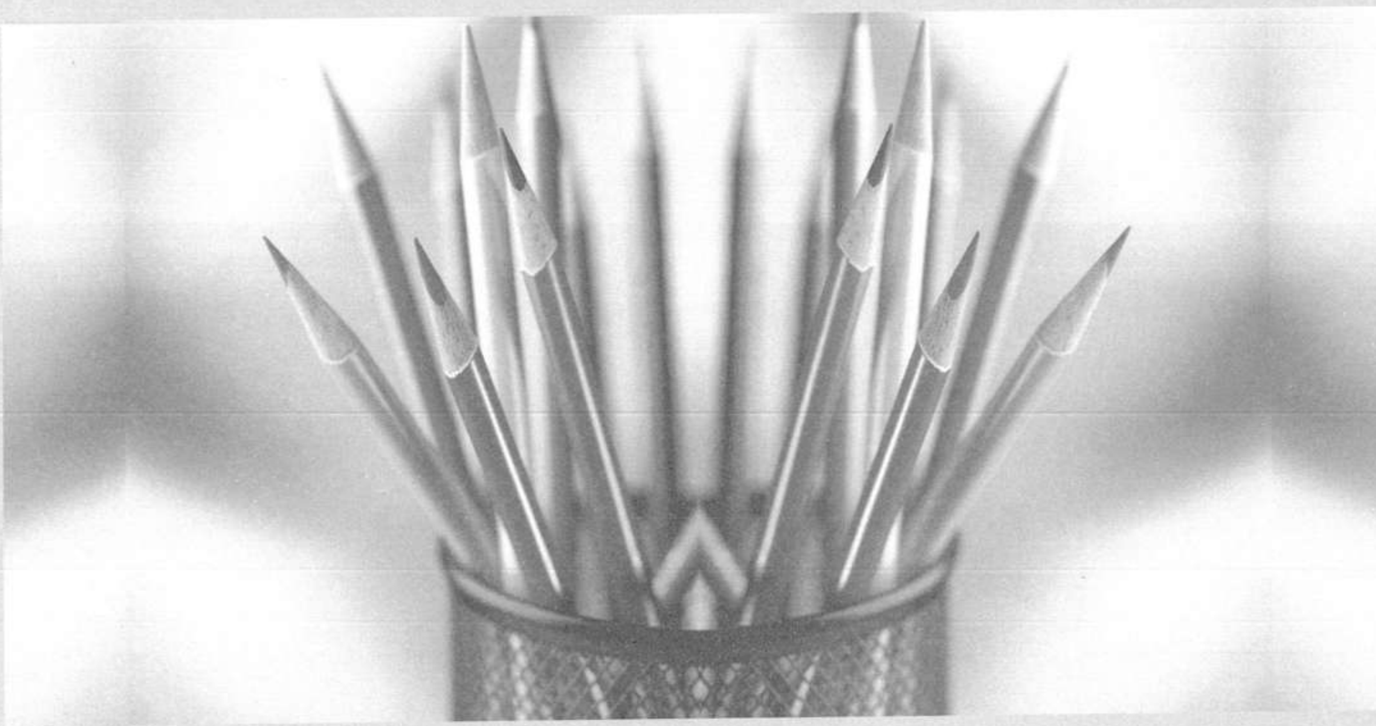
QUESTIONS FOR DISCUSSION

1. What IS solutions may be available for the automobile sector and what IS solutions would you recommend for Hira & Company And why?
2. As a CIO of the company, would you like to implement Dealer Management Systems and Customer Relationship Management Systems? What could be the strategies to implement these systems?
3. Prepare a feasibility report for the proposed system?

Part

2

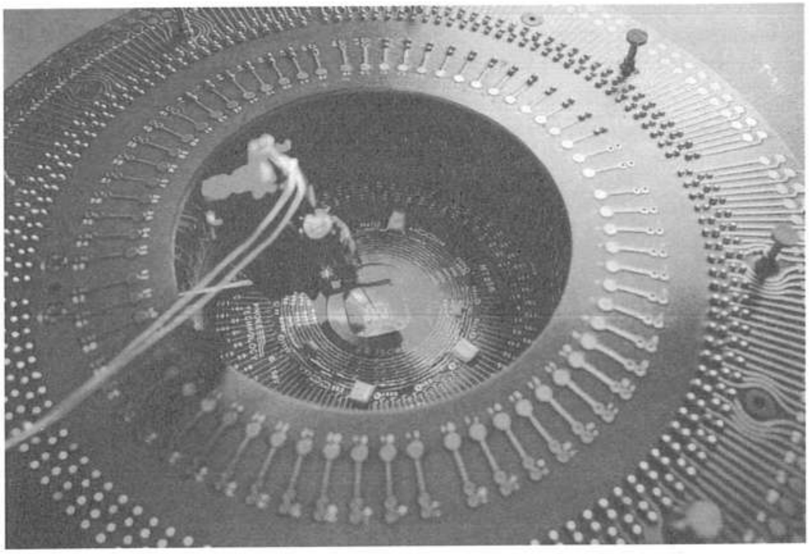
Information Technologies



Chapter Outline

Chapter 5

Computer Hardware, Software and Emerging Technology



Learning Objectives

After going through this chapter, you should be able to:

- Describe various components of a computer system and explain their roles
- Discuss various input and output devices
- Understand data capture methods
- Identify and distinguish among the different types of computers
- Understand the developments in computer software technology

It has already been discussed that today, the term MIS has become synonymous with computer-based management information systems (CBMISs). Therefore, every manager in any organisation has to be computer literate, and the best approach for learning about computers is first to be aware of the basics of a computer system.

5.1 A COMPUTER SYSTEM

A computer, in a simple language, may be understood as a fast calculating electronic machine that can perform arithmetic operations. However, a computer is not only a calculating machine. Today, it can perform a variety of activities involving arithmetic and logical operations on data. It accepts the data through an input device, processes it as per the instructions given and produces the information as output. Thus, a computer may be defined as a fast electronic device that processes the input data as per the given instructions and produces the information as output. A detailed description of a computer system is given in the following text.

FOCUS

A computer is a fast calculating machine that can perform arithmetic operations. A computer system performs the basic system functions of input, processing, output storage and control.

A computer system may be visualised as a set of inter-related elements that, perform the basic system functions of input, processing, output, storage and control. Figure 5.1 illustrates the basic hardware units of a computer system, which are organised according to the following system functions.

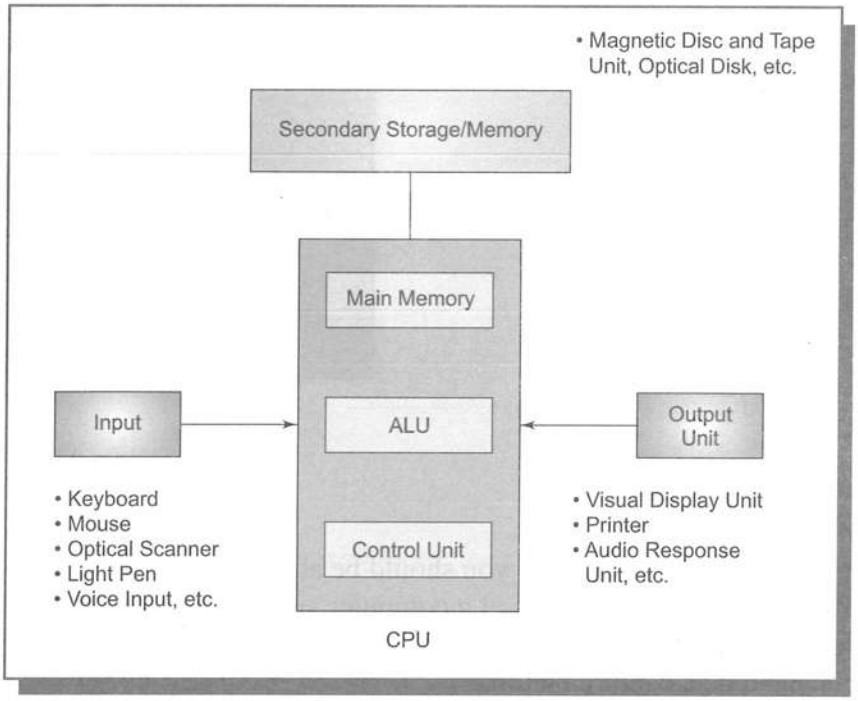


Fig. 5.1 Components of a Computer Hardware System

Input

The input devices of a computer system include keyboard, electronic mouse, touch screens and optical scanners. They convert data into electronic machine-readable form enabling data entry into a computer system.

Processing

The main processing component of a computer system is the Central Processing Unit (CPU). The arithmetic and logic functions in processing are carried over by one of its major components, known as Arithmetic and Logic Unit (ALU).

Output

The output devices of a computer system include Visual Display Unit (VDU), printers and speakers for audio. Through these devices, information is presented, in the understandable language, to the end-users.

Storage

This function is performed by the primary and secondary storage units (memory) of a computer system. These units store data and programs required for data processing.

Control

The control unit of the CPU interprets various computer programs and sends directions to the other components of the computer system for the required operations to be performed.

A computer thus receives data, processes it, stores it and displays results. As mentioned above, a computer captures data from *input devices*, processes this data in the *Central Processing Unit*, stores it in *memory*, and displays results through *output devices*. Like the human mind, a computer's memory is also limited. For this reason, computer stores most critical data and instructions in its *main memory*, whereas less critical and less frequently used data in its secondary memory. A brief description of hardware components alongwith a few important characteristics of each hardware is given now.

5.1.1 Central Processing Unit

The Central Processing Unit (CPU) is the 'computer' of a computer system. It is the centre of all processing activities. It is in the CPU that all processing is controlled, all data is manipulated, arithmetic computations are performed, and logical comparisons are made. It has an arithmetic/logic unit (ALU) and a control unit.

FOCUS

The Central Processing Unit is the 'computer' of a computer system. Controls processing, manipulates data, performs arithmetic computation and makes logical comparisons.

Arithmetic logic unit (ALU) as the name suggests, performs the arithmetical (like addition, subtraction, multiplication, division, etc.) and logical operations, e.g. Is $M = N$, where M and N are both numbers, Is the Unit Price equal to Total Cost/12? All such arithmetical and logical functions are carried out in special storage areas in the CPU, called registers which are vital to the functioning of a computer. The size and number of registers varies from one computer to another, since the register size refers to the amount of information that can be held in a register at a time. The processing speed will be faster for the larger register. The processing power of a CPU is measured in million instructions per second (MIPS). The speed of a CPU is usually measured in cycle time, i.e. the time required to execute one basic instruction.

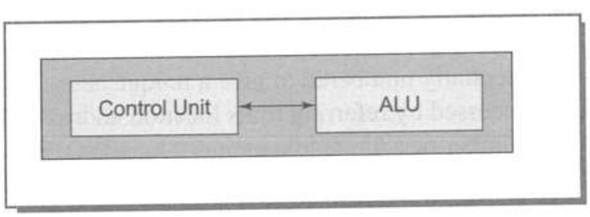


Fig. 5.2 Central Processing Unit

While on first generation computers, the CPU speed was measured in milliseconds (1/1000 of a second), it was in microseconds ($1/10^6$—one millionth of a second) on second generation computers, in nanoseconds ($1/10^9$—one billionth of a second) on third and fourth generation computers. In the future fifth generation computers, the CPU speed is expected to be in the range of picoseconds ($1/10^{12}$ of a second).

FOCUS

The Main Memory stores data and program statements for the CPU.

The control unit regulates all the operations of a CPU. It is the control unit which ensures the transfer of the required data between the CPU and the input-output devices in the required and desired sequence. It contains all logic circuits and storage space needed for the control of input-output devices.

5.1.2 Main Memory

Main memory or primary storage stores data and program statements for the CPU. The specific functions of the main memory are to:

(i) store all data to be processed;

(ii) store data and results during intermediate stages of processing;

(iii) hold data after processing until it is transferred to an output device; and

(iv) hold instructions required for ongoing processing.

It would be interesting to know the way a computer stores data, programs, etc., internally. It is generally said that whatever a computer does, it does through 0s and 1s or a computer cannot understand anything beyond 0s and 1s. Is it a fact? The answer is yes, as we know that a computer works with electricity and to make it more reliable and effective, a computer is designed using only two signals, i.e. the presence (1) and absence (0) of an electrical pulse, which is either the 'on' or the 'off' state of an electrical signal. These two digits, i.e. 0 and 1 are known as *binary digits* (bits). In order to represent information in a computer, we use a large number of symbols or characters, namely, numbers in the decimal system 0 to 9, alphabets A to Z (capital as well as lower case), arithmetical and relational operators like +, –, =, >, <, etc., and special characters like :,?, ', etc.

For representing these symbols and characters in a computer, a unique representation for each symbol and character is required. With two bits, four different characters/symbols, namely 00, 01, 10 and 11 can be represented. With 3 bits, eight (2^3) different characters/symbols namely, 000, 010, 011, 001, 100, 101, 110 and 111 can be represented. Similarly, we can represent 64 different characters with 6 digits. Since there are more than 80 characters to be represented and there may arise a need to include more characters in future, computers typically use eight bits to represent information internally. With 8 bits, up to 256 (2^8) different characters can be represented uniquely. A collection of 8 bits is known as a byte. One byte is used to represent one character of data by most computer coding schemes.

Two widely used 8-bit coding schemes are EBCDIC (Extended Binary Coded Decimal Interchange Code) pronounced 'eb-sa-dick' and ASCII (American Standard Code for Information Interchange), pronounced 'as-kee'. They use various arrangements of bits to form bytes that represent the characters of the alphabet, numbers 0 to 9, and many other special symbols.

EBCDIC was developed by IBM and is used primarily on large, main-frame computers. ASCII has emerged as the standard coding scheme for microcomputers. These coding schemes are shown in Fig. 5.3.

To represent numbers internally, most computers use two bytes or four bytes, hence the usage of the term 16-bit or 32-bit computers.

The memory is made up of a number of cells or memory locations. The cells are organised to hold information of a fixed size, which may be 8 bits of information, 16 bits, 32 bits, 64 bits, and so on. This is known as the word length or word size of the memory. Each cell is sequentially numbered to give a unique address known as location address. The contents of the memory locations are accessed by referring to its location address. The number of bits used to address a memory location determines the number of addressable memory locations. For example, with 10 bits, 1024 (2^{10}) locations can be addressed. The amount of information that can be stored in the main memory is referred to as the memory capacity of the computer and is measured in kilobytes (kB) or megabytes (MB). Although

1 kB (Kilobyte) = 10^3 bytes
1 MB (Megabyte) = 10^6 bytes
1 GB (Gigabyte) = 10^9 bytes
1 TB (Terabyte) = 10^{12} bytes
1 PB (Petabyte) = 10^{15} bytes
1 Ex (Exabyte) = 10^{18} bytes

Fig. 5.3 Measuring Units of Digital Data

Character	EBCDIC	ASCII Code
A	11000001	10100001
B	11000010	10100010
C	11000011	10100011
D	11000100	10100100
E	11000101	10100101
F	11000110	10100110
G	11000111	10100111
H	11001000	10101000
I	11001001	10101001
J	11010001	10101010
K	11010010	10101011
L	11010011	10101100
M	11010100	10101101
N	11010101	10101110
O	11010110	10101111
P	11010111	10110000
Q	11011000	10110001
R	11011001	10110010
S	11100010	10110011
T	11100011	10110100
U	11100100	10110101
V	11100101	10110110
W	11100110	10110111
X	11100111	10111000
Y	11101000	10111001
Z	11101001	10111010
0	11110000	01010000
1	11110001	01010001
2	11110010	01010010
3	11110011	01010011
4	11110100	01010100
5	11110101	01010101
6	11110110	01010110
7	11110111	01010111
8	11111000	01011000
9	11111001	01011001

Fig. 5.4 Coding Standards

'kilo' means 'one thousand' in the metric system, the computer industry uses 'k' to represent 1024 or (2^{10}) positions. However, such differences are ignored for the sake of convenience. Thus, a megabyte (2^{20}), is approximately one million (10^6) bytes, while a gigabyte is roughly one billion (10^9) bytes.

To make the main memory of a computer, two different technologies, namely, magnetic core technology and semiconductor (chip) technology have been used. However, for various advantages of semiconductor memory over magnetic core memory, all modern computers use semiconductor memory. Semiconductor memory is cheaper, faster and is available on miniaturised chips. The only disadvantage of semiconductor memory is its volatile nature, that is it loses its contents in the event of electric supply failure. However, this drawback can be easily overcome by keeping back-up power units (Uninterrupted Power Supply equipment known as UPS). The main memory of a computer, having semiconductor memory, can be of the following two types:

Random Access Memory (RAM)

The memory is known as RAM if any part of it can be accessed randomly (directly) for reading and writing. RAM is volatile and is erased when computer is switched off. This is the place in which the CPU stores the data and programs. The larger the memory area, the larger the programs that can be stored and executed. Nowadays, a typical multimedia personal computer requires a minimum of 512 MB to 1 GB of RAM. Two types of RAM, i.e. DRAM (Dynamic RAM) and SRAM (Static RAM) are commonly used in PCs. In DRAM, the stored information has to be refreshed after every few milliseconds, otherwise it is erased; whereas in SRAM, the stored information need not be refreshed; rather it remains in the memory until the computer is switched off.

Read Only Memory (ROM)

Read only memory (ROM) is another part of the main memory, which allows its contents to be read but does not permit any writing or alterations to be made by its users. The programs are continually retained within the ROM. This type of memory is non-volatile (that is, it does not lose its contents with the power failure as the programs are permanently written to it). Usually ROM is supplied by the manufacturer with all the frequently used routines, for example, program needed to start (boot) a computer, calculating square root or other utility programmes. ROM varies from 64 kB to 1 MB depending on the type of computer.

However, sometimes it becomes necessary to make changes in ROM for a particular client. In that case, a Programmable ROM (PROM) memory can be used. A PROM can be programmed once by a programmer. Once programmed, PROM becomes ROM. Another category of ROM is also available, which is known as Erasable PROM (EPROM), which cannot only be programmed by the programmer but also be erased by ultraviolet light for reprogramming. Similarly, other types of ROM available for microcomputers are EEPROM (Electrically EPROM), EAPROM (Electrically Alterable PROM), etc.

The CPU and memory usually reside on a larger circuit board in a Computer case called the *motherboard* or system board on smaller computers.

5.1.3 Secondary Memory

As the main memory of a computer is limited, volatile and expensive, secondary memory becomes essential to any computer to provide back-up storage and thus it supplements the main memory. While the main memory is contained in memory chips, secondary storage can be on many different types of media. However, as compared to main memory, the secondary storage, though non-volatile is relatively slower in storing and retrieving data. Nowadays, secondary storage media can be classified into three types, namely: magnetic, optical, and magneto-optical storage devices.

FOCUS

The Secondary Memory becomes essential to any computer to provide backup storage and thus supplements the main memory which has limited memory.

Magnetic Storage Devices

In this media, data is stored on a magnetic medium by polarising the medium's magnetic domains in either the north or the south direction which represent the binary states 0 or 1. These codes are interpreted by an inductive read-write head. The most common magnetic storage devices include magnetic disk and magnetic diskette.

Magnetic Tape

Magnetic tape is a compact medium for storing large amounts of information and is best-suited for applications that require a large amount of information to be backed-up or transported. Tapes are very cheap and offer one of the lowest cost per megabyte of storage. Magnetic tape is kept on a large reel or in a small cartridge or cassette. The standard tape reel is half-an-inch wide and 2,400-feet long and can store up to 35 GB, depending upon its permitted recording density. Magnetic tape is a plastic ribbon coated on one side with an iron oxide material that can be magnetised by electromagnetic pulses. Tiny areas on the coating are treated as small magnets whose polarity is set in one of the two directions, in order to store one of the two binary values Data can be read without altering the polarity. To read or write on secondary storage, the magnetic media is passed under a read-write head. The bits are arranged in channels (tracks) across the width of the tape. The magnetic tapes, which are nowadays in use are

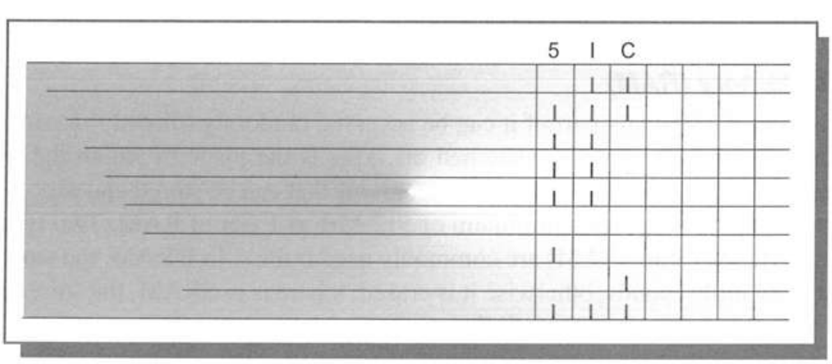


Fig. 5.5 Data Representation on a Tape (Using EBCDIC Code)

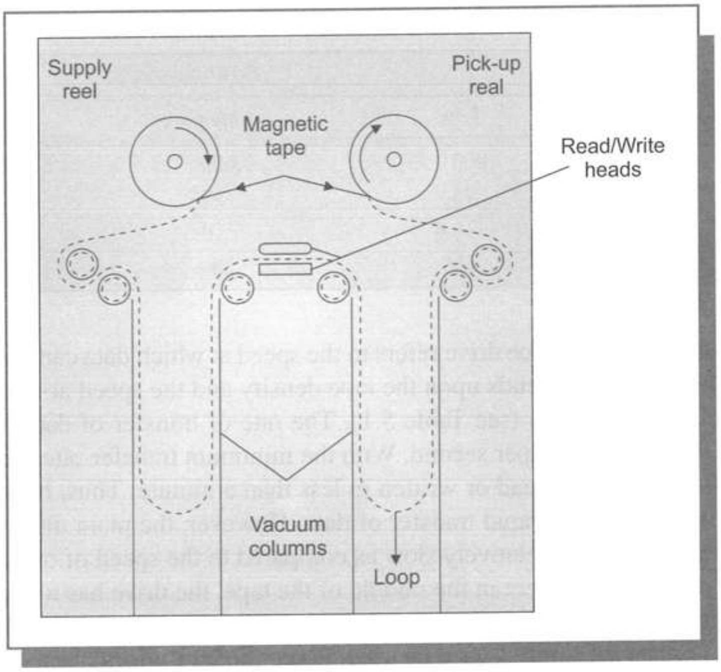


Fig. 5.6 Magnetic Tape Drive Unit

nine-channel tapes. The first eight channels are used to store the standard 8-bit code (EBCDIC or ASCII) of the character and the ninth channel stored a 'parity bit' (to check the validity of the character), which is assigned by the system automatically. Figure 5.4 depicts data recorded on a tape. Magnetic tape is mounted on a tape drive which has a read/write head and enclosed in a tape drive unit (see Fig. 5.5). There are no physical addresses on a magnetic tape to identify the location of stored data. The records are stored in blocks on the tape and each block is separated from the next by an interblock gap (see Fig. 5.6), which is necessary to accelerate the tape to read/write speed and bring it to rest at the end of a read/write operation.

Two characteristics, namely, density and transfer rate are important to understand. The density of a magnetic tape refers to the number of bits per inch (bpi) from a single track (along its length). Magnetic tapes are available with 800, 1600, 3200 or 6250 bpi. It is understood that bpi can be regarded as bytes per inch because of storing 8-bits in parallel across the width of a magnetic tape. In other words, on one inch of a 9-track tape for a 800 bpi recording, the total number of bits stored will be $800 \times 9 = 7200$ bits. It shows that magnetic tape is a very compact storage media. A book of 500 pages with 40 lines per page and 30–35 characters per line can be stored in less than 20 feet of tape of density 6250 bpi, and thus we can estimate the amount of data that can be stored on a 2400-feet magnetic tape.

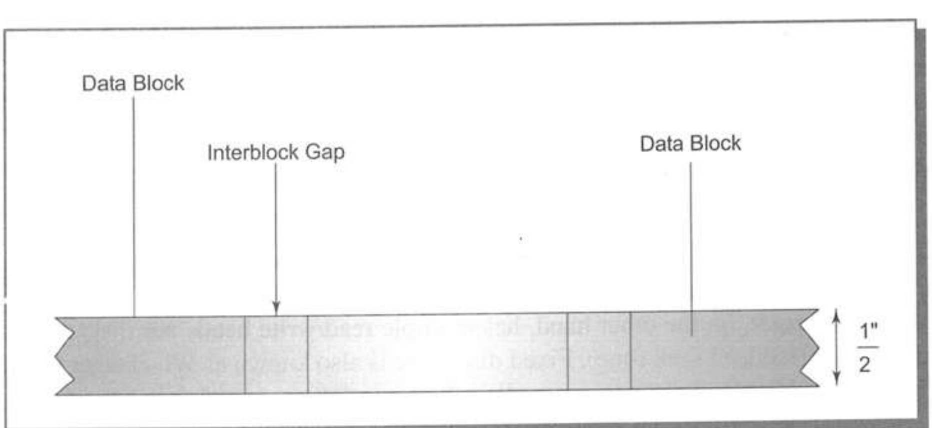


Fig. 5.7 Magnetic Tape

Table 5.1 Magnetic Tape Characteristics

Magnetic Tape Characteristics	*Performance*		
	Low	*Medium*	*High*
Tape density (bytes per inch)	800	1,600	6,250
Tape speed (inches per second)	75	125	200
Size of interblock gap (inches)	0.6	0.6	0.3
Transfer rate (thousands of Characters per second)	60	200	1,250

The second characteristic, i.e. the transfer rate of a tape drive refers to the speed at which data can be transferred from the tape to the CPU or vice versa. It primarily depends upon the tape density and the speed at which the tape moves (which is of the order of 100 inches per second) (see Table 5.1). The rate of transfer of data between the magnetic tape and the CPU is between 10 kB and 1 MB per second. With the minimum transfer rate, i.e. of 10,000 characters, an average-sized book of 300 pages can be read or written in less than a minute. Thus, besides being a compact storage medium, magnetic tape provides very rapid transfer of data. However, the main disadvantages of magnetic tape are that it stores data sequentially and is relatively slow as compared to the speed of other secondary storage media. To retrieve data, which is stored somewhere in the middle of the tape, the drive has to start from the end. After the data has been written on a tape, additions can be placed only at the end of the previous data. A file that lies in the middle cannot be deleted nor can the empty space be used. Since modern information systems need immediate access to data, tape is no longer a popular medium for such information systems.

Magnetic Disk

The major disadvantage of sequential processing of magnetic tape was overcome with the invention of magnetic disk, now commonly known as hard disk. A magnetic disk provides random access memory. A magnetic disk is somewhat like a phonograph record but is made up of Silica plates with magnetisable grooves on each side of the plate (disk). Each surface is divided into concentric grooves called tracks. Each track is further divided into sectors.

Six or more plates, are fixed to a spindle one atop the other to make up a disk pack (Fig 5.7), which is mounted on a disk drive. The disk drive consists of a motor to rotate the disk pack about its axis at a high and constant speed (3600 revolutions per minute). The top-most surface and the bottom-most surface of the disk are not used for storage. Thus, a disk pack with 6 plates has 10 storage surfaces, and each surface has a read/write head. Such a disk pack also has 5 access arms. Each access arm has two read/write heads, one to access the lower surface of the top disk and the other to access the upper surface of the bottom disk (see Fig 5.7). Data is accessed as the magnetised areas pass under read/write heads.

Access time of a disk drive, which refers to the time required to access the desired record from a disk, depends upon its seek time and rotational delay. Whereas seek time refers to the time needed to seek the desired track on the desired surface (by moving the access arm), rotational delay refers to the time needed for the rotating disk to position the desired data under the read/write head. Access time is measured in milliseconds. An average seek time of 20–35 milliseconds and an average rotation delay of 10–15 milliseconds, resulting in an average access time of 30–40 milliseconds are common. Nowadays, disks with access speed of 1.5–10 milliseconds and capacities of 400 gigabytes per unit are also available. Disk packs can be classified into two types:

(i) removable disks, and

(ii) fixed disks.

A removable disk pack, as the name suggests, can be replaced and transported, whereas a fixed disk drive is fixed permanently and cannot be removed or transported. A removable disk drive usually has only one read/write head per surface. A fixed disk pack, on the other hand, has multiple read/write heads per disk surface, enabling it to provide a faster access time (reduced seek time). Fixed disc drive is also known as Winchester disks, because the drive was first made by IBM at Hursley Laboratory near Winchester in UK.

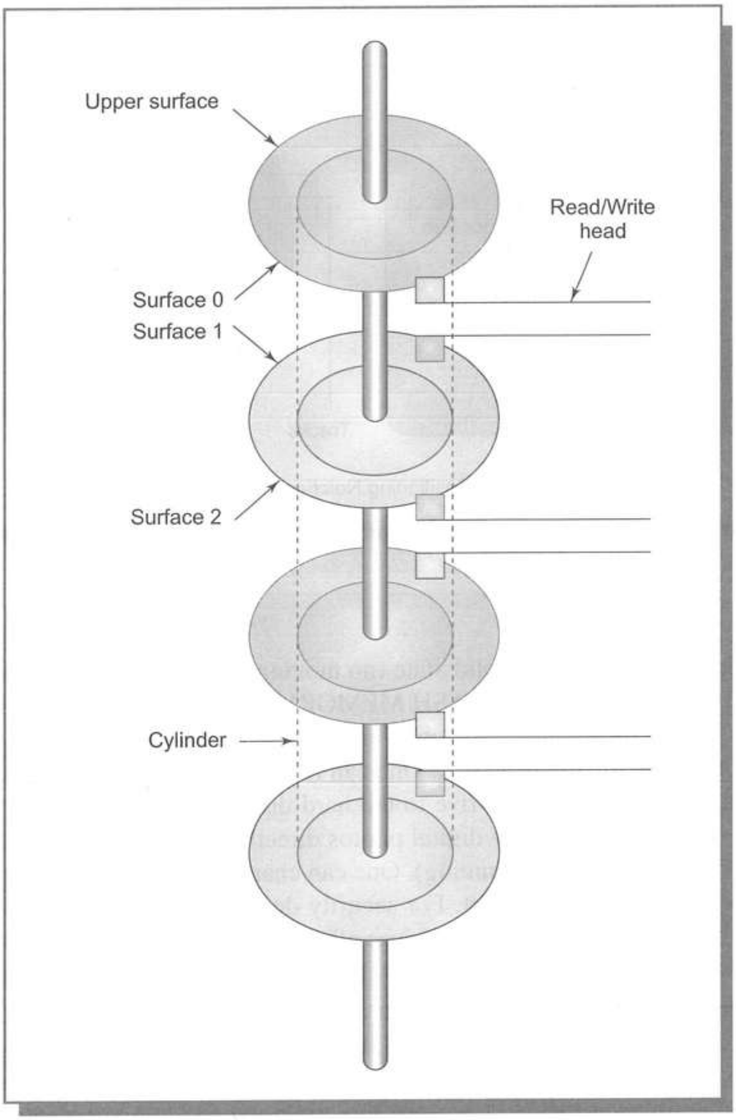


Fig. 5.8 A Disk Pack

Diskette (Floppy Disk)

Floppy disk, as the name indicates, is not hard or stiff like the disk pack, and is available in 3.5" size. It is a small random access disk widely used on workstations and personal computers. The floppy disk is removable, flexible plastic disk coated with magnetic material and looks like a phonograph record encased in a jacket. Similar to the hard disk, the floppy disk is also divided into concentric tracks, each of which is sub-divided into sectors.

However, unlike the hard disk unit, the read/write head of the floppy disk drive actually touches the surface of the disk, which makes the speed of the floppy drive much slower. The floppy disk is permanently enclosed in stiff paper jackets for protection and easy handling, with a long slit for read/write head access, a hole in the centre for mounting the disk drive hub and a hole for index mark sensing (Fig. 5.8).

The inner side of the envelope is smooth and allows free rotation of the circular magnetic medium. A low density floppy disk has 40 tracks, 9 sectors per track, 512 bytes per sector, and density of 4000 bpi, for a total capacity of 180 kB on one side of the disk. Nowadays, floppies are available which permit recording on both sides and with high density (up to 14000 bpi along each track), thus having a capacity of up to 1.44 MB.

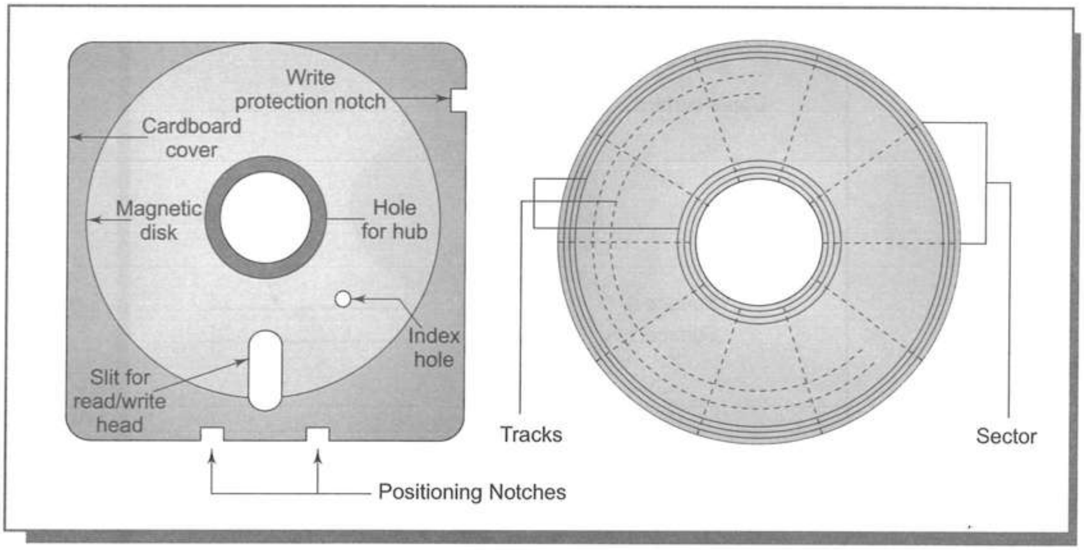


Fig. 5.9 Floppy Disk (5.25")

Pen Drive

Pen Drive is an external storage disk, which is in solid-state (no moving parts) and is sturdier and more resilient as compared to hard disks. The Pen Drive is a USB FLASH MEMORY DRIVE and can support up to 256 GB disk space. A Pen Drive USB flash disk, which is just 1.8 inch in size, is a plug-and-play device. It can be plugged into any USB port and the computer automatically detects it. One can read, write, copy, delete and move data from the hard disk drive to the Pen Drive or from the Pen Drive to the hard disk drive. One can even play MP3 files, run applications, view videos or even take high quality digital photos directly from the Pen Drive. Pen Drives support flash ROM (EEPROM) for ISP (In-System Programming). One can change / update the Pen Drive USB flash drive firmware anytime and anywhere through a USB port. For security demand, one can use the Pen Drive as key to valuable information on one's hard disk drive, as the pen drives offer software that facilitates easy data backup along with on-the fly encryption for added security. Without the key (which is the Pen Drive), the data is not accessible.

The Pen Drive is so compact that you can carry with you anywhere and you hardly notice its existence. It also comes in various storage capacities of 1 GB, 2 GB, 4 GB, 8 GB, 16 GB, and so on, so now you don't have to carry a laptop computer with you to work. A Pen Drive does not require any battery (for USB port), it does not need any software or cables and it is compatible with IBM PC/compatible desktop and laptop computers with USB or USB 2.0 port. Given below are a few examples of Pen drive family.

One drawback of this magnetic storage technology is that they are susceptible to strong magnetic fields. Stored over a long period of time, they eventually lose their data integrity under the influence of the earth's magnetic field.

Pen Drive Mini
Sleek, compact flash
storage device

Pen Drive Micro
Small, durable solid-state
storage device

Pen Drive USB2.0
Fast USB2.0 data transfer rate
Read and write at 20 Mbps

Optical Storage Devices

These storage devices work on a principle similar to magnetic storage media, however, they use light (laser) as the medium to represent binary information. The commonly used optical storage media includes Compact Disk (CD) and Digital video disc, also called Digital Versatile Disk (DVD).

Compact Disk

Compact disks, popularly called CDs store data at densities many times greater than those of magnetic disks. These disks are available for both microcomputers and large computers. To record data on this medium, a laser device is used to burn microscopic pits in the reflective layer of a spiral track. Binary information is represented by the length of these pits and the space between them. A compact disk can store a large amount of data, including not only text but also pictures, sound and full motion video. The most popular among all optical storage devices is the Compact Disk—Read Only Memory (CD-ROM), which is now available on almost all computers. A 4.75-inch CD can store more than 650 megabytes of data. Nowadays the writeable version of the CD-ROM (the CD-Recordable or CD-R) is a popular archival storage option, which allows the user to create their own CDs. A CD-R drive can write data to and read data from a compact disk. CD-R disc can be written only once whereas there is another type of CD known as CD-Rewriteable (CD-RW), which can be written multiple times, like a floppy disk. Compared with tape drives, CDs are faster, easier to handle and don't run the risk of being destroyed by strong magnetic fields. However, CDs are vulnerable to physical damages such as deep scratches (especially on the data surface), high temperatures and strong light sources.

Digital Versatile Disk

Digital Versatile Disk (DVD) is the next generation of optical storage media. DVDs are the size of today's CD, yet hold upto 17 GB of data, 26 times the data on a CD. A digital versatile disk also looks like CD. It is silvery platter, 4.75 inches in diameter, with a hole in the centre. Like a CD, data is recorded on the disk in a spiral trail of tiny pits and the disks are read using a laser beam. The larger capacity of a DVD is achieved by making the pits smaller and the spiral tighter and by recording the data in as many as four layers; two on each side of the disk. Though any kind of digital data can be stored on a DVD, the first application of this new media is movie distribution. DVD technology can be classified under five categories.

(i) *DVD-Video:* Read-only storage intended for playback of video content, such as movies, on consumer DVD players or on DVD drives in a PC.

(ii) *DVD-ROM:* Read-only storage intended for PCs, ideally suited for PC applications such as games, reference materials and other data intensive applications.

(iii) *DVD-R (Recordable):* A DVD format which supports write once, read many times storage. The target usage model includes archiving, software development and low volume data distribution.

(iv) *DVD-RAM:* A DVD format which supports write many, read many storage. The applications include short-term archiving, software development and media recording.

(v) *DVD-Audio:* This format focusses on music and other forms of audio-only content.

Magneto-Optical Storage Devices

These devices are hybrid devices that employ both magnetic and optical technologies to store large amounts of information on disks which are normally of the size of floppy disks, i.e. 3.5-inch.

This medium is made up of a rigid disk covered by a special alloy that has the property of reflecting laser light at a slightly different angle, depending upon its magnetic state. The magneto-optical disk, an example of magneto-optical storage device, is erasable and can be written on nearly a million times. The disk surface is coated with a magnetic material that can change magnetic polarity only when heated. To record data, a high-powered laser beam heats tiny spots in the magnetic medium that allows it to accept magnetic patterns. Reading the data requires a much weaker laser beam. When compared to magnetic storage, magneto-optical technology offers higher data storage along with the ability to randomly access stored data.

5.1.4 Input and Output Devices

FOCUS

The Input and Output Devices are channels for communication between the user and the CPU. Data and programs are entered into the CPU through input devices, whereas output devices provide the processed results.

The input and output (I/O) devices are channels for communication between the user and the CPU. Data and programs are entered into the CPU through input devices, whereas output devices provide the processed results. Most commonly used I/O devices are visual display unit (VDU), printer, keyboard, mouse, secondary storage devices (like magnetic tape, magnetic disk, magnetic diskette, compact disc, etc., and image-scanning devices. I/O devices are also known as peripheral devices. Let us discuss I/O devices under two categories.

Input Devices

In order to have simple, fast and error-free communication with computers, users make use of different input devices (see Table 5.2). Some of these are discussed here.

Table 5.2 Input Devices

Class	*Devices*
Keying devices:	Keyboard
	Terminals
Pointing devices:	Mouse
	Touch screen
	Light pen
	Joystick
OCR devices:	Bar code scanner
	Wand reader
	Optical mark reader
	Optical character reader
Voice recognisers:	Voice data entry terminal
MICR devices:	Magnetic ink character reader
Other devices:	Automatic teller machine (ATM)
	Digitisers (for graphs, maps, etc.)
	Cameras
	Smart cards
	Telephone, etc.

Keying Devices

As given in the table, the main keying devices are keyboards and POS Terminals (point of sale terminals). In such devices, the information is keyed-in by the users.

Keyboards

The most common input device is the keyboard. The keyboard is designed like a standard typewriter keyboard with a few additional keys. The basic QWERTY layout of characters has been retained to help trained typists to use the system.

Terminals

As discussed earlier, a keyboard is the most commonly used method for data entry. Similarly, video display units (VDU) (discussed later) are popularly used for output to users. Computer terminals are the most widely used methods of such input and output. A terminal is any I/O device connected by telecommunications links to a computer. In fact terminals have made on-line processing possible. Unlike the punched card input, which required a card reader to transmit data into the CPU, a terminal, when attached to a CPU, sends data entered from the keyboard directly into the CPU. Terminals are of two types, namely, hard copy terminals (that provide a printout on paper) and soft copy terminals or CRT (Cathode Ray Tube) terminals (that provide only a visual display on the screen).

Intelligent terminals have their own microprocessor and memory circuits. Nowadays, transaction terminals or point-of-sale terminals are also widely used in banks, retail stores and factories. These terminals use a variety of I/O methods to capture transaction data at its origin point and transmit it over telecommunications networks to a computer system for processing.

Pointing Devices

Pointing devices like mouse, touch screen, light pen, joystick, etc., are used for pointing to objects on the computer screen. They improve speed and ease of use as compared to keying devices.

Mouse

The electronic mouse is a hand-held device used to move the cursor on the screen as well as to issue commands and make icon and menu selections. The electronic mouse which has a roller ball, when attached to the computer, allows the user to move the cursor in the direction the ball is rolled. The mouse is moved on the desk top to point a cursor at a desired place on the screen. Once the object is reached, the user clicks a button on the mouse instructing the computer to take some action.

Touch Screens

These are the devices that allow a user to activate an object on the surface of its video display screen by touching it with his finger. Touch screen emits a beam of infrared rays, sound waves, or slight electric current, which is broken when the screen is touched. The computer senses the point of break and responds with an action. For example, an item in the menu can be selected just by touching the screen next to the desired menu item.

Light Pens

Instead of using a finger, a user can use a pen-shaped device with a light-sensing mechanism to touch the screen. It is connected to the computer through a cable and is considered more accurate because users can point at very small objects.

Joysticks

A joystick is used to move the cursor on the display screen. It is like a small gear shift lever set in a box. Joysticks are widely used at workstations for computer-assisted design and to play video games.

Nowadays, it is preferred to automate data input by capturing data as a byproduct of a business activity, rather than having it input manually. As automation completely eliminates manual input of data, there is no need for its editing. Examples of such direct data capture by computers are optical character recognition (OCR), optical mark recognition (OMR), magnetic ink character recognition (MICR), voice recognition systems, etc.

Optical Character Recognition (OCR)

Various types of OCR devices are available to scan data or graphs so that there is no need to type them manually. All these devices optically scan documents and convert them to computer readable form. The scanned data/graphs are stored as a bit-map representation in memory and special OCR software converts text into regular editable text. This technique is widely used in a number of applications. The main OCR devices are Bar Code Scanner, Optical Mark Reader and Optical Character Reader.

Bar Code Scanners

Bar code scanners scan the black and white bars written in a code called the Universal Product Code (UPC). The code specifies various types of information like the name of the product and its manufacturer, price, year of manufacture, etc. Bar code scanners are most widely used in super markets, libraries, airlines, etc. *Wand Redder* is a special type of hand-held bar code reader.

Optical Mark Reader

Optical mark reader (OMR) is a type of scanner for detecting the presence of marks on a specially designed sheet of paper (such as multiple choice answer sheets). The marks are read directly from the sheets and data is transmitted into a computer for processing. OMRs are widely used by many academic, training and research institutions.

Optical Character Reader

Like optical mark reader, optical character reader (optical scanner) also provides a method of direct input of data from source documents. However, with an optical character reader, source documents such as reports, typed manuscripts or even books can be entered directly into a computer without the need for keying manually. Optical scanners are widely used by the publishing industry to scan printed documents and converting them to electronic databases. Such converted databases can be referenced as required. Just like optical character recognition, handwriting recognition technology is also available for limited applications. Handwriting recognition technology is supported by expert systems and neural computing.

Voice Recognition Systems

Voice (natural language) is the most natural way to communicate with computers. To recognise voice patterns, a microphone is used. The microphone converts speech into analog electrical pulses which are then transmitted to a computer for processing. Voice recognition devices are sought after by a large number of users as they are fast and free the user's hands. A manager can directly input letters and other notes to a word processor through a voice recognition system. However, limited vocabulary and non-consistency are major limitations of this technology.

Magnetic Ink Character Recognition (MICR)

This technique is widely used by the banking industry. Magnetic ink character reader reads the data as per the shape of each character. Figure 5.10 shows a sample MICR code.

MICR codes are transmitted to an on-line computer and are used to sort, tabulate, and post cheques to the proper accounts. MICR codes can be either pre-printed on documents or encoded on documents using a keyboard-operated machine called inscriber.

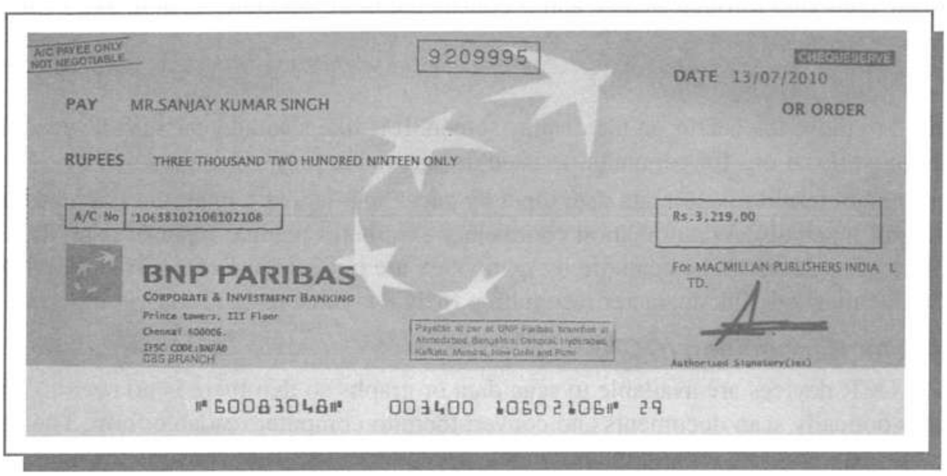


Fig. 5.11 A Sample of an MICR Code

Digitisers

Digitisers are devices that convert pen-made graphs on a sensitised surface to computer-readable input. As graphs/ drawings are made, images are transferred to the computer. The technology is based on changes in electrical charges that correspond to the drawings. Digitisers are made use of by engineers, artists, and designers.

Video cameras can be used to capture pictures which are digitised and stored in computers. While a digital camera can take photos and load them directly from the camera, digitally to a main or secondary storage device.

A *smart card* contains a built-in microprocessor and storage on a memory chip. The card is being used for several applications like banking, libraries, medical field, etc.

Output Devices

A user can get computer generated output through several output devices and media. Widely used output devices are monitors, printers and voice output devices.

Monitors

Computer monitor is essentially a video screen that displays both input and output. Video screens [also known as cathode ray tubes (CRT)] use a picture tube similar to TV sets. The clarity of the display and the support of monochrome or colour displays depend on the type of video monitor used and the graphics circuit board, or video adapter, installed in the computer. The interactive nature of monitor provides a major benefit. Portable computers use a flat screen consisting of a liquid crystal display (LCD).

Printers

Printed output is another common form of visual output for the user interface. Printers are used to produce permanent (hard copy) output in human readable form. *Plotters* are used for drawing graphs and designs on paper, thus they also produce printed output. Figure 5.11 illustrates two types of computer printers. Computer printers are categorised into two main categories, namely, line printers and dot matrix (character) printers. A line printer prints one complete line of data at a time, while a dot matrix printer prints one character at a time. Many dot matrix printers use a print head consisting of a 9×7 array of pins, and are bi-directional. A typical line printer has a speed between 150 lines to 2500 lines per minute, while a dot matrix printer has a speed of about 200 characters per second. A dot matrix printer produces a character, which is made up of a finite number of dots, resulting in a lower quality output. For better output, letter quality printers are available. Daisy wheel printers give excellent printing quality. Another advantage is the interchangeability of daisy wheels. A daisy wheel uses a plastic or metal wheel with characters moulded on the ends of its spokes. The wheel rotates very fast, bringing the desired character to the printing location, and prints it on paper.

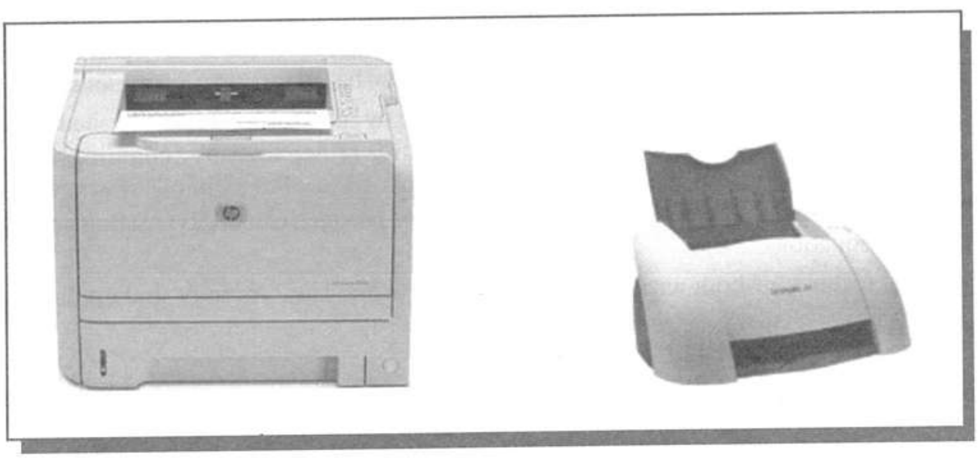


Fig. 5.12 Two Types of Computer Printers

On the basis of printing technology, we can classify printers into two more classes, namely, *impact printers* and *non-impact printers*. Printers like line printers, dot matrix printers, daisy wheel printers and letter quality printers are impact printers. These form characters on paper through the impact of a printing mechanism that makes physical contact with paper. Multiple copies can be produced with impact printers. Non-impact printers transfer data to paper without physical contact and are quieter than impact printers. However, multiple copies cannot be produced with non-impact printers. Laser printers, InkJet printers, Xerographic printers, etc., are examples of non-impact printers. Laser printers are high speed, high quality printers that use laser beams to transmit data upon photo-sensitive drums, a whole page at a time. The image is then picked up with the toner by the paper, which is passed over the drum. Laser printers, because of their 'print' quality, are used in desktop publishing and in reproduction of art work. InkJet printers, also called bubble jet printers, shoot small dots of ink onto paper. They are relatively inexpensive and are more suited for multicolor graphics. Electrostatic printers and electro thermal printers are also a type of non-impact printers. They create characters on specially treated paper that responds to heat patterns produced by a thermal mechanism. The output of these printers is of relatively a lower quality.

Voice Output

In voice output technology, the sounds that make up words and phrases are constructed electronically from basic sound components and can be made to form any desired voice pattern. 'Talking' chips are nowadays used to provide synthetic speech for toys, games, greeting cards, consumer applications, automobiles and many other commercial and industrial uses. Such speech synthesizing microprocessors are also being used in electronic calculators and in digital watches. Voice output devices allow computers to respond to queries.

5.2 COMPUTER HARDWARE CLASSIFICATION

Computer hardware can be classified by following different approaches. One may understand computers on the basis of operating principles, size, computer power, and even computer evolution. Let us examine these methods of looking at computers.

5.2.1 Operating Principles Basis

Based on the operating principles, computers can be classified into one of the following types.

(i) Digital computers
(ii) Analog computers
(iii) Hybrid computers.

FOCUS

Based on the operating principles, computers can be classified into one of the following types:
- Digital computers
- Analog computers
- Hybrid computers.

Digital computers operate essentially by 'counting', in which all quantities are expressed as discrete digits or numbers (zeroes and ones). Digital computers are extensively used in business and homes. They are faster, more accurate and easier to program than analog computers and are an integral part of all computer-based information systems.

Analog computers, on the other hand, operate by 'measuring' some physical property such as voltage level, temperature, or pressure, rather than by 'counting'. Analog computers are used almost exclusively in process control and scientific applications. For example, they are used in hydroelectric power stations, to monitor the flow of water to the turbines that produce electricity. Analog computers are also used to solve differential equations.

Hybrid Computers combine features of both analog and digital computers. These usually find application in aircraft simulation work.

5.2.2 Size and Computing Power Basis

Computer systems are available in different sizes and with different computing powers. Typically, computer systems are classified as microcomputers, minicomputers, and mainframe computers. However, these are not precise classifications as many variations of these categories exist in computer industry, which include supermicro computers, supermini computers, small, medium and large mainframe computers, minisuper computers and supercomputers. These categories are based on the relative computing power provided by computers. Computers may also differ in their processing speed and memory capacity, as well as in the number and capabilities of peripheral devices they can support. Advancement in computer technology has made this classification rather inexact. Today's supermicro computer provides almost the same computing power, which was provided by yesterday's minicomputers. Similarly, today, we find some minicomputers that are more powerful than some of the older mainframe computers. Thus, this classification of computers overlaps each other.

FOCUS

Based on their size and Computing Power Basis, the computer systems are classified into microcomputers, minicomputers, mainframe computers and supercomputers.

Microcomputers

Microcomputers are the smallest but most important category of general purpose computers for end users. They are also called micros or personal computers (PC). A microcomputer contains its entire CPU on a main microprocessor chip (integrated circuit) and is a self-contained unit. It can be used, both as a stand-alone computer and a terminal in a multi-user environment. Since microcomputers can be easily linked to large computers, they form an important segment of the integrated information systems.

A typical personal computer provides up to 512 MB of main memory, a processing power of 5 MIPS (million instructions per second), supports one or two diskette drives for random access secondary memory and a compact disk drive. It supports a keyboard, a visual display unit, a multimedia kit and a printer. A personal computer comes with varying processing powers, main memory capacity and hard disk space. Because of advancements in computing technology, today, a powerful microcomputer may be used as a substitute for the older mini or mainframe computers. These computers are commonly known as Personal Computers. IBM PC is a typical example of such a microcomputer. This class of computers is further categorised by size. This may include desktops, portables, laptops and palmtops. Some of the available CPU models of microcomputers alongwith other features are listed in Table 5.3.

Table 5.3 Types of Microcomputers alongwith Other Specifications

CPU Model (MHz)	*Speed*	*Data Bus (BIT)*	*Register (RAM)*	*Main Memory*
8088	8	8	16	640 kB
8086	8	16	16	604 kB
80286	20	16	16	1–4 MB
80386 SX	33	16	32	4–8 MB
80386 DX	40	32	32	4–8 MB
80486 SX	40	32	32	16 MB
80486 DX2	66	32	32	16 MB
80486 DX4	100	32	32	16 MB
Pentium Pro (P5)	200	64	32	32 MB
Pentium II (P6)	350	64	32	64 MB
Pentium III	450	64	32	64 MB
Pentium IV	1000	64	32	512 MB
Dual Core	1066	64	64	2 GB

Minicomputers

A minicomputer is a medium-sized computer that is more costly, powerful and larger than a microcomputer. However, as mentioned earlier, this is not a precise distinction, because many microcomputer systems are more powerful than some minicomputers. Minicomputers are usually designed to accomplish specific tasks, such as process control, scientific research or engineering applications, but these computers also find applications in business world. They also serve as powerful engineering workstations for computer aided design (CAD) applications. Digital VAX is a typical machine under the minicomputer category.

Mainframe Computers

Computers with large storage capacities (several hundred megabytes), very high speed of processing (50 Plus MIPS) and with a large secondary memory support, are known as mainframe computers (or large computers). Mainframes can process hundreds of different programs and handle hundreds of different peripheral devices (terminals, disk and tape drives, printers, etc.) for providing simultaneous access to hundreds of different users. Mainframe computers are used by major organisations, which require huge and complex data processing. For example, railways and airline reservations, banking applications, commercial applications of large organisations, etc., are some of its potential applications. Some of the typical examples of mainframe machines are IBM 3090, IBM 4381, IBM 4300 and IBM ES-9000, etc.

Supercomputers

These computers are a special kind of extremely powerful mainframes designed for high-speed numeric computation. For example, CRAY models of supercomputers produced by Cray research, can process from 100 to 900 MIPS. They find application in scientific, military and research programmes, which include applications in electronic design, petroleum exploration, energy management, defence, nuclear energy research, weather forecasting and medicine, etc. A supercomputer also allows multiple users to interact with the CPU simultaneously through multiple input/output devices. Examples of Supercomputer include CRAY 3, CRAY-XMP-14, NEC-500, PARAM 9000 and PARAM 10000. The last two have been developed in India by indigenous efforts.

Randam Access Memory (RAM) of Supercomputers couprises billions of bytes, and the processing speed of Supercomputers is in trillions of instructions per second. Supercomputers contain multiple processors that let them perform parallel processing and run at a very high speed. For example, cray XR3 computer has 1100 processors and a memory of 2.2 terabytes. It can perform 5.9 trillion calculations per second.

In parallel processing, several CPUs process different data at the same time.

This classification of micro, mini, mainframe and supercomputers, as mentioned earlier, is fast losing its meaning. In terms of performance, yesterday's mainframe has become today's micro. At present, this traditional classification of computers is being replaced with client-server machines. The servers provide sophisticated functions to a large number of users or client hardware that represent nodes or terminals through which users interact with these servers.

5.2.3 Computer Evolution

Technological advancements in the field of electronics have brought a revolution in the area of computing. It was the Abacus, the first manual calculating device, which was invented in Asia many centuries ago. The invention of a mechanical calculator by John Napier, a Scottish mathematician in the year 1617 was another milestone in computer evolution. Thereafter, many kinds of computers have been developed. This evolution of computers, is popularly categorised in terms of generations.

Zeroth Generation Computers

Blaise Pascal, a French mathematician, in 1642 invented the first mechanical device known as Pascal's Adding Machine, which worked with gears and was capable of adding and subtracting numbers. The first significant change was seen in the year 1804, when Joseph Marie Jacquard, invented a punch card system for controlling the threads on his weaving looms. However, it was only in the year 1833 that Charles Babbage designed the first computer capable of performing basic arithmetical functions, which he called the analytical engine. Charles Babbage designed his analytical engine around five components, viz., a Store to hold numbers, an Arithmetic Unit (Mill) to perform arithmetic operations, a Control unit to control and co-ordinate various activities in the right sequence, an Input device to transfer both numbers and instructions into the computer and an Output device to display the results of computations.

It was the vision of Charles Babbage who could conceive the idea of a sophisticated computing device, which incorporated the basic concepts of a modern computer. Babbage's device incorporated the concepts of input devices, output devices, and a Central Processing Unit consisting of memory (store), an arithmetic logic unit, and a control unit. However, modern electronic computers have three important characteristics, i.e. of speed, accuracy and ability to handle a large amount of data.

The invention of the first electromagnetic calculator invented by Dr Hollerith in 1889 was yet another milestone in the history of computers. Doctor Hollerith incorporated the idea of using cards along with the electrical sensing of cards. The zeroth generation of computers ended in 1946, when vacuum tubes were invented.

First Generation Computers

The first generation computers, which witnessed an era between 1949–55, used vacuum tubes. These computers were very slow (the ENIAC took about 200 microseconds to add two digits and about 3000 microseconds to multiply); were of very large size; consumed considerable power; dissipated a tremendous amount of heat; were of poor reliability due to the fact that the Mean Time Between Failure (MTBF) of vacuum tubes was of the order of an hour; and used only machine and assembly language. In 1946 John Mauchly and J.P. Eckert of Moore School of Electrical Engineering at the University of Pennsylvania in USA developed the first electronic computer known as ENIAC (Electronic Numerical Integrator And Calculator). This computer used vacuum tubes as its basic electronic component and consumed nearly 200 kW of power. It had a very small memory and was primarily designed to calculate the trajectories of missiles. Around the same time, Professor John Von Neumann introduced the concept of a Stored Program, and the first electronic digital computer using stored program, EDSAC (Electronic Delay Storage Automatic Calculator), was completed in 1949 at Cambridge University, UK under the leadership of Professor Maurice Wilkes. Subsequently, Univac division of Remington Rand at USA developed the first commercial computer UNIVAC (Universal Automatic Computer) using stored program technology in 1951. The US Census Bureau of USA was the first computer user, which acquired UNIVAC-I in the same year and the General Electric was the first business firm to acquire this computer (UNIVAC-I) in 1954. All these computers used vacuum tube circuitry. In India, these type of computers were first used at the Indian Statistical Institute (ISI) Calcutta and at the Tata Institute of Fundamental Research (TIFR) Mumbai.

Second Generation Computers

The invention of the semiconductor transistor by Bell laboratories in 1949, ushered the era of solid state technology. Computers which used transistors instead of vacuum tubes and became available in large quantities in 1959, are classified as Second Generation Computers. The computers of this generation used transistors, were faster, more reliable, relatively smaller, consumed considerably less power and generated much less heat than the first generation computers. Mean time between failure also increased with the replacement of vacuum tubes with transistors. Another major invention during this time was the magnetic disk, which allowed faster and random access of data. IBM 700, 1401, ATLAS and ICL-1907 are a few examples of second generation computers. This generation lasted till 1965. Development of high level languages such as Fortran, Cobol, Algol, etc., took place during this generation and as a result, more than 80 per cent of installed computers were used in business and industry for commercial applications.

Third Generation Computers

The third generation computers were introduced in 1965 with germanium transistors being replaced by silicon transistors. Integrated circuits (ICs), consisting of transistors, resistors and capacitors, made on a single silicon chip were invented. These circuits provided vast internal storage, had speed in nanoseconds, generated lesser heat, were highly reliable and of reduced size, which in turn resulted in the emergence of an extremely powerful CPU. Advancements in computer memory, CPU and large disk memories led to the development of time-shared operating systems. During this generation, high level languages like Fortran and Cobol also improved. Examples of computers of this generation include IBM 360–370, NCR 395, Burroughs B 6500, and CRAY-1. The third generation ended by 1975, around which time computers entered the fourth generation.

Fourth Generation Computers

Further miniaturisation of Integrated Circuits resulted the availability of large scale integrated chips in 1975. Computers which used large scale integrated chips and very large scale integrated chips (VLSI) can be called fourth generation computers. A major breakthrough in computing technology was achieved during this generation, i.e. with the invention of the microprocessor in 1972. It led to the emergence of the powerful microcomputer, which was very small in size and provided a user-friendly environment. The fourth generation, which started around mid-1970s, has also witnessed a significant development of concurrent programming languages (4 GLS), which have made computers all pervading. Examples of the fourth generation computers include IBM, PC, IBM PC/AT 286, 386, CRAY-2, 486, PENTIUM I, PENTIUM II and PENTIUM III, etc.

Fifth Generation Computers

Efforts are on to use recent advances in artificial intelligence for designing a knowledge-base computers which would be termed as the fifth generation computers. These computers of tomorrow will use ULSI (Ultra Large Scale Integration) chips and would be able to think and decide. Also, the fifth generation computers will have user interface in form of speech in natural languages. Though fifth generation computers are yet to be developed, Robotics has a few features of computers of this generation. These 'thinking computers', on which Americans and Japanese computer producers are competing with each other, are expected to be in the market in the first decade of the 21st century. Table 5.4 summarises and compares the various generations of computer.

Table 5.4 A Comparison of Computer Generations

Generation	*Period*	*Computer Circuitry*	*Storage Devices*	*Input Methods*	*Output Methods*	*Applications*
I	1950–55	vaccum tubes	magnetic drum 2 kB memory	punched cards, paper tape	punched cards, printed reports	scientific
II	1856–65	transistors	magnetic core memory, tapes and disk 100 kB memory	punched cards	punched cards, printed reports	extensive business applications, engineering design optimisation
III	1966–75	integrated circuits (ICs)	high speed magnetic core, large disks 4 MB memory	key to tape, disk	printed reports video displays	database management systems, on-line systems
IV	1975–till 1990s	large scale integrated circuits, micro-processors (VLSI)	semi-conductor, winchester disk 16 MB memory 4 GB disks	keyboard data-entry direct input devices, optical scanning	video-displays audio responses, printed reports	personal computers, integrated CAD/CAM real time control, graphical systems
V	1990s–till date	VLSI	16 GB disks Pen drives	direct input devices	video-audio responses	ERP, CRM, SCM, CAD/CAM

5.3 COMPUTER SOFTWARE

A computer system consists of two sub-systems, namely computer hardware and computer software. Whereas computer hardware includes physical units of a computer system, sets of programmed instructions (programs) are known as computer software. It is the computer software which enables the computer hardware to perform various activities and makes it a versatile machine.

Computer software can be classified into two categories.

(i) System software

(ii) Application software.

System software consists of sets of programs to support the efficient use of hardware resources that include primary and secondary memory, display devices, printers, communication links and other peripherals. It also interprets and executes application software. Examples of system software would include operating systems, language translators (compilers and interpreters) and utility programs.

FOCUS

A computer system consists of two sub-systems, namely, computer hardware and computer software. It is the computer software which enables the computer hardware to perform various activities and makes it a versatile machine. Computer software can be classified into System Software and Application Software.

Application software refers to programs or sets of programs that actually process data to generate information under various applications. Examples are payroll processing system, inventory control information system, etc.

Systems software and application software are inter-related and interact closely with each other. Systems software serves as an intermediary between hardware and application software. Figure 5.12 illustrates this relationship.

Let as now give a brief overview of system software and application software.

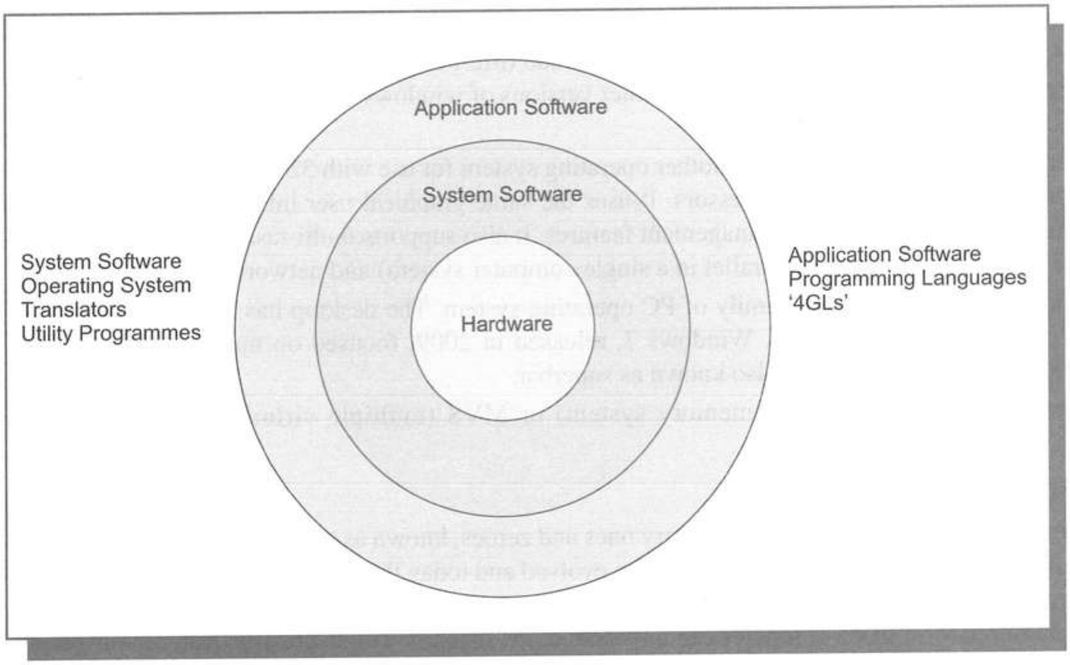


Fig. 5.12 Relationship of Software and Hardware

5.3.1 System Software

Operating Systems

The most important system software for any computer is its operating system. The operating system manages and controls the activities of the computer that include control of input/output devices, scheduling of operations and monitoring the activities of the computer. There are a variety of operating systems in use today. Each has its own merits and demerits. The most popular operating systems used on microcomputers are MS-DOS, Unix, Windows, Novell, etc.

CP/M (control program for microcomputers) was developed for APPLE-II, No doubt APPLE-II was initially an 8-bit microcomputer, but even after it was upgraded to 16-bit, CP/M continues to support a large number of business application programs. CP/M has good file handling and powerful memory management facilities. Its later versions have been upgraded and now provide even more facilities.

MS-DOS (microsoft-disk operating system) was developed by Microsoft for the IBM-PC and other similar 16-bit microcomputers. It is still widely used today with more powerful microcomputers. MS-DOS provides many capabilities that include efficient use of disk space, easy recovery facilities, high speed disk input/output operations and user-friendly command language. However, it does not support multi-tasking (one person running two or more programs concurrently on a single computer) and limits the size of a program in memory to 640 kB.

Unix operating system was developed by AT&T Bell Labs, mainly for supermini and supermicro computers. Unix is a powerful operating system which is today available on personal computers. It allows many users to use the system simultaneously and allows efficient sharing of the processing power. It also allows the users to perform many tasks simultaneously. Other features of unix include its powerful communication capabilities, graphical capabilities and a range of tools and utilities.

Windows, developed by Microsoft Corporation, resembles an operating system, which is an integrated package and a DOS extension. Windows is an operating environment that predefines the utilities that all applications share. It can be called the 'front end' to DOS as it accepts inputs from the user by means of a mouse or keyboard to be passed on to DOS for execution. However, with the development of *windows NT* and *windows 95*, DOS is no longer necessary and thus these versions may be termed as true operating systems, not merely front ends to DOS. In other words, Windows 95 is a 32-bit operating system having a graphical user interface (GUI), that can support software written for DOS and windows but can also run programs that take up more than 640 kB of memory. It is multi-tasking and has powerful networking capabilities. Windows 95 requires a 486 microcomputer, 8-megabytes of RAM, and 2 GB of hard disk storage. Windows 98, Windows 2000 (Me-Millennium Edition, and Windows 2000 Professional and Windows XP, Windows VISTA are the other versions of windows family. Windows 7 is the latest in the Windows suite.

Windows NT, also developed by Microsoft is another operating system for use with 32-bit microcomputers and workstations based on Intel and other microprocessors. It uses the same graphical user interface as windows but provides powerful multi-tasking and memory management features. It also supports multi-tasking, multiprocessing (links together two or more CPUs to work in parallel in a single computer system) and networking.

Windows 7, is the latest in the windows family of PC operating system. The desktop has a three-dimensional look with rounded corners and more shading. Windows 7, released in 2009, focused on multitouch support, a redesigned windows shell with a new taskbar, also known as superbar.

Mainframes primarily use VMS (virtual memory system) or MVS (multiple virtual system) operating systems.

Language Translators

Computers can understand programs written only in binary ones and zeroes, known as machine language. However, over a period of time, computer programming languages have evolved and today these have become fifth generation languages. Computer programs that are written in any of the popular computer languages like COBOL, FORTRAN, or C must be converted into a form that a computer can understand, i.e. machine language. This task of conversion is performed by a system software known as the language translator. Language translators are of two types, namely, compiler and interpreter. The program in the high level language is called *source code* and when it is converted into machine code, it is known as object code. For differences between a compiler and an interpreter, refer to the section of high level languages discussed in this chapter.

Utility Programs

The system software also includes utility programs for routine, repetitive tasks like sorting records, copying files and clearing primary storage, etc. These utility programs are pre-written programs that are stored to be shared by various users of a computer system.

5.3.2 Application Software

Application software refers to programs or sets of programs that actually process data or text to generate information under various applications. The basic purpose of application software is to provide functionality for users. That functionality may be limited to application-specific programs or may be very broad, to include general-purpose programs. Application-specific software supports specific applications of end-users. Examples of application-specific programs may include business application programs (e.g. inventory control, employee benefit analysis, material requirement planning, sales analysis, etc.); scientific application programs (e.g. scientific analysis, engineering design, monitoring of experiments, etc.); and other computer application programs to support applications in education, entertainment, music, art, medicine, etc.

General purpose programs are not linked to any specific business function, but support general types of processing. Examples of general purpose application software include packages of spreadsheet, data management, word processing, desktop publishing, graphics, multimedia, and communication. The term 'package' is used for a computer program (or a set of programs) that has been developed by a vendor and is available for purchase in a pre-packaged form.

5.4 PROGRAMMING LANGUAGES

FOCUS

A Programming Language allows users to tell (instruct/or program) computers what to do. In other words, they are the basic building blocks for all types of software.

Computer software, which is a set of instructions or programs, is written by following some programming language. It is thus the programming languages that allow users to tell (instruct/or program) computers what to do. In other words, programming languages are the basic building blocks for all types of software. Sometimes, general purpose software, such as database management system is also regarded as development software. This is so because applications are written using a programming language that is an integral part of the database management system. Over the past several decades, various types of languages have been developed. Details of these programming languages are complex and specific and are beyond the scope of this book. A brief discussion of these languages is as follows.

5.4.1 Machine Language

The internal representation of instructions and data in digital computers is in the form of binary numbers, i.e. zeroes or ones, and is known as machine language. Any program using this lowest level of coding is called a machine language program. Machine languages are the most basic level of programming languages, which are also known as First Generation Languages. In the early stages of computer development, programs had to be written in machine language. Such programs were machine-dependent, as these were computer-specific. Machine language programming, besides writing instructions in the form of strings of binary digits or other number system, requires detailed instructions even for simple processing tasks. This makes machine language a tedious, time-consuming, and difficult language. Moreover, being binary in nature, the language is error-prone as there are high chances of transposition errors, either in coding or in data entry.

5.4.2 Assembly Language

To overcome the problems of writing machine code, in the early 1950s, assembly language was developed. In this language, instead of writing the binary digit for each instruction directly, language-like acronyms and short words or abbreviations, such as ADD, SUB (Subtract), or MOVE, etc., could be used. Assembly language is also called the Second Generation of Computer Languages. While writing programs in assembly language, the words representing the instructions were selected to be more easily remembered than binary values, and so they came to be known as mnemonics. At first, the translation from assembly code to machine code was done manually but later to accomplish this task, a system software program called assembler was developed. An assembler is written in machine language used to translate *assembly* language instructions (the source program) into machine language instructions (the object program). This is done on an instruction for instruction basis.

There are two obvious advantages of assembly code over machine code.

(i) It is easier to learn and use a mnemonic.

(ii) It is easier to locate, correct and modify instructions written with mnemonics.

However, like the machine language, assembly language is also oriented towards the internal structure of the machine, which makes the language just as machine dependent. Because of being machine dependent, the programs are not portable across machines.

Despite its disadvantage, some programming is still done in assembly code, because it offers direct access to all the facilities of the computer. Carefully written assembly code is fast and efficient.

5.4.3 High-Level Languages

In the mid 1950s, the focus shifted from machine-oriented language to user-oriented language that led to the development of high-level languages. These languages are closer to natural languages like English and thus are easier to read, write and modify. In a high-level language, each statement generates a number of statements at the machine language level. As high-level languages are closer to natural languages, they are common words rather than mnemonics. In addition, the programmer is not required to write a program with particular machine requirements in mind.

The most commonly used high-level languages include FORTRAN, COBOL, BASIC, C++ and PASCAL. These languages are also called procedural languages or problem-oriented languages because they require the programmer to describe the step-by-step procedure for solving a particular problem at hand. This generation of high-level language is termed as the Third Generation of Computer Languages. As computers can understand only machine language, all programs written in a high-level language have to be translated into machine language. The translation of high-level language programs to machine language is accomplished by a language translator. There are two types of commonly used translators, namely, compilers and interpreters.

A *compiler* translates the entire text of a high-level program in one continuous process, creating a complete machine-code program. The compiled (machine code) program can then be executed independently, whereas an *interpreter* executes a program one statement at a time, transforming each high-level construct into machine instructions. Thus, an interpreter translates and executes the first instruction before it goes to the second while a compiler translates the whole program before execution.

The difference between a compiler and an interpreter is analogous to the difference between a translator of literary work and a conversational interpreter. A literary translator works on a complete manuscript to convert it into another language, whereas the conversational interpreter gives translated version of each phrase or sentence as it is spoken. Languages like FORTRAN, COBOL and PASCAL are generally complied; LOGO, FORTH and APL are interpreted, while BASIC and LISP are widely available in both forms.

It may be noted that a high-level language is less efficient than the machine or assembly language as it requires a greater amount of computer time for translation into machine instructions, yet it provides many advantages over a low-level language. These advantages of a high-level language are discussed here:

(i) It is easy to learn and understand.
(ii) High-level language is machine independent and the programs written in this language are portable across machines.
(iii) It is less error-prone.
(iv) It is easy to modify programs.

Given below is a brief description of some of the more popular high-level languages.

FORTRAN (FORmula TRANslation). Developed for mathematical and scientific problems. This programming language can be used for scientific and engineering applications.

COBOL (COmmon Business Oriented Language). An English-like language specifically designed for business data processing.

BASIC (Beginners All-purpose Symbolic Instruction Code). An easy to learn language, widely used for interactive programming on times-haring systems and for personal computers.

PASCAL. Named after Blaise Pascal, this is a structured language. It can be used for both scientific and file processing applications.

PL/1 (Programming Language 1). A general purpose programming language that provides the facilities of COBOL and FORTRAN.

C. A mid-level structured language that was developed as part of the UNIX operating system. This language combines some of the features of assembly language with machine portability. A superset of C language, called C++ has been developed to support object-oriented software development.

ADA. Named after Augusta Ada Byron, this language was mainly developed for the US Department of Defense as a standard, 'high-order language' to replace COBOL and FORTRAN.

LISP (List Processor). The language is widely used in artificial intelligence. It is oriented towards putting symbols such as operations, variables, and data values into meaningful lists. Better at manipulating symbols than at numerical operations.

PROLOG. Used in artificial intelligence that can run on general purpose computers.

5.4.4 Fourth Generation Languages

Fourth generation languages are also called non-procedural languages. These languages consist of a variety of programming languages that enable users to specify the results they want, while the computer determines the sequence of instructions that will accomplish those results. In contrast, procedural languages require specification of the sequence of steps, or procedures that instruct the computer what to do and how to do it. Thus, with fourth generation languages, software applications can be developed with minimal or no technical assistance, and the same task can be accomplished with fewer steps and lines of program code than a procedural language. In brief, fourth generation languages simplify and accelerate software development as well as reduce programming errors. Some of the common 4GL are dBASE, Foxbase, Foxpro, MS Access, Oracle, Sybase and Ingress.

The next evolutionary step in the user-oriented programming languages is the development of Natural Language programming languages that are very close to English or other human languages. These languages would be termed as the Fifth Generation Languages. Computer scientists have researched for long to develop such a programming language that could be used as conveniently as ordinary conversation in one's native tongue. However, conversion of natural languages into machine language is very complex and requires a large amount of computer resources.

5.4.5 Object-Oriented Languages

The concept of object-oriented programming (OOP) languages was introduced in early 1970 when Allan Kay of Xerox developed the language *Smalltalk*. However, it is in the recent years that object oriented programming has become a major consideration in software development. OOP languages are distinguished from other languages as they combine data and procedures into objects, whereas the other programming languages separate data from the procedures or actions that are to be performed on them. In other words, an object, in OOP language, consists of data and the actions that can be performed on the data. For example, an object could be data about a student and all the operations (such as marks, attendance calculations, etc.) that may be performed upon the data. Object-oriented programming has further grown into a new programming technology, known as *visual programming*, in which the user does not require to write any code for developing a software; rather, they select objects from a library and copy it into a specific location in the program.

SUMMARY

A computer, which may be defined as an electronic device capable of storing and manipulating data and instructions, consists of a central processing unit; main memory and secondary memory; and input and output devices. Data can be captured through keying devices like a punched card reader and keyboard, but nowadays, efforts are being made to capture the data at its source, i.e. eliminating the need for keying and its editing. Examples of such direct data capture by computers are optical character recognition (OCR), optical mark recognition (OMR), magnetic ink character recognition (MICR) and voice recognition systems, etc. Computers may be classified on the basis of operating principles, size and computer power. Based on the operating principles, computers can be classified into digital, analog and hybrid computers. While computers may be categorised as microcomputers, minicomputers, mainframe computers and supercomputers, another basis to classify computers may be computer evolution, which classifies the computers in terms of computer generations. The zeroth generation of computers started with the first efforts to invent computers as early as in the year 1642, when Blaise Pascal was successful in inventing the first mechanical calculator, known as Pascal's Adding Machine. However, it was only in the year 1833 that Charles Babbage designed the first computer capable of performing basic arithmetical functions, known as the analytical engine. The invention of the first electromagnetic calculator by Dr Hollerith in 1889 was another milestone in the history of computers. The era of computers entered the first generation computers when the first truly electronic computer called ENIAC (Electronic Numerical Integrator and Calculator) was developed in 1946 by John Mauchly and J.P. Eckert at the Moore School of Electrical Engineering at the University of Pennsylvania in USA. The first commercial use of an electronic computer was made by General Electric in 1954.

The computers of this generation used vacuum tubes and witnessed an era between 1949–55. They were very slow and were of a very large size. The computers which used transistors, became available in large numbers in 1959 and are classified as second generation computers. These computers were faster, and smaller in size. Third generation computers used silicon chips (ICs). They were highly reliable, had speed in nanoseconds and were still smaller in size. They witnessed an era between 1965–75. Computers started using very large scale integrated chips in 1970s and were called fourth generation computers. Efforts are on to use recent advances in artificial intelligence for designing knowledge base computers, which could be termed as fifth generation computers. The computer programmed instructions, that enable the computer hardware units to perform, are called software. Computer software can be classified into two categories, namely system software and application software. System software consists of a set of programs to support the efficient use of hardware resources that include primary and secondary memory, display devices, printers, communication links and other peripherals. It also interprets and executes application software. System software would include operating systems, language translators (compilers and interpreters) and utility programs.

Application software refers to programs or sets of programs that actually process data to generate information under various applications. Examples are payroll processing system, inventory control information system, etc.

Programming languages allow users to tell (instruct, program) computers what to do. In other words, programming languages are the basic building blocks for all types of software.

REVIEW QUESTIONS

1. Describe various components of a computer system. Discuss in detail the components of the central processing unit and give the functions performed by each.
2. Differentiate between RAM and ROM. Why do computers have both. Also discuss the differences between primary and secondary storage.
3. Give relative advantages and disadvantages of magnetic tapes and disks.
4. How would you classify computers? Discuss each class in detail.
5. Discuss the evolution of a computer system. Explain the differentiating factors among the generations of computers.
6. Write short notes on:
   (a) Optical storage devices
   (b) Magneto-optical storage devices.
7. Write a detailed note on Computer Software. Discuss all the advancements in software technology.

ASSIGNMENTS

1. Assume you are to recommend a computer system for
   (a) a doctor
   (b) a lawyer
   (c) an educational institution
   (d) a small businessman

   Prepare a report specifying the system recommended, the approximate costs and the rationale for the choice for each of the customer.
2. Assume you are to enter data from
   (a) printed questionnaires
   (b) telephone surveys
   (c) bank cheques
   (d) books.

   Which method of input would you use for these activities? Explain your choices.

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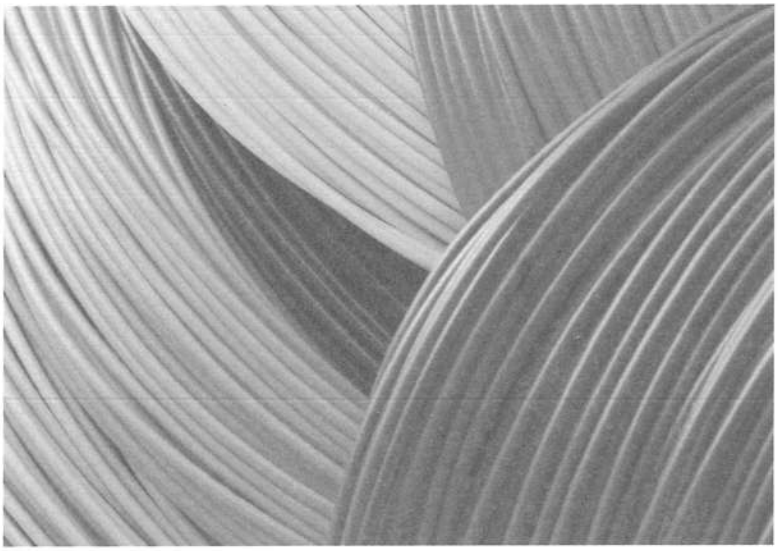
Chapter 6

Database Management



Learning Objectives

After going through this chapter, you should be able to:

- Understand the concept of database hierarchy
- Appreciate the limitations of the traditional approach to data organisation
- Identify the objectives and advantages of database approach
- Explain the types of data structures

6.1 INTRODUCTION

Data is a vital organisational resource, which is an important input in an information system. This data resource is traditionally called the database. It is from this database that data is processed and converted into information for satifying the information needs of an organisation. Nowadays we find that the internal and external information resources available to organisations are increasing at a rapid rate, due to which databases are becoming larger and larger in size. At the same time, the business environment has forced the businesses to take quick and right decisions for which databases are required to be queried frequently. Queries may be varied, e.g. one manager may be interested to know the names of all those products for which sales in the current year exceed that of the previous year, one may require information on the total amount outstanding, or one may require the list of products having a market share greater than 30 per cent and so on. To correctly process the varied types of queries and to ensure a fast response time, the use of computer-based information systems have become a necessity for any business.

> **FOCUS** Data is a vital organisational resource, which is an important input in an information system.

To meet the objective of fast retrieval of data, computer-based information system should be able to organise, store and manage data effectively and efficiently. There are two main methods to organise data on computer media, these are known as files and databases. Before we discuss the two approaches, let us look at the concept of a file and a database, popularly known as database hierarchy.

6.2 DATABASE HIERARCHY

Anything of interest to the user about which data is to be collected or stored is called an entity. An entity may be a tangible object such as an employee, a part or a place. It may also be non-tangible, such as an event, a job title, a customer account, a profit centre or an abstract concept. An entity has a number of attributes, which an individual may be interested to record, such as name, age, designation, etc. In order to know the entity, a user has to collect data about its characteristics or attributes. Generally, in data processing, one is interested in collecting similar entities, such as employees and would be interested in recording information about the same attributes of each of them. Each attribute is termed as 'data item' or 'data element'. Data item, the smallest unit in a database, is a combination of one or more bytes. Sometimes a data item is also called a 'field'.

> **FOCUS** Anything of interest to the user about which data is to be collected or stored is called an entity.

A field is, infact, a physical space on the storage device, whereas a data item is the data stored (value) in the field. For example, an employee of the organisation may be regarded as an entity of interest. The various attributes of this entity may be employee name, age, sex, address, etc. Thus, employee name is one of the data fields, age is the second data field and so on. The values of these fields, say Sandeep, 26 years, respectively are data items of the entity employee. All the data items related to an object are combined in a record. Thus, Mr Sandeep with all its data items is referred to as one record. Similarly, there may be many employees in an organisation and all would have individual records representing that employee. A collection of related records is known as a file. The employee file may contain one or more than one records. Similarly, in an application, there may be several related files. For example, in a salary processing system, the files may be employee file, provident fund file, income tax file, etc. All these files are combined in a database. Thus, database is a set of interrelated files that can be used by several users accessing data concurrently. The data hierarchy, along with another example has been shown in Fig. 6.1.

6.3 FILES – THE TRADITIONAL APPROACH

Traditionally, data files were developed and maintained separately for individual applications. Thus, the file processing system relied on the piecemeal approach of data across the organisation where every functional unit like marketing, finance, production, etc., used to maintain their own set of application programs and data files.

> **FOCUS** Traditionally, data files were developed and maintained separately for individual applications.

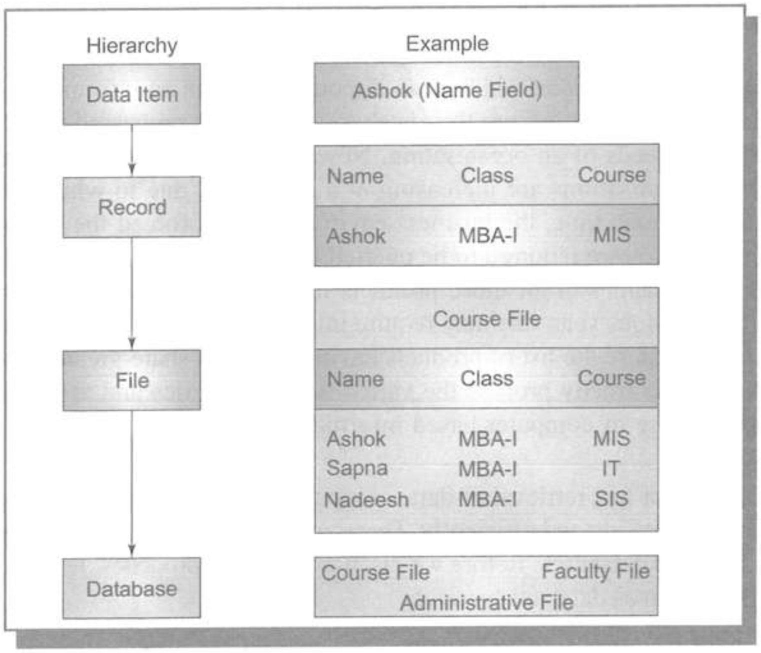


Fig. 6.1 The Data Hierarchy

There is no doubt such an organisation was simple to operate and had better local control but the data of the organisation is dispersed throughout the functional sub-systems.

This approach was rendered inadequate, especially when organisations started developing organisation-wide integrated applications. The major drawbacks of a file processing system are due to the following reasons:

(i) Data duplication,
(ii) Data inconsistency,
(iii) Lack of data integration,
(iv) Data dependence, and
(v) Program dependence.

6.3.1 Data Duplication

Since each application has its own data file, the same data may have to be recorded and stored in several files. For example, payroll application and personnel application, both will have data on employee name, designation, etc. This results in unnecessary duplication/redundancy of common data items.

6.3.2 Data Inconsistency

Data duplication leads to data inconsistency, especially when the data is to be updated. Data inconsistency occurs because the same data items that appear in more than one file do not get updated simultaneously in all the data files. For example, employee's designation, which is immediately updated in the payroll system may not necessarily be updated in the provident fund application. This results in two different designations of an employee at the same time.

6.3.3 Lack of Data Integration

Because of independent data files, users face difficulty in getting information on any *ad hoc* query that requires accessing data stored in more than one file. Thus, either complicated programs have to be developed to retrieve data from each independent data file or users have to manually collect the required information from various outputs of separate applications.

6.3.4 Data Dependence

The applications in file processing systems are data dependent, i.e. the file organisation, its physical location and retrieval from the storage media are dictated by the needs of that particular application. For example, in order processing application, the file may be organised on customers records sorted by their last name, which implies that retrieval of any customer's record has to be through his/her last name only.

6.3.5 Program Dependence

The reports produced by the file processing system are program dependent, which implies that if any change in the format or structure of data and records in the file is to be made, a corresponding change in the programs has to be made. Similarly, if any new report is to be produced, a new program will have to be developed.

These drawbacks in the traditional files approach of organising data led to the development of databases.

6.4 DATABASES – THE MODERN APPROACH

An alternative approach to the file processing system is the modern approach, known as the database approach. A database is an organised collection of records and files that are related to each other. In a database system, a common pool of data can be shared by a number of applications as it is data and program independent. Thus, unlike a file processing system, data redundancy and data inconsistency in the database system approach are minimised. The user is free from the detailed and complicated task of keeping up with the physical structure of the data. Figure 6.2 presents a simplified view of a database system. Ad hoc queries from the user are accepted and standard outputs (reports) may be changed or reformatted as per the information needs of the users.

FOCUS

In the modern or database approach a common pool of data can be shared by a number of applications as it is data and program independent.

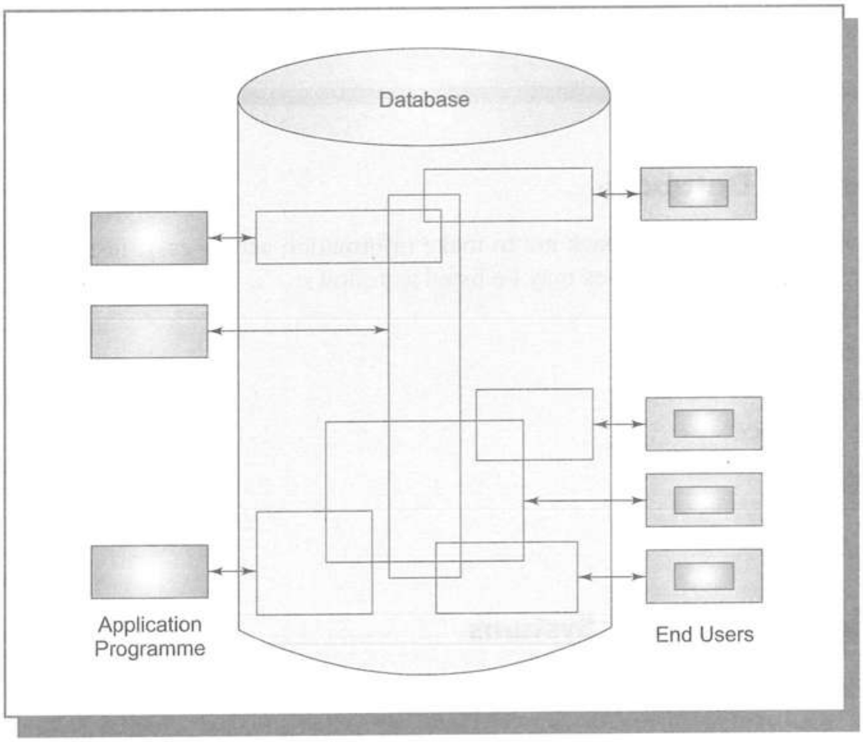


Fig. 6.2 Simplified View of a Database System

The software (set of programs) that provides access to a database is known as a database management system (DBMS). A clear-cut distinction between traditional file system and database system is illustrated in Fig. 6.3.

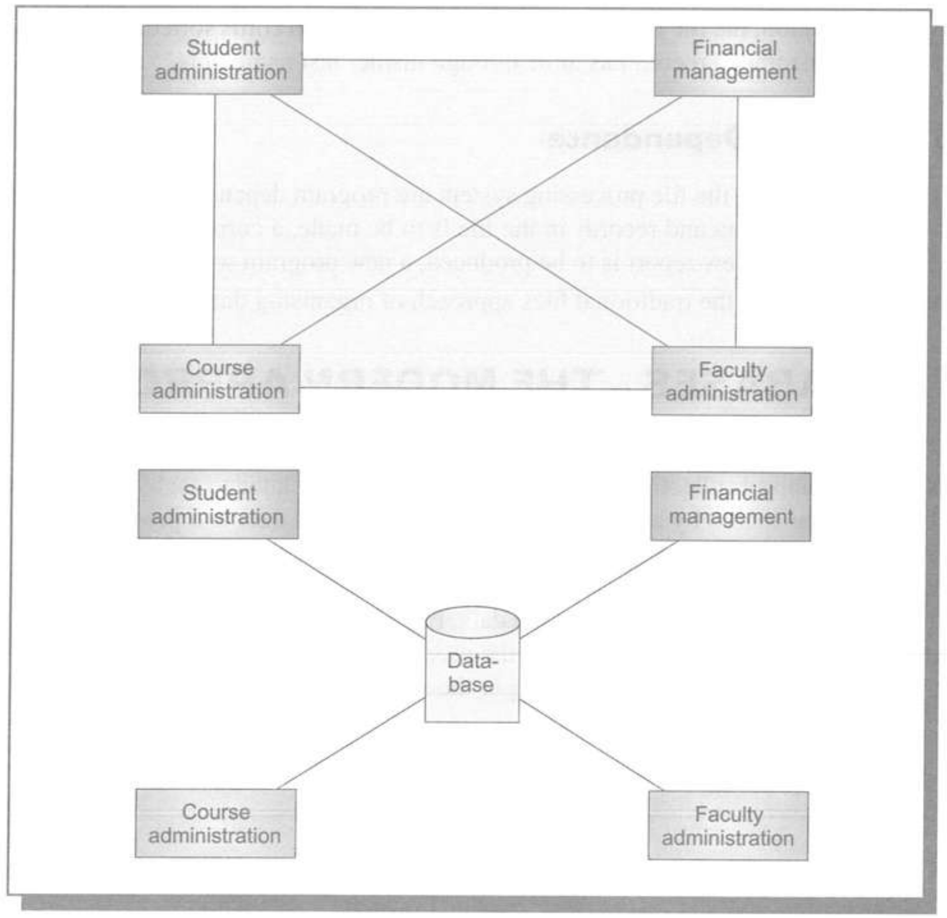


Fig. 6.3 (a) File System Approach, (b) Database Approach

6.4.1 Objectives of a Database

Broadly, the objectives of the database approach are to make information access easy, fast, relatively inexpensive and flexible for the user. The specific objectives may be listed as follows:

(i) Controlled data redundancy
(ii) Enhanced data consistency
(iii) Data independence
(iv) Application independence
(v) Ease of use
(vi) Economical
(vii) Recovery from failure.

6.4.2 Advantages of Database Systems

The database approach provides the following benefits over the file management systems:

Redundancy Control

In a file management system, each application has its own data, which causes duplication of common data items in more than one file. This data duplication needs more storage space as well as multiple updations for a single transaction. This problem is overcome in database approach where data is stored only once.

Data Consistency

The problem of updating multiple files in file management system leads to inaccurate data as different files may contain different information of the same data item at a given point of time. In database approach, this problem of inconsistent data is automatically solved with the control of redundancy.

Thus, in a database, data accuracy or integrity and accessibility of data is enhanced to a great extent.

Management Queries

The database approach, in most of the information systems, pools the organisation-wide files at one place. This is known as central database and is capable of answering queries of the management, relating to more than one functional area. Also, as the related data is centralised and the relationship structure among entities is designed into the database, it is a convenient approach to handle even unstructured queries.

Data Independence

Most of the file management systems are data dependent, which implies that data organisation and access strategies are dictated by the needs of the specific application and the application programs are developed accordingly. However, the database approach provides an independence between the file structure and program structure. This gives a flexibility to the application programs in the Database Management System (DBMS) environment. Such a system provides an interface between the programs and the database and takes care of the storage, retrieval and updation of data in the database. It allows applications to be written as general programs to operate on files whose structures can be made available to the program. In simple words, DBMS may be called a generalised file processing system.

Enforcement of Standards

In the database approach, data being stored at one central place, standards can easily be enforced. This ensures standardised data formats to facilitate data transfers between systems.

6.4.3 Disadvantages of a Database

In contrast to the many advantages of the database approach, there are a few disadvantages as well. The disadvantages of a database approach are given below.

Centralised Database

The data structure may become quite complex because of the centralised database supports many applications in an organisation. This may lead to difficulties in its management and may require a professional/an experienced database designer and sometimes extensive training for users.

More Disk Space

Database approach generally requires more processing than file management system and, thus, needs more disk space for program storage.

Operationality of the System

Since the database is used by many users in the organisation, any failure in it, such as one due to a system fault, database corruption, will affect the operationality of the system as it would render all users unable to access the database.

Security Risk

Being a centralised database, it is more prone to security disasters.

Besides the above-mentioned disadvantages, sometimes the database approach may not be cost-effective for smaller organisations. This is due to the fact that as with other complex software systems, the cost in terms of software, hardware and operating/administrative personnel also increases.

6.5 DATABASE STRUCTURE

Data is structured on the basis of one of the several data models. A data model refers to the logical structures of data and the relationships among them. In database approach, relationships between entities may also be defined and stored. For example, a user may store a teacher record, a subject record and a third record that defines the relationship between the two, i.e. the teacher and the subject. There may be three types of relationships that exist among entities, namely, one-to-one; one-to-many; and many-to-many.

FOCUS

Data is structured on the basis of one of the several data models.

A one-to-one (1:1) relationship is an association between two entities. For example, a relationship between husband and wife, where the husband is legally allowed one wife at a time and vice versa (see Fig. 6.4).

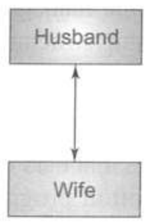


Fig. 6.4 1 : 1 Relationship

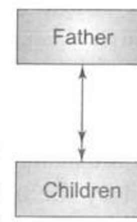


Fig. 6.5 1 : M Relationship

A one-to-many (1 : M) relationship represents an entity that may have two or more entities associated with it. For example, father may have many children and a state may have many districts but each child has only father and each district has only one state (see Fig. 6.5).

A many-to-many (M : M) relationship describes entities which may have many relationships both ways. For example, teachers and students where a teacher teaches many students and a student attends the classes of many teachers (see Fig. 6.6).

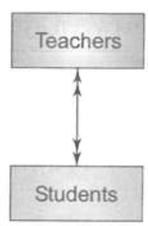


Fig. 6.6 M : M Relationship

The database concept clearly distinguishes between logical and physical views of data. The logical view is the representation of data as it would appear to an application programmer or end user, whereas the physical view shows how data is actually organised and structured on the physical storage media. To illustrate this, Fig. 6.7 depicts a programmer who requires a five-record file in a particular order (A, D, C, B, S). The programmer, in this database approach, does not know about the physical 'map' on the storage media.

FOCUS

Database Management System is a software that facilitates flexible management of data.

The structure of the database, defining the records of entities and the relationships among entities in the databases is called 'schema'. Users of the database may view only a portion of the database known as sub-schema. It is not necessary for the user to know the complete structure of the database. Thus, various sub-schemas may represent the external view (see Fig. 6.8).

6.6 DATABASE MANAGEMENT SYSTEM

Database Management System is a software that facilitates flexible management of data. It is generally composed of three sub-systems which are described as follows:

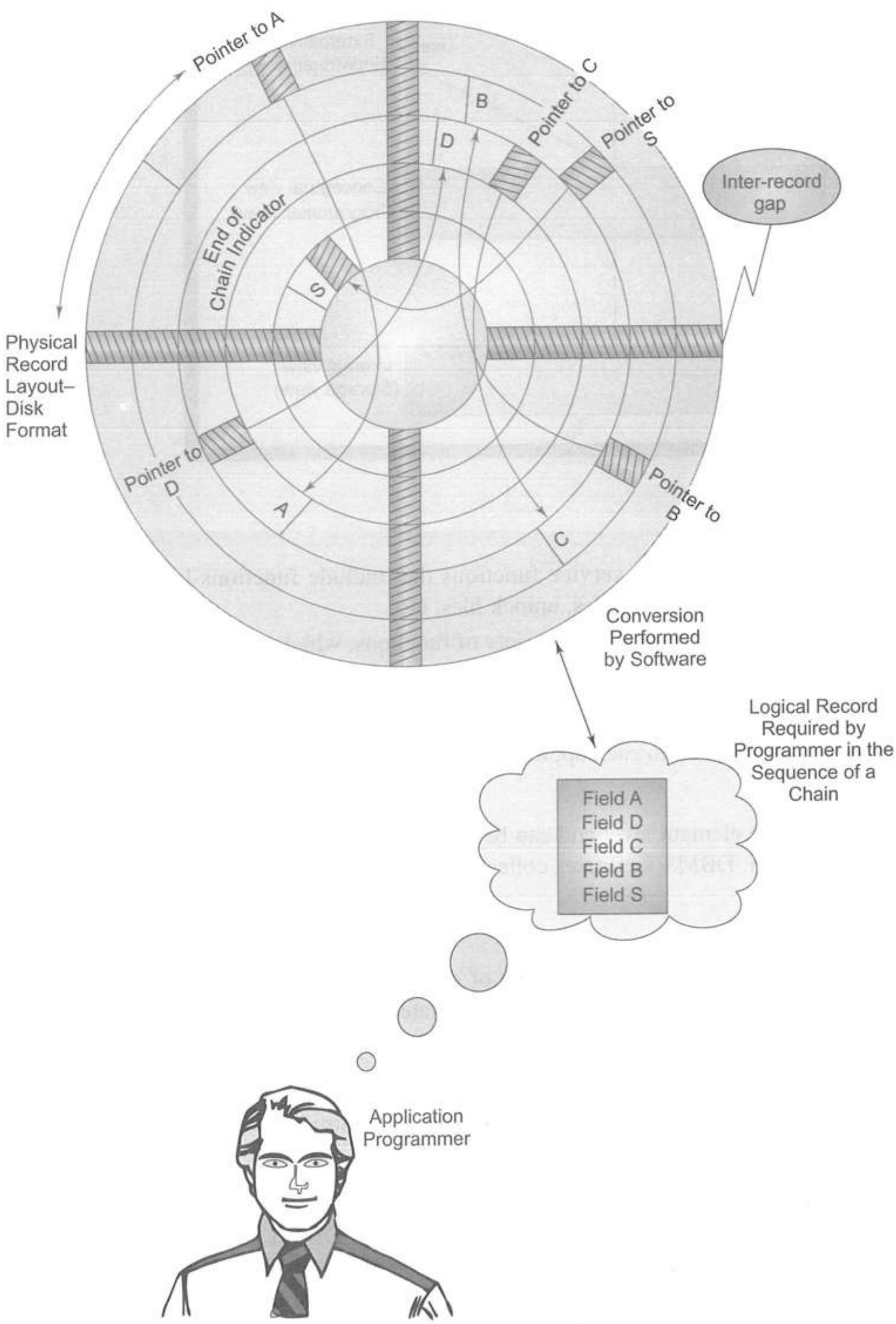


Fig. 6.7 Physical and Logical Records – A Contrast

Database Definition

In this sub-system, the complete database (schema) is described with the help of a special language known as the data description language (DDL). However, in the case of database in different files, one file should be defined at one time as this would give the maximum flexibility.

Database Manipulation

After the database is defined, elements of data can be stored. The stored data may either be retrieved and updated later through data manipulation language (DML). The manipulation sub-system can retrieve the required elements of data (the sub-schema) in a variety of sequences.

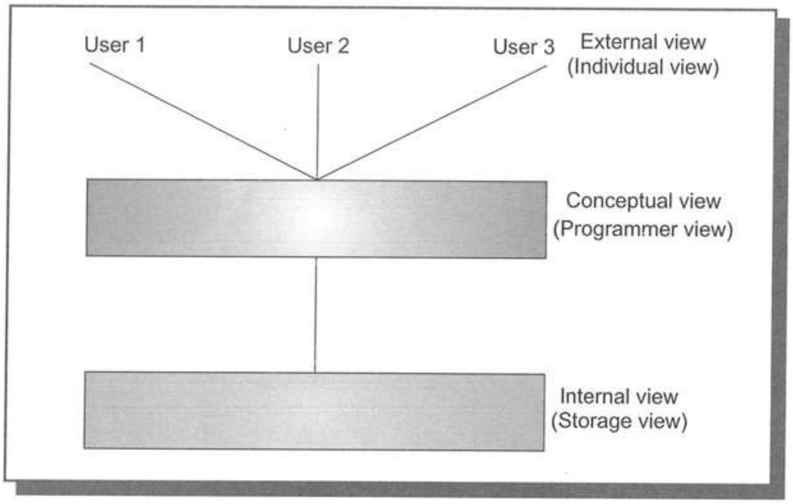


Fig. 6.8 Three Levels (Views) of DBMS

Database Support

This sub-system performs database utility or service functions that include functions like list files, change file passwords, change file capacities, print file statistics, unlock files, etc.

A database management system performs a wide variety of functions, which are discussed below.

Data Organisation

DBMS organises data items as per the specifications of the data definition language. Database administrator decides the data specifications that are most-suited to each application.

Data Integration

Data is inter-related together at the element level and can be manipulated in many combinations during execution of a particular application program. DBMS facilitates collection, combination and retrieval of the required data to the user.

Physical/Logical Level Separation

DBMS separates the logical description and relationships of data from the way in which the data is physically stored. It also separates out application programs and their associated data. This adds data security in view of the data access by different programs that describe data in different ways.

Data Control

DBMS receives requests for storing data from different programs. It controls how and where data is physically stored. Similarly, it locates and returns the requested data to the program.

Data Protection

Data protection and security is one of the major concerns in a database. DBMS protects the data against access by unauthorised users, physical damage, operating system failure, simultaneous updation, etc. It also protects and secures the content of a database as well as the relationships of data elements. DBMS is equipped with a facility to backup data and restore it automatically in the case of any system failure. Concurrent access control is ensured by the provision of 'locks'. Other security features implemented in the system include password protection and sophisticated encryption schemes.

6.7 TYPES OF DATABASE STRUCTURES OR DATA MODELS

Generally, database systems are classified on the basis of one of the three data models, which they use in building the conceptual structure or schema of the database. The three models are:

(i) Hierarchical model
(ii) Network model
(iii) Relational model.

Let us briefly discuss these database structures.

6.7.1 Hierarchical Model

In the hierarchical structure, the relationships among records are stored in the form of a hierarchy or a tree which has a root. In this model, all records are dependent and arranged in a multi-level structure, thus the root may have a number of branches and each branch may have a number of sub-branches, and so on. The lowermost record is known as the 'child' of the next higher level record, whereas the higher level record is called the 'parent' of its child records. Thus, in this approach, all the relationships among records are one-to-many, Figure 6.9 depicts a hierarchical data structure. A hierarchical approach is simple to understand and design but cannot represent data items that may simultaneously appear at two different levels of hierarchy, e.g. a person may be a boss and a subordinate at the same time, for different persons of course. Also this approach creates a problem when real world data does not follow a strict hierarchy. For example, in a matrix organisation, an employee may report to more than one manager.

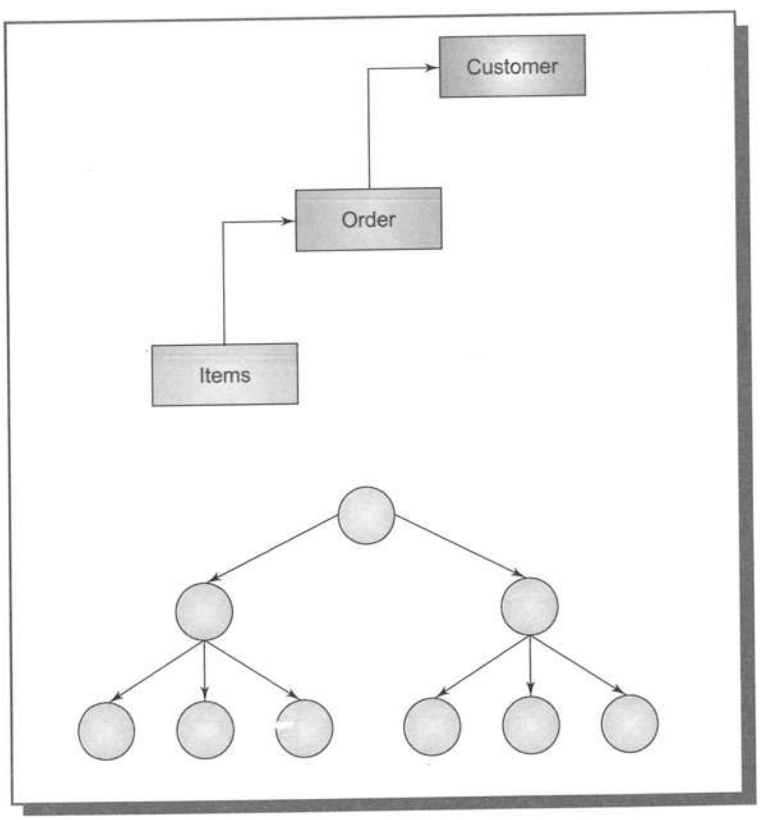


Fig. 6.9 Hierarchical Data Model

6.7.2 Network Model

The network model allows more complex 1:M or M:M logical relationships among entities. The relationships are stored in the form of linked list structure in which subordinate records, called members, can be linked to more than one owner (parent). An example of a network model is shown in Fig. 6.10. This approach does not place any restrictions on the number of relationships. However, designing and implementing this network model is ralatively more complicated.

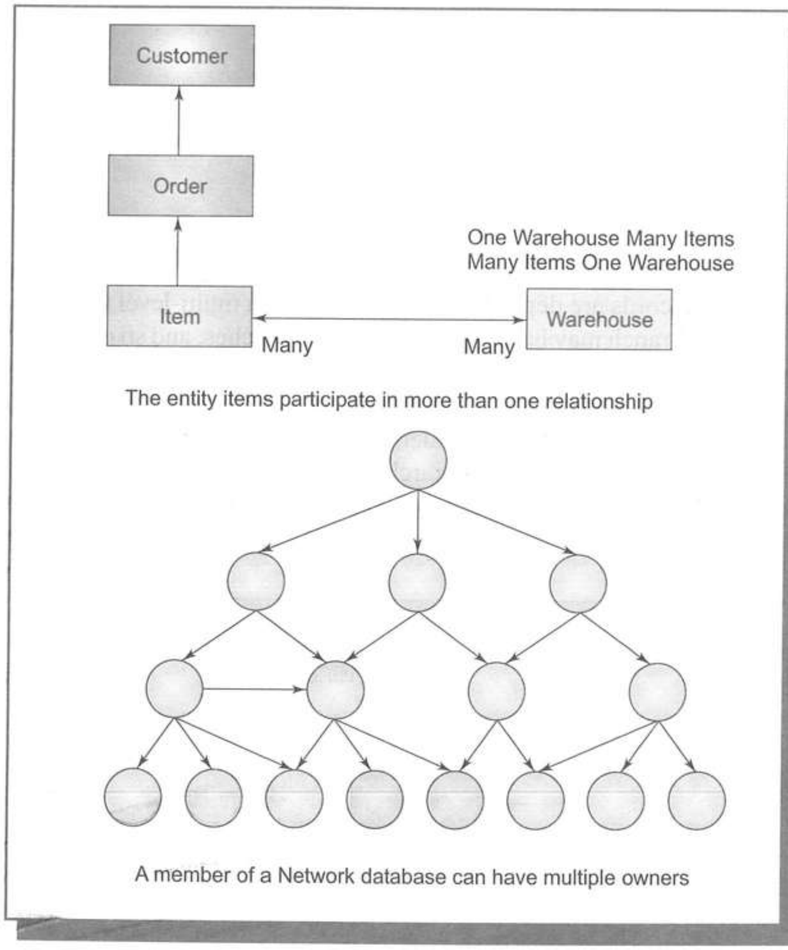


Fig. 6.10 Network Model

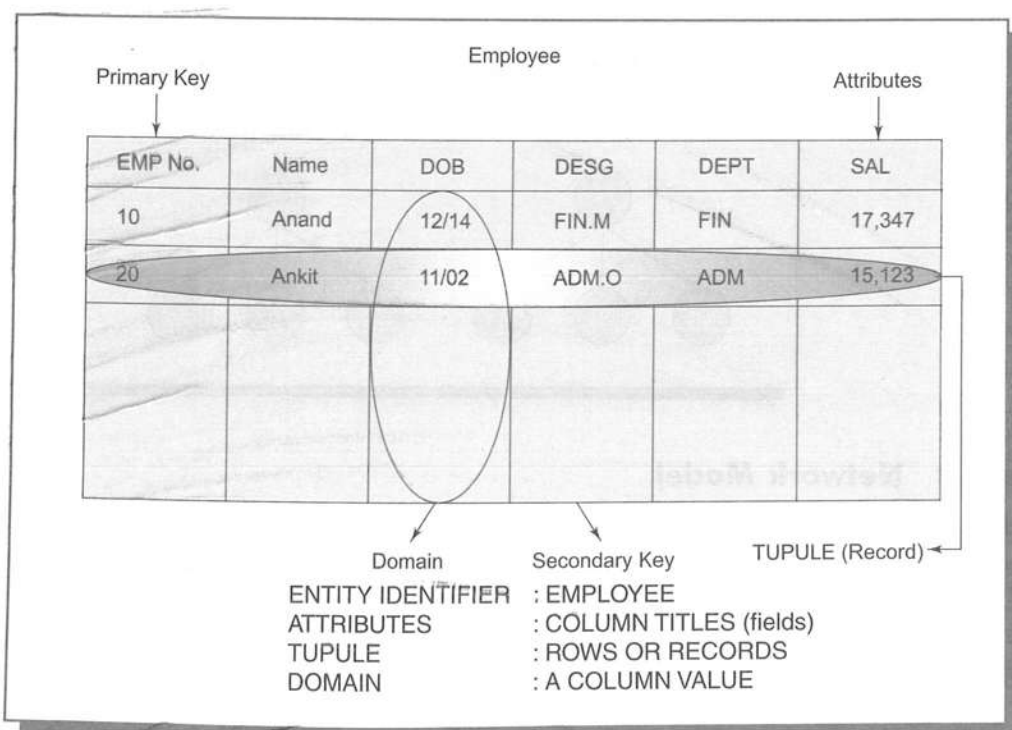


Fig. 6.11 Relational Data Model

6.7.3 Relational Data Model

In a relational structure, data is organised in two-dimensional tables, called relations, each of which is implemented as a file (see Fig. 6.11). Relational model, that was proposed by Dr E.F. Codd in 1970, is based on the mathematical theory of sets and relations. In this model, each row of the table is referred to as a 'tupule' and each column in the row as 'attribute'. A tupule refers to a set of data item values relating to one entity. A tupule of two values is called a pair, and if it contains *N* values, it is known as *N*-tupule. Figure 6.11 represents 6-tupule. A column consisting of a set of values of one data item, is referred to as a 'domain'. A relation consisting of two domains (2 data-item types) is called a relation of degree 2 (binary). Similarly, degree 3 is called ternary and degree *N* as *N*-ary. To avoid redundancy, the database is not designed only in one big table, (generally called a flat file) rather it is designed as many related tables. For example, Tables 6.1 and 6.2, respectively illustrate the representation of data by the relational model. Table 6.1 represents a variety of data elements on each course offered by a business school, while Table 6.2 represents data about the faculty of the school. The two tables are linked to each other by a common column, i.e. teacher code (TCODE).

Table 6.1 Data Table Course

C.No	*Ctitle*	*Credits*	*Stdno*	*Tcode*
CS 101	MIS	6	25	07
CS 201	SAD	4	25	15
CS 304	Software Engineering	4	25	30
CS 406	Information Technology	3	20	06
CS 303	Strategic Systems	4	20	11

Table 6.2 Data Table Teacher

Tcode	*Name*	*Deptt*	*Desig*	*Phone*
07	Goyal D P	BM	Professor	305224
06	Sangal A L	CS	Professor	212582
30	Ramachandran	CS	Professor	523214
15	Singh I J	ES	Professor	282574
11	Rao T R	BM	Reader	352107

The relational model is currently more popular among users and developers because the model provides a great deal of flexibility and ease of use. But in large-scale databases, because of the many inter-related tables, the overall design may get complicated, which may further lead to slower searches and thus affect the access time. However, such processing inefficiencies are continually being reduced through database designs and programming. Initially, DB2 was developed as a mainframe product but now many miniplatform products are available in the market that include Ingres, Oracle and Informix, Dbase IV and Rbase.

6.8 STRUCTURED QUERY LANGUAGE (SQL)

Structured Query Language, more popularly known as SQL (pronounced as 'sequel') is the language that is used in most relational database systems. It is called structured query language because it follows a rigorous set of rules and procedures in answering queries. SQL is also termed as 4GL to distinguish it from other 3GL programming languages like Pascal, Cobol or C.

SQL is a simple and powerful query language that is capable of answering both simple and complex queries. Any query on a single table can be performed by using only two basic operators, namely SELECT and PROJECT.

FOCUS

SQL follows a rigorous set of rules and procedures in answering queries and is used in most relational database system.

The SELECT operator selects a set of records (rows) from the table, whereas PROJECT takes out selected fields (columns) from the table. The two operators can be understood, in the users' view, as a horizontal cut and vertical cut, respectively, of the table. Another operator JOIN is also used in SQL when the query requires more than one table. JOIN links or combines two tables together over a common field.

Let us illustrate the working of RDBMS system with the help of the following examples.

The tables are created using data definition language. Typical constructs for creating Tables 6.1 and 6.2 would be as follows.

Create Table Course
CNO Char (5),
CTITLE Char (25),
CREDITS integer,
STDNO integer,
TCODE Char (3),
Create Table Teacher
TCODE Char (3),
NAME Char (20),
DEPTT Char (5),
DESIG Char (12),
PHONE Char (6),

Having created the tables and having entered the data as shown in Tables 6.1 and 6.2, the above-mentioned basic operators, viz., SELECT, PROJECT and JOIN may be used. For example,

(i) SELECT DEPTT = 'CS'
FROM the table Teacher, we get Table 6.3 (a).

Table 6.3 (a)

Tcode	*Name*	*Deptt*	*Desig*	*Phone*
06	Sangal A L	CS	Professor	212582
30	Ramachandran	CS	Professor	523214

(ii) PROJECT CNO, STDNO.
FROM the table Course, we get Table 6.3 (b).

Table 6.3(b)

C.No	*STD No*
CS101	25
CS201	25
CS304	25
CS406	20
CS303	20

(iii) Similarly, two or more than two tables can be joined over a common field. For example, table course and table teacher may be joined together over a common field TCODE to obtain the following result (see Table 6.3(c)).

Table 6.3(c)

C.No	*Ctitle*	*Credits*	*STDNO*	*Tcode*	*Name*	*Deptt*
CS101	MIS	6	25	07	Goyal D P	BM
CS201	SAD	4	25	15	Sangal A L	CS
CS304	Software Engineering	4	25	30	Ramachandram	CS
CS406	Information Technology	3	20	06	Singh I J	ES
CS303	Strategic Systems	4	20	11	Rao T R	BM

In the above example, the use of three basic operators has been explained. However, it may be noted that SQL does not use the SELECT, PROJECT and JOIN formats at the syntactic level, rather it follows a generic format consisting of the following three subcommands:

SELECT	Field list
FROM	List of tables
WHERE	Condition

For example, say we want to know the name of course(s) where the number of students are less than 21 from our earlier database stored as relation course (Table 6.1).

The following command format will be used.

```
SELECT CNO, CTITLE, CREDITS, STDNO
FROM Course
WHERE STDNO < 21
```

This will produce the report as given below.

CNO	CTITLE	CREDITS	STDNO
CS406	Information Technology	3	20
CS303	Strategic Systems	4	20

In a similar way, the result of the following instruction should be obvious.

```
SELECT CNO, CREDITS, STDNO
FROM Course
WHERE STDNO < 21 or CREDITS <= 4
```

This instruction would select the following four records.

C.No	Credits	STDNO
CS201	4	25
CS304	4	25
CS406	3	20
CS303	4	20

Information from two different tables may be extracted by using dot (.) notation as shown below.

```
SELECT CTITLE, NAME
FROM Course, Teacher
WHERE Course. TCODE = Teacher.TCODE;
```

SQL can also perform many other functions that include sorting (ordering), group functions of averaging, summing, locating maximum and minimum values, counting the numbers in a column, etc. (refer to any SQL text for more features).

FOCUS

Normalisation may be defined as a step-by-step process of simplifying the relationships between data elements in a record.

6.9 NORMALISATION

In order to facilitate a flexible usage of the database and to minimise the effect of application changes on its structure, a process called 'normalisation' is used. Normalisation can be defined as a step-by-step process of simplifying the relationships between data elements in a record. The designers of information systems/system analysts must know the process of normalisation, since this process can improve the quality of database design. The three types of normalisations, i.e. normalised relations, namely first normal form (1NF), second normal form (2NF) and third normal form (3NF) are discussed here through an example of consultant data.

Example: Consultant Data

CONSULTANT DATA

NUMBER	*NAME*	*GRADE*	*SCALE*	*CAR TYPE*
051011	Nitin	E	S2	Fiat

ADDRESS
B-218, Hill-view Tower
M G Road
Borivli (North)
Mumbai 400 013
SKILLS

CODE	*DESCRIPTION*	*QUALIFICATION*
CS01	COBOL	CSI Cert.
CS05	C	CMC Course
SW02	UNIX	IIT Cert.

The Consultant Data is in unnormalised form. Let us make a relation from all attributes.

CONSULTANT RELATION
Consultant #
Name
Address
Grade
Scale
Car Type
Skill Code
Skill Descr
Qualification

Note: Last 3 attributes have many values for each consultant; called a repeating group.

First Normal Form

(i) Applied to all relations
(ii) Test: No repeating groups

Steps

(i) Remove repeating group to form new relation
(ii) New relation has compound key consisting of:
  (a) Key of parent relation
  (b) Key of repeating group

Example: Consultant Data First Normal Form

Existing Relation	New Relations
CONSULTANT RELATION	CONSULTANT RELATION
Consultant #	Consultant #
Name	Name
Address	Address
Grade	Grade
Scale	Scale
Car Type	Car Type
Skill Code	
Skill Descr	QUALIFICATION
Qualification	RELATION
	Consultant #
	Skill Code
Skill Descr	
Qualification	

Each new relation now meets first normal form requirements.

Second Normal Form

(i) Applies to compound key relations only

(ii) Test: Each non-key field must depend on entire key (No part key dependencies)

Steps

(i) Remove fields that depend on part key

(ii) Form separate relation with part key as prime key

Dependence: attribute A depends on B when its value in real world can be determined given value of B, e.g. Skill descr depends on Skill code

Example: Consultant Data Second Normal Form

Existing Relation	New Relations
QUALIFICATION RELATION	QUALIFICATION RELATION
Consultant #	Consultant #
Skill Code	Skill Code
Skill Descr	Qualification
Qualification	
	SKILL RELATION
	Skill Code
	Description

Each new relation now meets second normal form requirements.

Third Normal Form

(i) Applies to all relations

(ii) Test: dependencies between non-key attributes is not allowed.

(a) Dependencies should be between key and non-key attributes only.

(b) Relationship between each possible combination of fields (including key fields) within a relation is examined.

Steps

(i) Remove dependent items to form new relation

(ii) Retain key of new relation in parent relation as foreign key e.g. Scale depends on Grade (in this application)

Example: Consultant Data Third Normal Form

Existing Relation	New Relations
CONSULTANT RELATION	CONSULTANT RELATION
Consultant #	Consultant #
Name	*Name
Address	Address
Grade	*Grade
Scale	Car Type
Car Type	
	GRADE RELATION
	Grade
	Scale

Each new relation now meets third normal form requirements.

Integration of Views

(i) Pool relations derived from all user views (Input/Output documents)

(ii) Check relations/field names for:

(a) Same name but different meaning

(b) Different name but same meaning

(iii) Consider identical relations only once

(iv) Merge relation with same key e.g. Rl (A, B, C) and R2 (A, D, E) become R(A, B, C, D, E)

(v) Ensure that merged relations do not violate normalisation conditions (otherwise repeat normalisation steps): inter-attribute dependencies may get introduced in merging relations with same key.

Exercise: Order Data

ORDER

ORDER#		DATE
1234		01/03/98
CUSTOMER #		CUSTOMER
321		LIT. MUMBAI
ITEM#	QUANTITY	PRICE
123	2000	43.50
234	1050	22.00
345	2575	55.00

Solution: Order Data Normalisation

UNNORMALISED	FIRST ORDER	SECOND ORDER	THIRD ORDER
ORDER			
Order #	Order #	Order #	Order #
Date	Date	Date	Date
Customer #	Customer #	Customer #	Customer #
Customer	Customer	Customer	
Item			
Quantity	ORDER-ITEM	ORDER-ITEM	ORDER-ITEM
Price			
	Order #	Order #	Order #
	Item #	Item #	Item #

Quantity	Quantity	Quantity
Price		
ITEM		ITEM
Item #		Item #
Price		Price
		CUSTOMER
		Customer #
		Customer

6.10 ADVANCES IN DATABASE TECHNOLOGY

6.10.1 Object-Oriented Databases

Object-oriented database is an approach to data management that stores both data and the procedures (functions) acting on the data as objects that can be automatically retrieved and shared. While traditional database management systems are designed for homogeneous data that can be structured into pre-defined data fields and records, object-oriented databases are capable of manipulating heterogeneous data that include drawings, images, photographs, voice and full-motion video. Object-oriented approach also enables to overcome the limThisations of the relational database management system. There is no doubt, that the relational model is powerful but its abstraction level is low and the manipulation of the relationships of tables is captured by the programs and not by the model itself. On the other hand, an object-oriented database, stores the data and procedures as objects that can be automatically retrieved and shared.

FOCUS

It is an approach to data management that stores both data and the procedures (functions) acting on the data as objects that can be automatically retrieved and shared.

6.10.2 Distributed Databases

A distributed database, as the name indicates, is stored in more than one physical location. The database is stored partly in one location while it is partly stored and maintained in other locations. In other words, a distributed database coordinates data access from various locations. In this approach, databases are designed as an entity and are linked through communication networks. Distributed database approach is an alternative to the central database approach that advocates concentration of all databases at a central place. However, any breakdown in the central database approach leads to system-wide breakdown and it also causes undue congestion of traffic at the central hub. On the other hand, distributed systems overcome these problems. They also allow increases in the system's processing power by installing smaller, less expensive minicomputers, in turn increasing the responsiveness to local users. Nowadays, many databases are distributed across geographical areas. For example, networks of libraries, networks of banks, transactions of credit in one or more countries and networks of offices of organisations across the world are now a reality. These systems are growing rapidly. The advent of microcomputers and powerful telecommunication systems will further boost the growth of distributed systems.

FOCUS

This database is stored partly in one location while it is partly stored and maintained in other locations.

6.10.3 Client-Server Systems

These systems are closely related to the concept of distributed database. In the client/server model, the database and processing power are distributed over the organisation rather than having a centralised database. This model splits processing between 'clients' and 'servers' on a network, assigning these functions to the machine that it is best-suited in terms of performance.

Servers, in general, are high performance machines that support heavy transaction processing known as server processes, whereas the clients are low-end microcomputers with rich graphical user interface (GUI). Client-servers are growing in popularity these days and are being used by a large number of organisations.

FOCUS

These systems are closely related to the concept of distributed database.

SUMMARY

In order to support decision-making, strong databases are essentially maintained in organisations. The complexity of the database as well as the variety of queries is ever increasing. To elicit quick responses, there is a need to organise data in the most effective and efficient manner. Data is organised in a hierarchy where data elements or fields are at the lowest level of hierarchy. A collection of related data elements is termed as a record, related records are combined into a file and related files in a database. Traditionally data was stored and maintained separately for individual applications in the organisation. This had many disadvantages like data duplication, data inconsistency, data dependence and program dependence. An alternative approach to the traditional file processing system was developed and is known as the Database approach. In database approach common pool of data can be shared by a number of users concurrently. Moreover, database approach provides more flexibility and ease of use. Unstructured queries can also be handled with this approach. In the database, data is structured on the basis of one of the three data models, namely, hierarchical, network and relational model. In the hierarchical structure, entities are related by parent/child or superior/subordinate relationships. This model allows one-to-one and one-to-many relationships. The network model is also similar to the hierarchical model, except that in this approach an entity can have more than one parent. The relational data model, which is based on a two-dimensional table known as relation, is currently the most popular data model.

REVIEW QUESTIONS

1. Explain the drawbacks of the file processing system. What is the alternative to the files approach?
2. Define, in your own words, a database and database management system. Discuss the objectives and advantages of a database. Illustrate.
3. Define database structure. Illustrate its major types.
4. How would you differentiate between hierarchical and network data models?
5. Discuss the features of a relational DBMS.
6. Consider the following schema and write the queries in SQL:
   FACULTY (eno, name, dno, salary, age, numpubs)
   DEPT (dno, name, budget, floor)
   COURSES (cno, name, prereq)
   STUDENTS (sno, name, hno, age, year, grade)
   REGISTERED FOR (sno, cno)
   TAUGHT BY (sno, cno)
   Queries:
   (i) Print the names of students who have registered for Distributed Database course.
   (ii) Print the names of students in Hostel number 5 in sorted order (ascending).
   (iii) Print the distinct salary values of the faculty in Computer Science Department.
7. Briefly describe the concept of SQL. Give the results of the following constructs:
   (i) Select faculty, name
   from faculty, dept
   where faculty.dno = dept.dno
   and dept.name = 'cs'
   (ii) Select c.name, p.cname
   from course as c, course as p
   where c.prereq = p.cno

8. Define normalisation and explain the first, second and third normal forms by taking a suitable example.

Exercise

Input-output forms and operational data in Student Academic System at an academic institution is given below.

- Course registration form: gives course number, title and credits for courses enrolled by a student, the total credits and academic year, semester-number is also given.
- Roll list: produced for taking class-room attendance.
- Teacher's evaluation: gives grades obtained by registered students; includes some control fields like total students, number of students in each grade.
- Student's grade card: consolidated grade report, giving courses and grades, semester, cumulative performance index, etc.
- Courses of study bulletin: defines courses available and their pre-requisites.

You are required to use normalisation approach to design a schema for this application.

9. Create tables using the following SQL commands:

```
create table students (
roll no                  number (8),
name                     char (30),
deptcode                 char (3),
hostel                   number (2),
parent_inc               number (8, 1);
create table depts (
deptcode                 char (3) primary key,
deptname                 char (30);
```

Using insert statement, load the above tables with data, using insert statement and try out the following queries on these tables: insert into depts (deptcode, deptname) values ('CSE', 'Computer Science and Engg');

```
select * from students;
select rollno from students;
select distinct rollno from students;
select rollno, name from students order by rollno;
select rollno, name from students order by rollno DESC;
select rollno, name, deptcode from students order by rollno, deptcode DESC;
select * from students where deptcode = 'CSE';
select * from students where deptcode = 'CSE' and hostel = 3;
select * from students
where deptcode = 'CSE' or deptcode = 'ELE';
select * from students
where (deptcode = 'CSE' and hostel = 3) or
(deptcode = 'ELE' and hostel = 9);
select rollno, name, deptname
from students s, depts d
where s.deptcode = d.deptcode;
select rollno, name, deptname
from students, depts d
```

where s.deptcode = d.deptcode and hostel = 3
and s.deptcode = 'CSE';

Exercises

1. Count the number of students in the CSE dept.
2. Find out the number of students by hostel and deptcode.
3. Count the number of students in each of the depts ELE and CSE.
4. Print out the name and parental income of each student greater than the parental income of rollno 92005008 (say).

ASSIGNMENTS

1. Visit your local bank. Determine the Data Base Administrator's responsibilities to the organisation and to the users. Find out whether or not the DBA logically designs databases. Do you think DBAs' responsibilities will change in the future?
2. Contact the librarian of your institution. Determine the scope of information available to library users. How many different files are maintained? What DBMS is being used? Document the benefits that have resulted from the use of the DBMS, if not already in use. How extensively is the database used?
3. Compare the strengths and weaknesses of the following DBMS products:
   (i) ORACLE,
   (ii) SYBASE and
   (iii) INGRES.

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EXERCISE 1

DATABASE MANAGEMENT

Mr. Navjot owns a Paying Guest (PG) house in a metro city in India. Many students often stay at Mr. Navjot's house because it is reasonable in price, clean and comfortable. The PG house has nine rooms, some of which are double rooms i.e. have two twin beds, and some are single rooms. In addition some rooms have an attached bath room.

Mr. Navjot has hired a consultant to develop a Microsoft Access database system for him to streamline his operation.

The database management system will be used to do the following:

1. Keep track of the customers and their permanent address.
2. Keep track of the rooms in the house and their room type.
3. List the rent of each type of room.
4. Record the length of stay in the specific room by a customer.
5. Rank the popularity of each room.
6. Generate monthly bills for customers.

The consultant has designed four tables as given below (in Microsoft Access) in order to do the first four tasks.

In addition to having these tables, Mr. Navjot requested two reports:

(i) A report should show him how often each type of room is rented, with the most popular room being noted first, sorted for the least popular; and

(ii) A report on occupants' "end–of– month" bills. This report should include the occupant's name, address, and date first rented and the total amount due.

Table 1 Customer

Customer ID	*Last Name*	*First Name*	*Address*	*Telephone*
1001	Aggarwal	Ramesh	Jail Road, Hissar	+91-752-0052
1002	Goel	Raj	Edi Street, Kolkata	091-011-7531
1003	Chadha	Balbir	B.S. Road, Mumbai	+91-012-55532
1004	Singh	Sarika	New City, Mumbai	+91-124-32637
1005	Sharma	Sunita	51, Raja Place, Amritsar	+91-52-5324

Table 2 Room Charges

Room Type	*Rent Per Room/night (in Rupees)*
Double with Bath	5000
Double without Bath	4000
Single with Bath	3000
Single without Bath	2000

Table 3 Room Data

Room ID	*Room Type*	*Location*
1	Double without Bath	First Floor
2	Double without Bath	First Floor
3	Double without Bath	First Floor
4	Single with Bath	First Floor
5	Double with Bath	Second Floor
6	Double with Bath	Second Floor
7	Double with Bath	Second Floor
8	Double without Bath	Second Floor
9	Single without Bath	Second Floor

Table 4 Length of Stay

Customer ID	*Room ID*	*Date IN*	*Date Out*
1001	1	6/15/06	6/20/06
1002	2	6/12/06	6/15/06
1003	5	6/18/06	6/23/06
1004	9	6/21/06	6/25/06
1005	7	6/14/06	6/17/06
1006	6	6/7/06	6/10/06
1007	5	6/6/06	6/12/06
1008	4	6/8/06	6/15/06

ASSIGNMENTS

1. Use Microsoft Access to create the four tables. Use the data provided in the tables. Add your name and address to the customer table, using a customer ID of 1006.
2. Create a report that lists the numbers of nights each room is rented, listing the most popular room at the top and the least popular room at the bottom.
   - Create a sigma query and sort the output on the number of nights.
   - Title the report Number of Nights Rooms were Rented.
   - Headings for the report are as follows:

   Room Type Number of Nights
3. Generate a report that shows each customer's bill for June.
   - Create a query with a calculated field to figure the changes for each person.
   - Give the title "June Bill" to the report.
   - Use the following headings in the order given:

   First Name; Last Name; Address; Date in; Charges.

EXERCISE 2

DATABASE MANAGEMENT

SMS institute is a reputed institute of management, situated in the heart of Chennai. The institute has more than 300 faculty members on its rolls. The institute has got a Maharaja Faculty Club, which contains a bar and restaurant. Faculty members from SMS institute can join the club and have dinner or drinks. The club charges the members an yearly fee of Rs 10,000 for joining. The club does not handle any cash transactions. All meals and drinks are charged to the members, using a plastic card similar to a credit card. No tips are allowed. Members must pay for guests. At the time of their leaving the club, all transactions and bills are prepared by hand.

Each of the members get a monthly bill from the club, itemising charges by the type of food and drink bought on each date. For instance, charges on a member's bill for a month may look like the ones given in the following table:

MONTHLY BILL

Mr. R. S. Purohit *Date of Bill: 30/06/06*

Date	*Type of food/drink*	*Charges(in Rupees)*
June 5, 2005	Soft Drink	45.00
June 6, 2006	Dinner	275.00
June 8, 2006	Dinner	275.00

The Maharaja Club of SMS institute wants to computerise its operations. The manager of the club has approached a consultant to develop a database management system, so as to do the following tasks:

1. List the faculty members and their campus address.
2. List the type of food and drink.
3. List the price of food and drink;
4. Record an individual members' purchases of food and drink;
5. Rank the frequency of purchases of food and drinks types;
6. Generate monthly bills for individual members

The consultant designed the following four tables to perform the first four tasks:

(a) List members;

(b) List food and drink available;

(c) Record Charges members have incurred.

The structure of these four tables is given as below:

Table 1 Member

Members ID	*Name*	*Address*	*Telephone*
601	Jyoti	05, Senior Faculty	(515) 7352
602	Raghbir Singh	08, Senior Faculty	(515) 8420
603	Umesh Kumar	15, Faculty I	(515) 7321
604	Rajiv Singhal	30, Faculty II	(515) 5421
605	Satbir Singh	10, Senior Faculty	(515) 3222

Table 2 Charges

Type of meal	*Price(in Rupees)*
Dinner	275.00
Soft Drink	45.00
Beer/ Wine	200.00
Dessert	95.00

Table 3 Food and Drink

Item ID	*Item Type*	*Food and Drink Type*
1001	Coke	Soft Drink
1002	Cold Tea	Soft Drink
1003	Red Wine	Bear/ Wine
1004	Ice Cream	Dessert
1005	Hot Gulab Jamun	Dessert
1006	Chicken	Dinner
1007	Malai Kofta	Dinner
1008	Paneer	Dinner
1009	Daal	Dinner
1010	Tandoori Roti	Dinner
1011	White Wine	Beer/Wine
1012	Beer	Beer/Wine
1013	Salad	Dinner

Table 4 Orders

Date	*Members ID*	*Item ID*	*Quantity*	*Order No.*
6/5/2010	605	1001	3	1
6/6/2010	605	1010	4	2
6/7/2010	603	1005	1	3
6/8/2010	604	1004	2	4
6/12/2010	604	1013	1	5
6/16/2010	601	1002	6	6

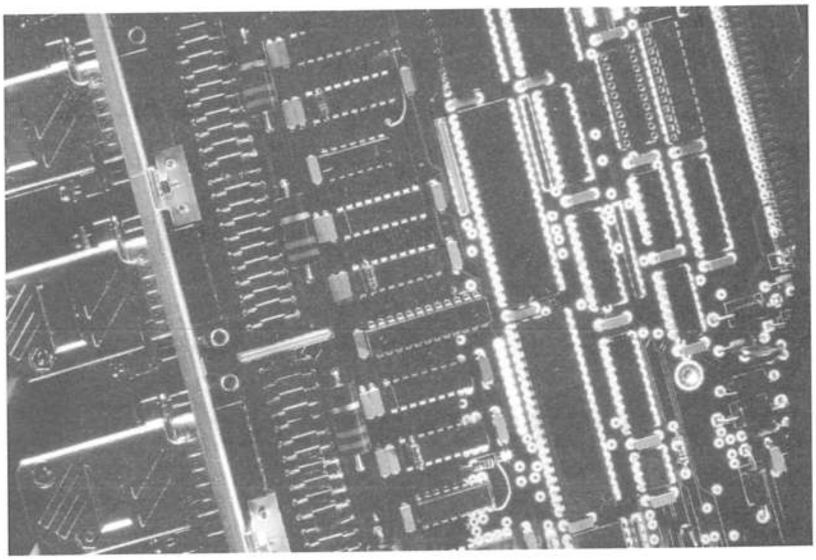
Assignments

1. Use Microsoft Access to create the output as given above. Use the data given in the table. Add your name and address to the member Table, using member ID 606.
2. Create a report that ranks, in descending order, the frequency of and drink type purchased.
   - You will need to create a sigma query.
   - Title the report frequency of food and drink ordered in June.
   - The headings should be as follows:
     Food and Drink Type; No. of times ordered.
   - Your report should look like the one given below:

Frequency of Food and Drink ordered in June	
Food and Drink Type	*No. of Times ordered*
Soft Drink	
Dinner	
Dessert	
Beer	

Chapter 7

Telecommunications and Computer Networks



Learning Objectives

After going through this chapter, you should be able to:

- Understand the conceptual model of communication
- Describe and differentiate among the most common types of data communication media
- Understand characteristics of data communication media and common types of hardware used in data communication
- Explain the different types of communication network architectures
- Identify and describe the most common applications of data communication

7.1 TELECOMMUNICATIONS

Telecommunication refers to the transmission of information from one point to another through a communication medium. In today's dynamic business environment, people, in order to perform their work activities and to compete successfully, need to communicate electronically within and outside the organisation. As a result, telecommunication takes on a significant role in an organisation. Sometimes, the term data communication, which is a narrow and specific term also refers to the transmission of data.

FOCUS

Telecommunication implies the transmission of information from one point to another through a communication medium.

A telecommunication system may be represented by way of a simple conceptual model as shown in Fig. 7.1.

The data source is the originator of information while data destination is the receiver of information. The channel is the path through which information is transmitted to the destination from the source. Before some information is sent through the communication channel, it is converted into coded symbols by a transmitter encoder, only to be decoded at the receiver's end by the receiver decoder. The encoded data is transmitted through the channel by an electronic signal or waveform.

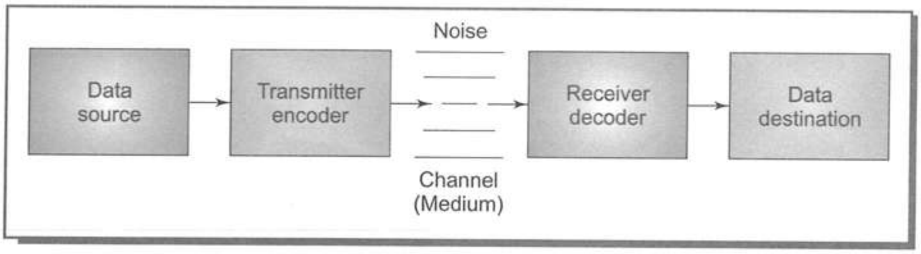


Fig. 7.1 A Conceptual Model of Communication System

7.2 TYPES OF SIGNALS

FOCUS

To connect computer-based information systems, two basic signals used are Analog and Digital.

To connect computer-based information systems, two basic types of signals are used. These are discussed below.

7.2.1 Analog Signals

These signals are continuous waves with no discontinuity or break in between. All the real world signals or natural signals like sound, pressure, temperature, etc., are analog in nature. To explain analog signals, let us take an example of a telephone conversation. When we speak on the telephone, the mouth-piece in the telephone set converts our voice or speech into analog electrical signals. These signals are then transmitted through the telephone lines to the called party, where these are converted back to the speech signals by the ear-piece in the telephone set.

An important feature of analog signals is that they can travel long distances but they get distorted by noise. Noise being another analog signal can affect the contents. Secondly, in long-distance travel, the strength of the signal starts decreasing. Signal strength is increased with the help of boosters. This, however, also increases the noise content.

7.2.2 Digital Signals

Digital signals are discrete on–off pulses, i.e. they represent information in terms of only two states of signals – either one (1) or zero (0). Any number has to be represented as a combination of ones and zeroes. These are called binary digits (bits). Digital transmission is preferred over analog signals because of its high quality. Digital signals are affected less by disturbances or noise and they can be repeatedly strengthened for long-distance transmission, without accumulating noise. Since digital signals in long-distance transmission are amplified, by first absorbing and then regenerating them at regular intervals, the noise signals, in the process, are completely eliminated. Figure 7.2 represents the two types of electronic signals.

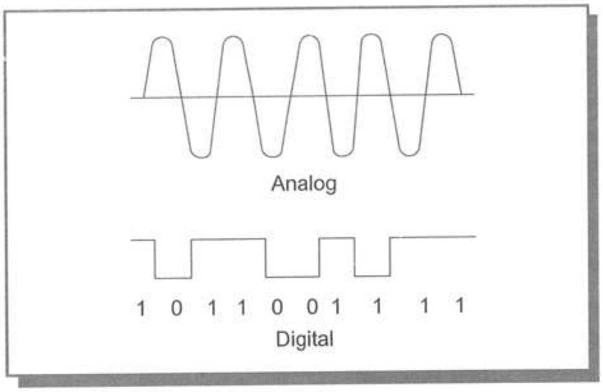


Fig. 7.2 Types of Electronic Signals

7.3 COMMUNICATION CHANNELS

To transport data from one location to another, some type of medium or channel is used. A wide variety of communication channels, known as lines, are used in data communication. The text below discusses these lines under two broad categories.

(i) Physical Connection Lines: This channel includes:
- (a) twisted-pair wires,
- (b) coaxial cables; and
- (c) fibre optic lines.

(ii) Wireless Lines: Communication channel under this category includes:
- (a) microwave,
- (b) satellite; and
- (c) radio.

FOCUS
Communication channels, known as lines, are used in data communication to transport data from one location to another.

7.3.1 Physical Connection Line

This is one of the commonly used channels for transferring data from one location to another. Data transfers take place over common twisted-pair of copper wires over coaxial cables or over glass fibre cables, all of which physically link the devices in data communications.

Twisted-pair Wire

This method is relatively inexpensive, widely-used and easy to implement. However, it is subject to electrical interferences. The ordinary telephone wire, which consists of copper wire twisted into pairs, is an example of twisted-pair wire.

Coaxial Cable

A coaxial cable is a copper or aluminium wire wrapped with spacers to insulate it. This cable can carry much more data and is less susceptible to electrical interference.

It is because of these features that the coaxial cable is also known as a high speed transmission cable. This is, however, is relatively more expensive and inflexible. It is about 15 times more costly than the twisted-pair cable. This cable is now being used in cable TV and for short distance connection of computers and peripheral devices.

Fibre-optic Cable

This cable consists of thousands of very thin (approximately half the diameter of a human hair) filaments of glass. Such a cable transmits data as beams of light as opposed to pulses of electricity. This cable is immune to electrical interferences and hence is more reliable. Besides providing speedy transmission and greater carrying capacity, this cable provides substantial size and weight reductions over coaxial cable. A half inch diameter fibre optic cable can carry upto 50,000 channels, as compared to about 5,500 channels for a standard coaxial cable. Its main disadvantage is the difficulty of splicing the cable to make connections. However, because of its obvious advantages, the fibre-optic cable is being used extensively in telephone networks, etc. The three types of communication cables are shown in Fig. 7.3.

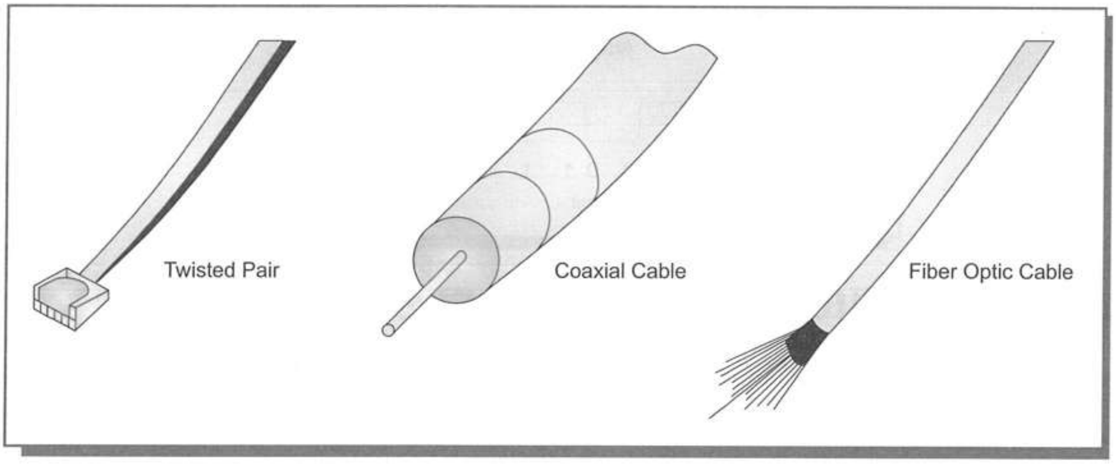


Fig. 7.3 Types of Communication Cables

7.3.2 Wireless Communications

Physical connection lines, which have already been discussed in the preceding text, have a fairly limited capacity. This limitation is overcome by another alternative of communication channel known as wireless communication. Let us briefly discuss the more common wireless lines.

Microwave

In the microwave channel, transmission is carried out by very high frequency radio waves in a 'line of sight' path. That is, these signals travel in a straight line through the air. Because of Earth's curvature and the fact that microwave transmission is in straight line this system requires a relay station, with a dish like antenna every 30 to 40 kilometres for the reception, amplification and transmission of data. To minimize line-of-sight problems, microwave antennas are usually placed on top of buildings or on specially constructed towers. Microwave transmission, despite its limitations, is still a popular medium for both long-distance and metropolitan area networks.

Satellite

This is another important data communication medium for microwave transmission. Satellites serve as relay stations for communication signals transmitted from earth stations. Satellites are launched by rockets to an orbit around the earth at a distance of approximately 35,000 kilometres over the equator. Once the satellite is put in its position, data in the form of microwave signals, can be beamed to it from an earth station. The satellite amplifies and retransmits the signals to some other earth stations that may be a great distance away. Today, there are many satellites from several countries in stationary (geo-synchronous) orbits.

Radio

No microwave or satellite links, especially for short ranges, are required for this channel of data communication. It is used to connect computers and peripheral equipment or computers and Local Area Networks (LANs). Though this channel, like other electromagnetic media, has all the advantages, it suffers from the limitation of being susceptible to electrical interference.

7.4 CHARACTERISTICS OF COMMUNICATION CHANNELS

FOCUS

The main characteristic of Communication channels: are Bandwidth, Synchronisation, Transmission Error Control, Transmission Modes

The following are the main characteristics of communication channels:

7.4.1 Bandwidth

The bandwidth of a communication channel indicates its capacity to transmit data. The capacity can be expressed in 'bits per second' (bps). This is sometimes referred to as the baud rate although baud is more correctly a measure of the speed of transmission. Channel capacity is categorised into three classes, namely:

Narrowband or Low Speed

In this bandwidth, data is transmitted in the range of 300 to 1200 bits per second. They are mainly used for low-speed terminals.

Voice Band or Medium Speed

This channel is the standard telephone line, one which allows transmission rates from 300 to 2400 bauds. However, dedicated lines can allow data transfer rates of up to 9600 bauds or more.

Broadband or High Speed

These channels allow transmission rates at specific intervals from 19,200 bps to several billion bps. Thus, when large volumes of data have to be transmitted at high speeds, a broadband channel is appropriate. Such capacities can be achieved with data transmission through coaxial cables, fibre-optic cables, microwaves and satellites.

7.4.2 Synchronisation

Data transmission can either be asynchronous or synchronous. Asynchronous transmission transmits one character at a time, with each character preceded by a start bit, followed by a stop bit. A synchronous transmission is inefficient because of the additional bits required for indicating start and stop, and an idle time between transmission of characters. It is, therefore, normally used for low-speed data transmissions at rates below 2400 bps.

In synchronous transmission, one group of characters is sent at a time. The start and end of a character is determined by a timing signal initiated by the sending device. Thus, it eliminates the need for the start and stop bits. However, the sender and receiver should be in perfect synchronisation to avoid any loss or gain of data. For this purpose, a unique pattern of bits and synchronised clocks are used. The unique pattern of bits is called sync bits and is generated automatically. Synchronous transmission is generally used for high-speed data transfers.

7.4.3 Transmission Error Control

A communication 'line' may be subject to noise, i.e. disturbances from storms, signals from other lines and interference from some other sources. This noise may cause errors in the data transmitted over the communication line, leading to data corruption. Thousands of bits travel over one line and the loss of even one of them may alter a character or control code. This necessitates accuracy controls for data transmission. These controls consist of bits known as parity bits that are similar to check sums added to data at the sending end of the line. Parity bits are checked at the receiving end to find whether bits were lost during data transmission. Errors once detected, may be rectified by taking two types of actions, namely backward error correction and forward error correction.

Backward Error Correction (BEC)

In this method the sender is requested to retransmit the entire data or a particular part, if it can be identified.

Forward Error Correction (FEC)

This technique makes use of the knowledge about the message stream and mathematical algorithms to allow the receiver to correct the received data without going back to the sender. BEC is simpler and less expensive when there are only a few errors or when the time delays are not critical. However, FEC is more complex but may be preferred over long distances when retransmissions are costly.

7.4.4 Transmission Modes

In communications, data can flow in three modes or directions: *Simplex Channel* uses one circuit in one direction only and thus allows data to be transmitted only in one direction, that is 'send only' or 'receive only', e.g. radio or TV broadcasting. This mode is rarely used.

A *half-duplex channel* also uses only one circuit but it is used in both the directions—one direction at a time. Thus, this channel allows data to be transmitted in either direction, but in only one direction at a time. To give response back to the source terminal, the line has to switch directions. For example, an intercom user can, at one point of time, either receive or transmit. This is usually used for low-speed terminals (PC communications). In full-duplex mode, two circuits are used for data transmission—one for each direction simultaneously, e.g. a telephone. The full-duplex mode is faster and more efficient but is expensive. This mode is generally used for mainframe connections. Figure 7.4 depicts the three types of transmission modes.

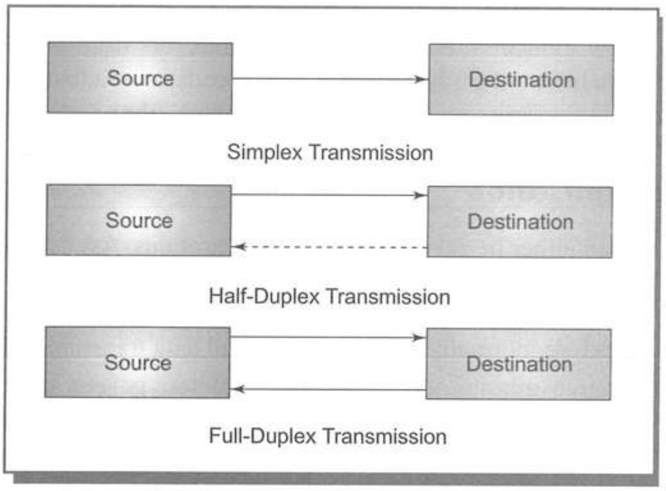


Fig. 7.4 Transmission Modes

7.5 COMMUNICATIONS HARDWARE

FOCUS

Communication Hardware is the most common equipment used in data communication and it includes modems, multiplexers, concentrators and front-end processors.

Having discussed data communication lines, it will be appropriate to discuss the interface between the computer and communication equipment, i.e. how to get onto the communication channel. The following text deals with the most common equipment used in data communication and its use, inclucing modems, multiplexers, concentrators and front-end processors.

7.5.1 Modems

Most of the communication systems, like public telephone systems, were designed to carry voice or sound signals in an analog format. To transmit digital information over this channel, it has to be first converted into an analog wave pattern. This conversion from digital to analog is known as modulation, and the reverse is demodulation. The device that modulates/demodulates is called a modem (see Fig. 7.5).

Modems are of two types:

(i) Internal modem, and

(ii) External modem.

An internal modem looks like a printed circuit board. Like other PCB-based devices such as a network interface card, an internal modem slips into a free slot within the PC. Since modem is plugged directly into the computer's motherboard and is powered by the system's power supply. This protects it from power fluctuations.

An external modem is a stand-alone device and has to be plugged both to a power point and to the computer.

Recently, a third type of modem, known as the software modem has also become a reality. The increasing power of microprocessors makes it possible to emulate a modem in the memory. So instead of the modem's processor

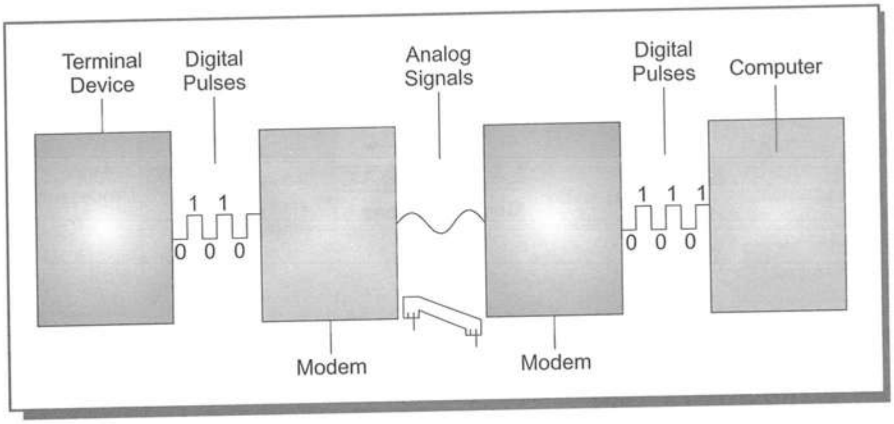


Fig. 7.5 Use of Modem with Analog Transmission

doing all the digital-to-analog and analog-to-digital processing, it is PC's microprocessor that does all the works based on instructions from the software. Since it does not involve any hardware components, software modems are relatively cheaper. On the flip side, the software modems consume a lot of computing power.

A modem does more than just transmitting and receiving digital data in the analog form. It also deals with errors that creep into the transmitted or received data, due to the noise the transmission networks suffer from. Since data travels in the analog form over the telephone line, it is susceptical to line disturbances, resulting in corruption. This is managed by the modem through a cyclic redundancy check. When modems transmit data, they do not send it over the wire in one continuous stream. The data is divided in small packets. The modem then runs a mathematical formula on the data packet and arrives at a figure known as the cyclic redundancy check (CRC) value. The CRC value is then suffixed to the data packet and the combined packet is finally transmitted. Upon reaching the destination, the receiving modem strips the CRC value from the packet and using the same algorithm, recalculates the CRC value. If data has been corrupted during the transmission, the two CRC values will not match and the receiving modem requests re-transmission of the data packet.

To work efficiently together, modems need to adhere to certain standards. These standards are generally known as 'V-dot' standards that tell the modems how to compress data, carry out error correction, and also at what speeds to operate. These standards are defined by the international telecommunications union (ITU). Nowadays modems are available with speeds of up to 56 kbps.

However, a modem is not required if the communication carrier is designed for digital transmission.

7.5.2 Multiplexers

A multiplexer is a communication electronic device that allows a single communication channel to carry data simultaneously from many terminals. Thus, a single communication line can be shared by a number of devices. The purpose of a multiplexer is to reduce the cost of data communication by making it more efficient. Generally, a multiplexer merges the transmission of several terminals at one end of a communication channel, while a similar unit separates the individual transmissions at the receiving end. There are several approaches to multiplexing. Three main approaches are listed below.

Frequency Division Multiplexing (FDM)

In this method, the multiplexer divides a high-speed channel into multiple low-speed channels by allocating different frequencies to different channels. However, FDM is now rarely used for general purpose data multiplexing because of its inefficiency and inflexibility.

Time Division Multiplexing (TDM)

In TDM, the multiplexer divides the time that each terminal can use on a high-speed line into very short time slots or time frames, i.e. the terminals can send or receive data only in their respective turns. In this technique, the data from one terminal is interleaved with data from another terminal. Figure 7.6 gives an interwoven data stream.

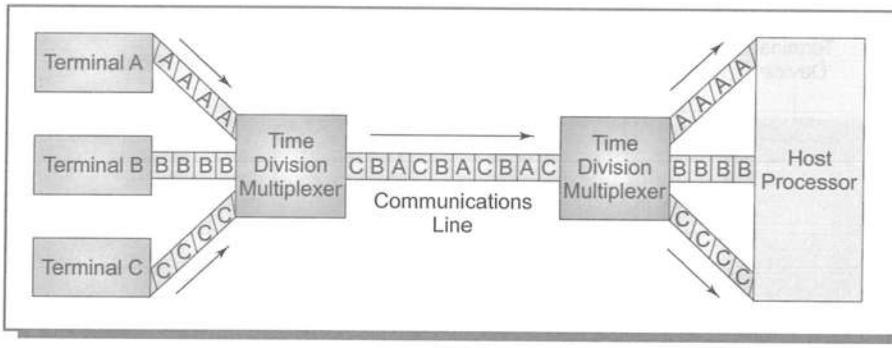


Fig. 7.6 Data Transmisison with TDM

Statistical Time Division Multiplexer (STDM)

An STDM determines which terminals currently want to send or transmit data and it serves only those terminals. Thus, in this method variable rather than fixed time slots are allotted to terminals, based on priorities. An STDM is illustrated in Fig. 7.7.

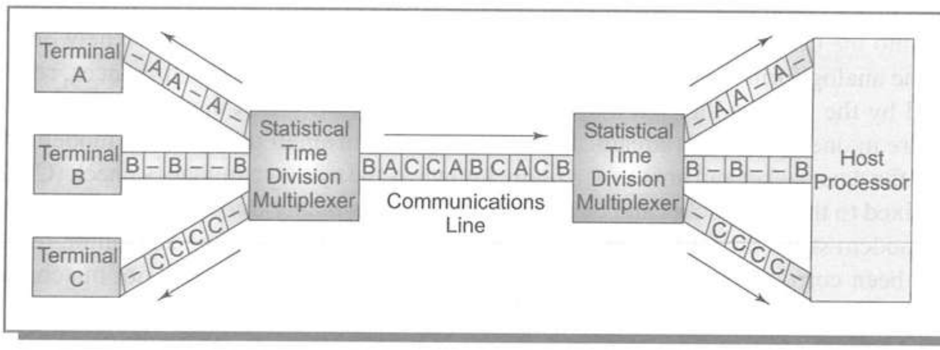


Fig. 7.7 Data Transmisison with STDM

Concentrator

A concentrator is also another data communications electronic device that helps in concentrating a set of terminals at one site. It has microprocessor intelligence, stored communication software and buffer storage. Thus, a concentrator can be called a small computer that performs a function similar to a multiplexer along with other functions related to validation of data, formatting of data, backup, etc.

7.5.3 Front-End Processors

A front-end processor is a specialised computer that is dedicated to handling the data communication control functions for a large computer system. These control functions include data coding and decoding, error detection and recovery, recording, processing and interpreting of control information, temporary buffer storage, etc. A front-end processor can poll remote terminals to determine if they have a message to send or are ready to receive a message. In addition, it has the responsibility of controlling access to the network, assigning priorities to messages, logging all data communication activity, computing statistics on network activity and re-routing messages among alternative communication links. Thus, a front-end processor can relieve the host computer of its data communication control functions and provide up to 30 per cent additional processing time. Figure 7.8 illustrates the use of a front-end processor.

7.6 COMMUNICATION NETWORKS

FOCUS

A communication network is required to connect a central computer to remote devices and a computer in one location to a computer in some other location, within or outside an organisation.

An information system may consist of a self-contained and stand-alone computer with no data communications, however in many cases the information system is a network of terminals or other devices interconnected by a communication network. A communication network is required to connect a central computer to remote devices

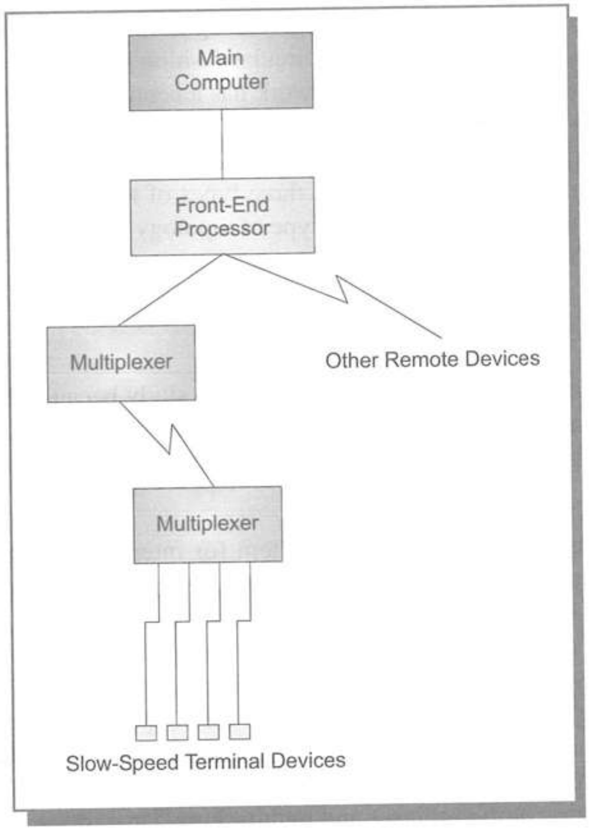


Fig. 7.8 Use of Front-End Communication Processor

and a computer in one location to a computer in some other location, within or outside an organisation. Depending mainly on the applications and geographical locations to be supported, a network can be configured (designed) in many different ways. The common network architectures or topologies, the main types of networks in terms of scope and common network processing arrangements are discussed in the following text.

7.6.1 Network Topology

This is the physical and logical arrangement of its parts, relative to one another. Each part is termed as a node, which is any device on the network that can accept and redirect a message. Thus, a node may be a computer, a multiplexer or a terminal controller. Nodes are connected to each other by links. Links can be telephone lines, private lines, satellite channels, etc. Thus, a network topology can be viewed as an architectural design of the communication links between nodes. There are three common network topologies, namely, bus, ring, and star (see Fig. 7.9).

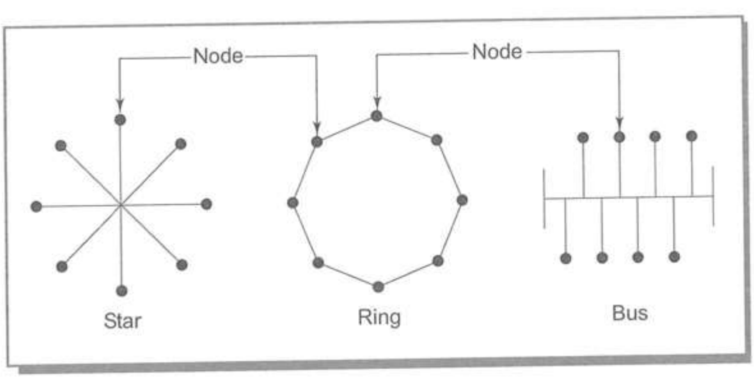


Fig. 7.9 Three Networks for Data Communications

A bus network is a network in which nodes are arranged along a single length of cable that can be extended at the ends. In the ring network, nodes are organised in a circular fashion. In this network, transmission takes place from one node to another in a given direction. A star network has a central node that connects to each of the other nodes by a single, point-to-point link. Thus, in a star topology, all messages pass through the central computer from where they are switched to the desired node. This process of switching messages from the central node to its respective node is known as message switching. The three types of topologies have their own advantages and disadvantages. However, an organisation can decide one type of topology or the other, based on its processing needs and performance issues – like delay, throughput, reliability, etc.

7.6.2 Network Scope

The scope of data communication network is an important topic to study because the users' need to communicate differs from short distances to long distances. On the basis of network scope, data communications can be termed as local area network or wide area network. Let us briefly discuss each of the networks.

Local Area Networks

A local area network (LAN) is a data communication system for interconnecting two or more communicating devices within one to two kilometres. The devices can range from a large mainframe system to personal computers and peripherals. A local area network is designed using high capacity lines, such as coaxial cables. However, if the cable is long, electronic devices are attached to keep signals strong and clear. A LAN allows a large number of devices to share organisational resources like storage devices, printers, programs and data files. Besides, a LAN also integrates a wide range of functions into a single system. Figure 7.10 depicts a typical local area network consisting of terminals and servers. A server on the network provides a specific service like file storage and access facility, external communication facility and printing facility, for all terminals connected to the LAN. The terminal may be a personal computer or a workstation with multiuser and multitasking capabilities.

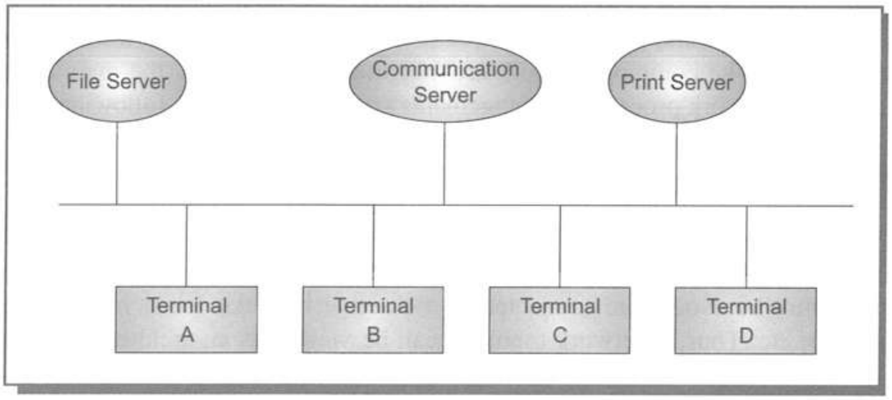


Fig. 7.10 A Typical Local Area Network

The common proprietary designs for constructing a LAN include Ethernet (Xerox), Decnet (Digital Equipment), Hyper Channel (Network Systems Corporation) and IEEE 802.3, etc. Another alternative to the LAN is the private automatic branch exchange (PABX) which acts as a central switch board to connect devices that need to communicate. In integrated services digital networks (ISDN), a PABX integrates data and voice.

Wide Area Networks

A wide area network (WAN), in contrast to a LAN, provides communication over long distances. A WAN may be spread over a city, a region, a nation or the entire world and may include regional networks provided by telephone department or international networks managed by global communication service providers. A quite popular WAN, which is increasingly being used by businesses is the Internet (see the latter part of this chapter).

Sometimes besides using LAN and WAN, another term called MAN is also used, MAN stands for metropolitan area network, which is a hybrid of the two.

7.6.3 Distributed Data Processing Networks

In distributed data processing networks, a number of geographically dispersed independent computers are connected by telecommunication networks. Thus, in distributed processing, information processing is accomplished by a network of computers interconnected by data communication links instead of depending on a centralised processing approach. The latter relies on one large central computer or on a decentralised processing approach, which involves completely independent user computers with their own databases, programs, applications, etc. The objective of distributed data processing is to provide to the end user, at his own location, all the required data to him as well as the requisite computing and communication resources. Distributed computers may be arranged in a hierarchy or in a ring. Figure 7.11 gives a hierarchy of processors.

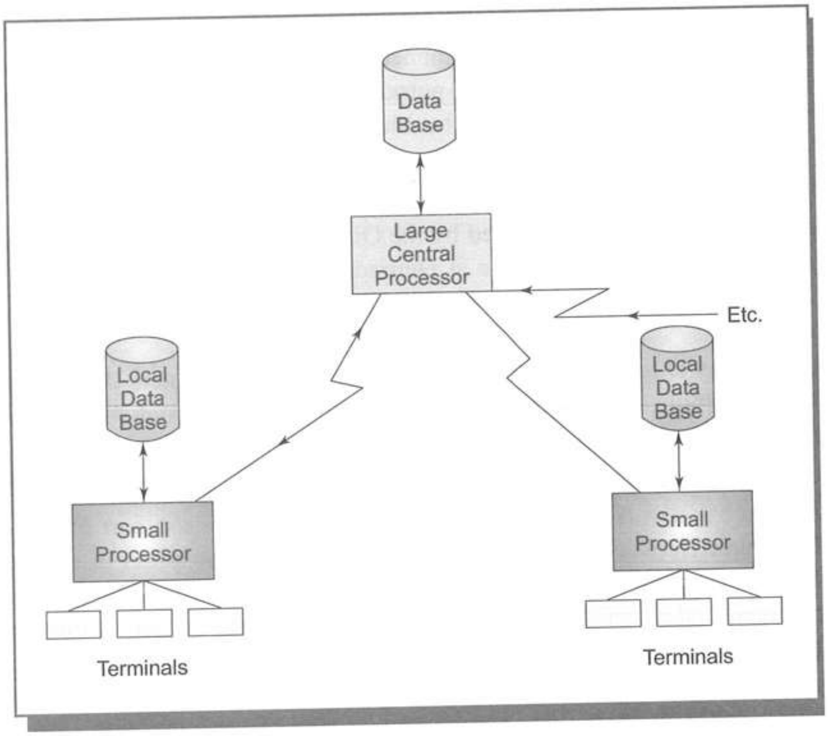


Fig. 7.11 Distributed Database Using Hierarchy of Processors

7.6.4 Protocols

A standard set of rules and procedures for the control of communications in a network is known as a protocol. Though it is obvious that different computers using different operating systems should have a common communication protocol to facilitate data communication, many competing and incompatible protocols are also in use today. Efforts are being made to develop a common communication protocol that will facilitate different computers to communicate with each other. Some of the important standards that are being used today are described in the following section.

Open System Interconnect (OSI)

This model has been developed by International Standards Organisation for linking different types of computers and networks, and serves as a standard for network architecture. The OSI model is a seven-layer system that divides the telecommunication process into seven layers, where each layer deals with a specific aspect of the communication process. The OSI, being a multilayer protocol, has the advantage of having each layer independent of the others. Thus, any layer can be changed without affecting the other layers.

Transmission Control Protocol/Internet Protocol (TCP/IP)

This model was developed by the US department of defence for connecting different types of computers.

Integrated Service Digital Network (ISDN)

This protocol has been developed for transmitting digital data over public switched networks.

7.7 COMPUTER NETWORKS IN INDIA

A number of computer networks have been planned in India and are at various stages of execution. These are mentioned below.

(i) *RAILNET* is a country-wide computer network that is organised by Indian Railways with large computers at each of its nine zonal railway headquarters and one at the Railway Board at Delhi. This computer network is being used for commercial and production activities of Indian Railways.

(ii) *NICNET* is a National Informatics Centre Network, which is organised by National Informatics Centre, Delhi. The host computer is a cyber computer which is connected to NEC computers at various places in India like Pune, Hyderabad, Bhubaneshwar, etc. Its main purpose is to collect first hand information at the district level for centre and state sectors, e.g. agriculture, health, education, etc.

(iii) *EDUNET* is organised by Tata Institute of Fundamental Research, Mumbai, for academic institutions and centres of excellence in educational computing.

(iv) *OILNET* is a computer network that has been organised by the Oil and Natural Gas Commission (ONGC) with IBM 3083 supercomputer as the host computer at Dehradun and EC-1061 computers at Baroda, Calcutta and Nazira (Jorhat). This network has been developed primarily for seismic exploration, well-logging and reservoir modelling.

(v) *POLICENET* has been organised by Directorate of Co-ordination of Police Computers (DCPC) with TDC-316 computers in many states of India. The network is used for crime-criminal statistical system, finger print system, arms licensing system and vehicle licensing system.

(vi) *BANKNET* has been developed among Indian banks for banking applications and electronic fund transfers.

(vii) *ERNET* (Education and Research Network) is a network that has been set up as a part of the Advanced Technology Program in Computer Networking (ATPCN) initiated under the auspices of the Department of Electronics, Govt. of India and UNDP (United Nations Development Program). The objective of this network was to set up an academic and research network in India and to promote communication networking research and training. The initial participation in this venture was of five IITs, IISc, NCST and DOE. ERNET is a packet-switching computer communications network that uses the Internet Protocols and is fully interconnected with the Worldwide Web. The network can be viewed as comprising a backbone that interconnects the eight core nodes listed above.

7.7.1 Internet

The internet, which is the world's largest computer network, is termed as a network of networks and is often described as the prototype for a worldwide information 'superhighway'. The word 'Internet' has been coined from the words, 'Interconnections' and 'Networks'. The Internet was born in 1969, out of efforts to connect together a US Defence Department network called the ARPAnet (Advanced Research Projects Agency Network) and various other radio and satellite networks. In order to share information, researchers and scientists from universities and research laboratories developed the interconnection of their computers and over time, the internet has grew a global resource. The internet has became explosively in the 1990s. It is composed of over 30,000 connected networks from more than 100 countries.

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Popularity of Internet

The popularity of internet can be attributed to the reason that people around the world can routinely send and receive e-mail over the internet at a low cost and there is something for all ages on the internet from music, videos, comics, to medical encyclopaedias and the latest in sports and world news.

Internet Ownership

No one owns the internet, rather every person who makes a connection, every group whose Local Area Network (LAN) becomes connected, owns a slice of the Internet. Thus, while no one person or entity owns the Internet, all who use it or supply materials for it, play a part in its existence.

Internet Connectivity

There are many ways to connect to the internet. But there are two main types of internet connections, one through satellite that is also known as true direct network IP connection and the other through telephone lines, (also called Dial-up or 'virtual' direct network IP connection).

Connectivity Through Satellite

A person would be using this type of Internet access if his computer (or LAN) is directly connected to a host computer via a dedicated high-speed line (e.g. frame relay or T-1), rather than via a modern. The host computer is directly connected to the Internet using TCP/IP protocols. The advantages of this type of set-up are that many computers can access the Internet simultaneously via a single highspeed line, the data transmission is very fast, and the computers can run user-friendly (i.e. graphical user interface or GUI) software (e.g. Netscape and Fetch). The disadvantages are primarily cost and maintenance. This is the preferred type of connection for teachers wishing to connect an entire networked computer lab to the internet.

Connectivity Through Telephone Lines

In order to use a modem to establish a direct IP connection, one must have two types of system software installed on one's Macintosh computer's hard drive, TCP/IP (e.g. MacTCP, version 2.06 or later) and the other has to either SLIP or PPP. These two pieces of software will need to be configured to connect you to a host computer that provides SLIP or PPP access. One should check with the local internet service provider for specific details about getting a SLIP or PPP account. The advantages of this type of access are that one can run user-friendly software on one's computer and no special hardware (other than a high-speed modem) is required. The disadvantages are that high-speed modems (9600 bps to 28.8 kbps) are much slower than direct highspeed lines, and some Internet providers charge a premium fee for this type of Internet connection. In addition, it is not feasible to connect an entire classroom of networked computers in this manner because each computer would need its own modem and a dedicated phone line. This is the preferred type of connection for individuals wishing to run Netscape from a single computer.

Internet Protocol

Protocols are rules that allow co-operating computers to share resources or understand each other across a network. The various protocols are sets of technical specifications that "let computers exchange information, no matter what kind of computers they are, or what kind of technology hooks them together".

TCP/IP

Transmission Control Protocol/Internet Protocol is a set of protocols developed to allow co-operating computers to share resources across the network. It was developed by a community of researchers centred around the ARPANET. TCP/IP is a family of protocols and it is common to use TCP/IP to refer to the whole family. TCP, IP and UDP are a few that provide the low-level functions needed for many applications. The others are for doing specific tasks, e.g. transferring files between computers and sending mails, etc.

TCP/IP is built on a connection-less technology. Information is transferred as a sequence of 'datagrams' (packets). A datagram is a collection of data that is sent as a single message. The term datagram and packet seem to be nearly interchangeable. Technically, datagram is the right word when describing TCP/IP. A datagram is a unit of data, which is what the protocol deals with and a packet is a physical thing, appearing on an ethernet or a wire. In most cases a packet contains a datagram.

TCP is responsible for breaking up the message in datagrams, reassembling them at the other end, resending anything that gets lost and putting things back in the right order. TCP also has to know which connection this datagram is a part of. This process is referred to as demultiplexing. In fact, several levels of demultiplexing operate in TCP/IP.

Internet Capabilities

Given below is a brief discussion of internet capabilities.

E-mail (Electronic Mail)

E-mail is the oldest and the most widely used application on the Internet. As the name implies, electronic mail, popularly called E-mail is the sending messages through computer terminals instead of physically delivering mail. For sending an electronic mail message, the sender inputs the message at a terminal with the address of the intended recipient. The system then transmits the message to the receiver's terminal from where the receiver may read the message, print it, file it, edit it or pass it on to other users. An E-mail can be simultaneously sent to many persons. It eliminates time delays and other problems associated with physical mail. As a message transmitted via E-mail can be stored, the recipient need not be physically present at the time of sending the message.

It is called E-mail because it is similar to the paper mail that the postal service delivers. An E-mail has the following disadnantages:

- You can put it into an electronic envelope and address it.
- You hand the message off to someone else to be delivered.
- You do not know when the E-mail is read.
- If the address is incorrect, you get it back.
- If the recipient leaves a forwarding address, the E-mail system will keep trying to route it to him/her until it runs out of forwarding locations.
- Anyone who knows your address can send an E-mail to you.
- Commercial companies can send you advertising or 'junk mail'.
- If you go on vacation, your mailbox can fill-up.

E-mail address is used to identify a person and a computer for purposes of exchanging electronic mail messages.

Every E-mail address has three parts:

(i) A user name,

(ii) an 'at' sign @, and

(iii) the Address of user mail server.

Example: dharam@pbi.ernet.in

where dharam is the user name and 'pbi.ernet.in' is the mail server's address.

World Wide Web

The World Wide Web, more commonly known as the Web or W3 is an Internet retrieval tool. It helps you to search information using links to other WWW pages. Web links are stored within the page itself and when you wish to 'jump' to the page that is linked, you select the 'hotspot' or 'anchor'. This technique is also called Hypermedia or Hypertext.

Gopher

Gopher was developed at the University of Minnesota. It is a menu-driven utility that allows the user to hop around the globe looking for information in various information libraries or servers. Thousands of specialised libraries are interconnected and make up what is called 'Gopher space'. While an Archie tells you where a particular information lies, a Gopher actually goes out, gets the information that you want and puts the information on your computer screen.

Archie

An Archie is a utility that searches through hundreds of different anonymous FTP sites and tells you where all of the files that you want are located.

An Archie is actually a collection of servers. Each of these servers is responsible for keeping track of file locations in several different anonymous FTP sites. All of the Archie servers talk to each other and pool their information in a huge, global database that is periodically updated.

Nowadays, a number of new tools, also known as search engines, like Altavista, Excite, Lycos. Infoseek, Yahoo, Google Webcrawler, etc., have been developed that enable information available on the Web to be searched more effectively.

Remote Login (Telnet)

Telnet is a utility which allows the user to log-in to another system and use various services available on that host. You can Telnet into huge databases to research or even Telnet into other libraries around the world to check if they have a certain book that you are looking for.

Telnet also offers an easy entry into the world of Gophers and the World Wide Web for those people who may have access to these tools.

File Transfer Protocol (FTP)

File Transfer Protocol (FTP) is a tool, as the name suggests, to copy files from one computer to another. Hundreds of software suites connected to the Internet have file libraries, or archives, accessible to the public. One can copy these files, if required. There are libraries of documents as well. You can get a copy of a recent US Supreme Court decision, copies of historical documents, song lyrics, poems and even summaries of events.

Usenet News Groups

While an E-mail lets you send a message to a specific person or a group, usenet lets you send a message on an electronic bulletin board for anyone to see. Usenet is the international meeting place, where people gather to meet their friends, discuss the day's events, keep up with computer trends or talk about whatever is in their minds. The basic building block of Usenet is the news group, which is a collection of messages with a related theme. Over 10,000 such news groups exist on almost any conceivable topic.

Wide Area Information Servers (WAIS)

The WAIS, which was developed by M/s Thinking Machines, scans Internet libraries. It is another solution for handling the problem of searching files around the world. It returns a master index, which provides links to all the sites related to your request. The index is weighted by identifying which links are most closely related to the topic.

E-commerce

Electronic commerce (E-commerce) is the general term used for a buying and selling process, which is carried out electronically. In this process the selling companies describe their products and services on the net, which can then be searched by prospective customers and orders may be placed by the buyers using their credit cards. The product is then delivered physically to the buyer. Software can be directly sent, electronically to the computer of the customer.

7.7.2 Intranet

Intranet, which is an important application of the Internet, is a network designed to deliver internal information over the local area network. It uses Internet technology. Intranet generally consists of internal corporate web servers, which use the corporate databases. When accessed by employees across the LAN or through private dial up, it provides diverse kinds of information.

> FOCUS: Intranet, which is an important application of the Internet, is a network designed to deliver internal information over the local area network

Today, intranet has become very popular in organisations. Most of the companies already had LANs in place. Effectively, this meant that all the required hardware was already up and running. The only additional requirement to run an intranet was the applications and a bit of standardisation. Since intranets employ exactly the same technologies used on the Internet and with the incredible growth experienced by the Internet itself, applications were available in abundance. Today, new versions of applications (like word processors, spreadsheets, database programs) have built-in Internet and thereby intranet capabilities.

The Internet and intranets can be called identical twins as both use the same technology, the same applications and the same concepts. However, there are subtle differences between the two. The biggest difference is the issue of bandwidth. The Internet typically uses 28.8 kbps dialup modems, 64 kbps/128 kbps ISDN, and leased lines or 1.5 mbps T1 lines. Therefore, the design of the network needs to include this bandwidth factor; whereas the intranets have more than enough bandwidth available to them. Even the slowest LAN today claims to have 10 mbps ethernet speeds, while more modern LANs offer 100 mbps and even faster speeds. The other differences are, of course, accessibility and security. The Internet is an open environment where anything stored there is essentially for public use. Intranet-based information, on the other hand, is secure and is contained within the organisation.

7.7.3 Issue of Internet Security

Security was not a priority for the original designers of Internet protocols. Networks were assumed to be either private, isolated and physically secure, or else completely public. This assumption is no longer true because of the growing commercial use of the Internet; a considerable amount of private information is now being sent over public networks. Cryptographic techniques have been developed to keep this traffic secure. However, many of the implementations are proprietary and require the two parties to use the same software. A number of standards have been proposed that would allow different systems to exchange secure data over the internet.

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Security was not a priority for the original designers of Internet protocols.

Possible Controls

The security of a computer network has the following three aspects:

(i) Authentication,

(ii) Authorisation, and

(iii) Privacy.

Authentication

The main purpose of authentication is to verify the identity of the person using a service, though it can also be used to prove the identity of the service to the user. The required level of proof will vary depending upon the nature of the service, but will usually be based on one or more of the following:

What you know? (for example a username and password)

What you have? (a smartcard or some other token)

What you are? (fingerprints, retinal scan, etc.)

Most security systems require a combination of at least two of these forms of proof: many tokens require that a password be entered to unlock them. This protects against accidental loss or theft of a token, but cannot prevent deliberate deception where a registered user hands over his identity to another person. Users should always be warned against doing this. For the most secure information, however, expensive biometric techniques may be necessary.

Any authentication method that is transmitted across a public network may be recorded by any third party with access to the network. If this person can later use the recorded transaction as his own 'authentication', then the method is of little value. These 'reply' attacks can be prevented by ensuring that the credentials exchanged across the network are different for every transaction, either by using one-time passwords or by encrypting each transaction with a unique key. A further danger of replay attacks is that, unlike the loss of a physical token, the theft may go unnoticed by the rightful owner.

Methods which prevent replay attacks are known as 'strong authentication' and can be divided into three classes:

(a) Shared Sequence,

(b) Challenge/Response; and

(c) Asymmetric Key.

(a) In shared sequence methods, the user and the service, both, have access to a sequence of passwords, which are in turn used to authenticate the user. The sequence may be printed as a list or be generated on demand by a dedicated calculator or program. Once used, each password is invalidated so a replay attack is bound to fail. The best known of these methods is Bellcore's S/key, which has been implemented on both hardware tokens and general purpose computers.

(b) In challenge/response systems, the service issues a challenge string, which should be different for every transaction. The user then responds with a combination of the challenge and his own password. The operation used to form the response is a message digest function, designed to make it virtually impossible to reconstruct the password from the response. Replay attacks will fail because the response is only valid for the particular challenge issued. The digest authentication scheme included in version 1.1 of the Hypertext Transfer Protocol uses challenge/response as do commercial systems such as CryptoCARD and Digital Pathways' SecureNet.

(c) Asymmetric key systems use pairs of numbers with the property that a message encrypted using one of the pains can only be decrypted using the other. If every user has his own pair, one of which is widely publicised (the public key) while the other is known only to him (the private key), these can then be used to authenticate the user. If a service receives a message which correctly decrypts using someone's public key, it can be virtually certain that it was encrypted using the private key. Similarly, a service which encrypts its replies with the user's public key can be confident that they can only be read by using the corresponding private key. The best known implementation of these methods is PGP (Pretty Good Privacy), now freely available as software for most platforms.

Authorisation

Once a user has proved his identity, the service must check whether that person is allowed to perform the operation which he has requested. This authorisation is normally done within the service machine by checking against a list of registered users and their access rights. For some services, however, it may be necessary for the lists of users and their rights to be maintained by the users' own institution, rather than the provider of the service. This might apply to where an institution has paid for a license to use the service and needs to control which users have access to it.

A sccure protocol is then needed for the service to query an authorisation server at the institution. A single service may have different areas of information, for example different datasets, each of which have a different group of authorised users.

This means that the request for authorisation must include details of the information being requested for by the user, not just the identity of the service involved.

The simplest approach would be to combine the functions of the authorisation and authentication servers at the institution and only issue authentication information to those services for which the user is authorised. However, this requires that each authentication server acts as a Certificate Authority. It also means that the same authentication information cannot be used for signatures and electronic mail, since requests to validate signatures may come from any host on the Internet.

Privacy

The Internet carries an increasing amount of private traffic. This may be personal information about the user or information of commercial value. Whether the messages contain credit card details, purchased software or examination marks, their owners need to keep all of them secret. Unfortunately messages can be read off the network as easily as usernames and passwords, so the only solution is to encrypt them. It is important to note that any mathematical encryption scheme can be broken by the use of sufficient computing power, the best that can be hoped for is to make the cost in time and CPU power needed to break the code significantly greater than the value of the encrypted material.

If an authentication process occurs before a user gains access to a service, it may be possible to use information gained during authentication to encrypt the subsequent traffic. This requires care to ensure that only the intended user can decrypt the traffic, it is, therefore, most suited to asymmetric key methods. If the server issues a public key as proof of its identity, this key may be used to negotiate an encryption method for the subsequent session. This may also be done in reverse if the server knows the user's public key. Asymmetric key systems require too much calculation to be used directly to encrypt the whole session; the usual method is to choose a random symmetric key for the session and exchange this securely using the asymmetric keys. If neither of the parties have been authenticated, then it is still possible to agree to a session key, however this provides no protection against clients or servers obtaining information by deceit.

Internet protocols are based on nesting different layers of information, so there is always a choice of the layer to which it can apply encryption. One approach is to encrypt at the Transport Layer, leaving un-encoded only the information required to route packets to their destination. The network simply transfers the packets between the two endpoints, which are the only machines capable of making any sense of the information. The encryption occurs below the level where different services (WWW, E-mail, FTP, etc.) are distinguished, so can be used equally-well by any of them. Transport layer encryption is used by Netscape's Secure Socket Layer (SSL) protocol, also known as TLS, and is proposed as an option for the new version of the Internet Protocol itself, IPv6.

While it seems attractive to apply a single encryption method to all Internet Services, some services benefit from specific operations performed by intermediate systems. For example, mailbagging reduces the bandwidth required to send multiple copies of electronic mail messages to distant sites, FTP requests may be re-directed to local mirror sites and web requests may be serviced by caches rather than the original servers. Each of these operations require that some intermediate machine is able to read the request contained within a packet, which is impossible with transport layer encryption. The alternative is to encrypt at the application layer, leaving the useful header information readable but encrypting the content. The most popular system for encryption at this level is Pretty Good Privacy (PGP) which is widely used for E-mail and FTP, and is one of the options supported by the proposed Secure HTTP (SHTTP).

Given below are some general tips for Internet privacy.

(i) Choose a pass phrase that is hard to guess. Do not use English words. The best pass phrases contain non-alphanumeric and both capital and small letters.

(ii) Change your password regularly. Do not use the same one on multiple accounts. Do not store your pass phrase in your Internet account. And do not share it or write it.

(iii) If you use Telnet remote access capability to get your Internet account from a public place, change it as soon as is practical afterward.

(iv) Do not give out personal information to strangers on the Internet.

(v) Do not save sensitive files in your Internet account.

(vi) As electronic-mail are just like postcards do not use unencrypted E-mail to send, receive or store messages you want to keep private.

(vii) Don't walk away from your computer with your E-mail window open.

(viii) Review your electronic messages carefully before you send them.

(ix) Don't send your credit card number or bank account number unencrypted over E-mail.

7.8 APPLICATIONS OF TELECOMMUNICATIONS

There is a wide variety of communication applications that provide invaluable services to the organisations and their users. Figure 7.12 lists the major categories and types of applications supported by communications. Some of the most prevalent applications are electronic mail, facsimile (fax), video teleconferencing, electronic data interchange, electronic fund transfer, etc., which are discussed in the following text.

Voice Communication	Data Communication
Standard telephone service	Online transaction processing
Voice response systems	Inquiry/response systems
Audio conferencing systems	Hardware and software sharing
Voice mail	File and database transfers
Voice recognition	Cooperative processing
Public address systems	Electronic funds transfer systems
Intercom systems	Point of sale systems
Electronic Document interchange	
Text and Messaging Communications	*Information Retrieval*
Electronic mail	Bibliographic search services
Computer conferencing systems	News and economic database services
Electronic bulletin boards	Videotex
Multimedia document interchange	
Teletype systems	
Image Transmission	*Monitoring and Control*
Image processing	Process control systems
Equipment monitoring	Security surveillance
Facsimile	Card-key security systems
Closed circuit television	Hospital patient monitoring
Video teleconferencing	Energy management
Electronic meeting systems	

Source: Ralph Sprague and Barbara McNurlin (eds.), *Information Systems Management in Practice*, Englewood Cliffs. N.J., Prentice-Hall, 1986, p. 142.

Fig. 7.12 Applications of Telecommunications

Facsimile

Facsimile, popularly known as Fax, allows a user to transmit images of documents over communication links. this can also be called long-distance copying. Generally, a fax machine at a location transmits to a fax machine at another location, with both units connected to high-speed internal modems.

Video-conferencing

This technique allows two or more persons to have 'face-to-face' communication with a group separated by long distances. Videoconferencing, which is a multiple-input television session, facilitates meetings and conferences without the need to travel and saves time and money.

Electronic Data Interchange (EDI)

It involves the electronic transmission of routine business transactions data directly between the computer systems of different organisations doing business with each other. In EDI, formatted documents are transmitted over communication links directly between computers, without paper documents or manual data entry. Thus, EDI helps in providing faster, consistent and complete information to organisations.

Electronic Funds Transfer (EFT)

Nowadays, electronic funds transfer is widely used in the banking industry. It is a very fast technique for capturing and processing cash and credit transfers between businesses and customers. EFT eliminates delays associated with sending hard copy documents. However, security being a serious issue with EFT, it should be used with utmost care and precautions.

SUMMARY

An understanding of data communication is very important in the design of many information systems. Data communication refers to the means and methods of exchanging data between various types of terminals and the main computers, which are separated geographically. Data may be transmitted from one place to another in the form of signals, which may be of two types, i.e. analog or digital. These signals pass over a variety of communication media, commonly called communication lines. Broadly, data communication lines can be classified into two categories, namely, physical connection lines, and wireless transmission lines. Physical connection lines include twisted-pair wires, coaxial cables and fibre optic lines, whereas wireless transmission lines include microwave, satellite and radio. Data transmission may have any one or a combination of more than one communication lines. One data communication channel may be selected over the other on the basis of data communication needs and the features of the data communication channel. Important characteristics of data communication channel include bandwidth, synchronisation, transmission mode, transmission error control, etc. To communicate data, a medium alone is not sufficient, rather a wide variety of communication hardware is also necessary. Some of the commonly used communication hardware are modems, multiplexers, concentrators, front-end processors, etc.

It is mainly depending mainly on the applications and geographical locations to be supported that a communication network is designed. A communication network, which may be viewed as an architectural design of the communication links between various nodes, can have different types of designs or architectures. The communication architectures are known as communication topologies. The commonly used network topologies are bus, ring, and star. On the basis of the scope for the network, data communication network is basically of two types, i.e. Local Area Networks (LAN) and Wide Area Networks (WAN). Distributed data processing networks are a recent development, in which a large number of geographically separated independent computers are linked by communication networks. A protocol establishes a set of rules and procedures for the control of communications in a network. International Standards Organisation (ISO) is trying to develop common protocols to facilitate communication of different computers with each other. Today, a wide variety of applications of communication are in use. Electronic mail, facsimile (fax), electronic fund transfer, etc. can be called as some of the important data communication applications.

REVIEW QUESTIONS

1. Elaborate the concept of data communications. Describe the two main types of data transmission media.
2. Define the following terms:
   (a) Analog signal
   (b) Digital transmission
   (c) Communication satellite line
   (d) Voice band.
3. Define and contrast the following terms:
   (a) Multiplexer and concentrator
   (b) Front-end and Main computer
   (c) LAN and WAN
   (d) Star and Ring network
   (e) Simplex and Duplex transmissions.
4. What is meant by network topology? Discuss the common network topologies.
5. Discuss the concept of distributed data processing. List the various applications of data communications.
6. What is bandwidth and why is it important? What are the two types of data transmission synchronisations and how are they different? What is data communication protocol?
7. Discuss data communication hardware. What purpose do modems serve? What is a multiplexer and why is it used?
8. Briefly discuss Electronic Mail, Facsimile, Video Conferencing, Electronic Data Interchange and Electronic Fund Transfer.

ASSIGNMENTS

1. Suppose you have been asked to recommend a network topology for your university network. Suggest the most optimum network topology for individual departments and for the whole of the university. Justify the network topologies you have recommended.
2. Suggest a transmission medium for:
   (a) University network
   (b) Banking network.
   Prepare a chart, giving advantages, disadvantages and approximate cost required for the proposed media. Also discuss the kind of communication applications the network will be able to handle.

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CASE STUDY 1

NETWORKING AT A TECHNOLOGY INSTITUTE

Objectives of Networking

The objectives of networking at Technology Institute (TI) (real name has been disguised) may broadly be divided into the following two categories:

1. **Academic** This includes faculty and students using the network for instructional and research purposes and also includes access to the library catalog and database searches.
2. **NonAcademic** This itself can be split into two somewhat inter-dependent subcategories.
   (i) **Internal Usage** This includes computerising and linking all sections, including administration, accounts, academic records, stores, hostel units and the hospital, thereby facilitating all internal transactions and interactions.
   (ii) **External Interface** The TI network can also help the institute in various interactions with the outside world, including sister campuses, corporate institutions, vendors and ordinary visitors. There is also a potential to generate revenue by:
      (a) making available services to the rest of the world using the TI network.
      (b) acting as consultants to other organisations involved in setting up such networks. Once the networking is complete, one would be able to access all online resources, including departmental computers, the library system and the institute administration system.

Current Status

Today, TI has eight academic departments (computer science, electrical, mechanical, aeronautical, metallurgical, humanities, chemical and chemistry) on the TI network (and hence are nodes on the INTERNET) in addition to the library and various administrative sections (accounts, cash, dean R&D, academic, administration). Five more departments and centres (civil, physics, mathematics, RSIC and ACRE) will be online within the next few weeks. This would leave only a few academic centres (like biotech, earth sciences) and some nonacademic areas (hostel, hospital) that would remain to be hooked on to the TI network.

Typically, these departments have first set up a departmental LAN and then have connected to the TI backbone after being allotted IP addresses by ERNET. Given below is the survey of the current scene in terms of the hardware used and the system software.

Networking Technology

Ethernet is the obvious choice for most departments. For historical reasons, there do exist one or two ARCNET segments in the mechanical engineering department and parts of the main building (administration), but even these are expected to be phased out soon.

The TI backbone (thick Ethernet) runs close enough for most departments to hook on to. Within departments, the current trend is to use only twisted pair (10 Base T) ethernet in the place of thin ethernet, due to its reliability and ease of management. Some departments (especially computer science) use category 5 cable (which can support 100 Mbps) to connect their core segments. Category 3 cabling is used in all other places.

Bridging Segments within a Department

Due to an increasing number of machines and the physical distance, most department LANs need to be broken into segments and bridged. For bridges, the solution of choice has been to dedicate a PC running free public domain bridging software rather than purchasing hardware bridges. A very useful innovation developed in the computer science department at TI is the multi-segment bridging software. This department currently uses a diskless 486 machine to bridge four Ethernet segments. The performance and reliability has been found to be excellent.

Routing IP and IPX

Unix machines and Novell netware file servers are the two major systems in use in the institute. They use different networking protocols (TCP/IP of Unix and SPX/IPX of Netware). Within a single LAN they can coexist peacefully, but because different department LANs are connected to the TI backbone using routers, sometimes problems surface.

As far as INTERNET access (TCP/IP) is concerned, 32 Class C addresses are available for use at TI. Big departments are given a full class C address and others are given subnet masks (allowing 64 IP addresses for that department).

The following are the routers and routing software in use at TI:

Cisco

There is one CISCO router used by ERNET to connect the TI backbone to the rest of ERNET (and INTERNET). It routes only TCP/IP packets. This is a costly, but high performance and reliable router for Wide Area Networking. Its multi-protocol routing capabilities (X.25, IPX) are not being utilised in the current scenario.

Netware Servers

Departments (like computer science, library, main building) use their Netware servers themselves as routers to connect to the TI backbone. Netware (versions 3.11 and above) can route both IP and IPX, making access of other departments' machines (both Unix and Netware) possible.

Dedicated PCs using PD Software

For TCP/IP routing, some free public domain software packages are available. At TI, PCROUTE is used by electrical and humanities departments and PKTPKT is used by chemical engineering. While this is cost-effective and good enough for TCPAP, they do not handle IPX packets intelligently. They also require a PC to be dedicated as the router.

LINUX

More recently, the aeronautical department is using their LINUX machine as the router. LINUX is a free version of UNIX, available with full source code and no restrictions on usage and has been a boon for the campus.

Network Software Used on DOS Front-ends

Machines using DOS are the most common on the campus. They need connectivity to both Netware and Unix machines. The solution adopted has been to use free public domain software only and this has worked very well.

(i) TPCIIP The telnet suite of programs from NCSA and Clarkson University are the most widely program, used to connect to Unix machines. These run on top of packet drivers available free (Crynwr Packet Driver Collection) for all common Ethernet cards (NE 200, VVD, DLINK, etc.) ODIPKT of Novell is also in use.

The Minuet suite of programs is also being used of late since it includes many utilities like telnet, FTP, gopher, news, finger and nslook up.

(ii) IPX Novell's ODI solution (Isl, ne2000, ipoxdi) is one of the methods used to get DOS machines to connect to Netware servers. The other is to run the Crynwr packet drivers followed by pdipx.

Netware-Unix Connectivity

There are still many issues to be resolved here. Netware allows (by purchasing packages for their server) enough access to machines (FTP, NFS mounting and so on). But in the public domain, only Email connectivity is easy. By running Mercury and Pegasus Mail (both available free), one can get full E-mail connectivity for all Netware and Unix users.

LINUX is the answer to accessing Netware resources from Unix machines. Linux has DOSemulation package that makes this possible. This is still in its experimental stages and is being tried out at TI.

Facilities and Usage

The benefits of campus networking are immense.

For academic use the ability to access so much information (call for papers, technical reports, research software source) and resources (working with machines and programs unavailable in the campus) has opened up new avenues for progress. Specific examples are collected in a separate document. These, of course, rely on the ability to use network services like telnet, FTP, newsgroups, Email, gopher and WWW.

Networking of the non academic sections (administration, accounts, stores, etc.) also has many indirect benefits, including saving of cost to the institute. The status of this aspect of campus networking is to be surveyed.

Usage Policies

There are very few restrictions on users accessing network resources within the institute. People can send E-mail to any user, telnet and FTP to any machine, read newsgroups (NNTP) from many servers and use the information servers (gopher). These policies are decided by individual departments and system administrators.

Today, access to any resource outside the institute has to go through ERNET. The E-mail and news services have stabilised. Email is accessible to faculty, research scholars and project engineers for official work. Final year B.Tech. and M.Tech. students can use E-mail after payment (Rs 200 for 50 messages incoming plus outgoing). Others do not have E-mail access.

The policy on other services (FTP, telnet, etc.) is being evolved, While the trend at TI has been towards decentralising the policy decision-making, this has been a very slow evolution, leaving many users unsatisfied.

The main reasons for this are believed to be the following.

(i) The perception that ERNET resources are mainly for research use of the ERNET project group members and not for general access by other users.

(ii) The perception that giving users more access to Internet will lead to abuse (like obtaining in appropriate pictures, using this for applying to foreign universities).

(iii) The perception that the bandwidth (9600 to sangam) will get choked if greater use is allowed.

While some of these may be justifiable fears, a broader perspective needs to be taken to realise the immense benefits a more open access will have on the academic work of the institute. In any case, the restrictions should be only time-based (available at certain times) or load-based (available when the network load is below a threshold), rather than a blanket denial.

Problems and Suggestions

To summarise, the TI network is a collection of department LANs (10 Base T and 10 Base 5 Ethernet), hooked on to a thick Ethernet TI backbone. Bridges are used to segment department LANs and routers to interconnect various departments. Unix and Netware machines are common in many departments and they can both be accessed. The TI solution is workable, cost-effective and easily implementable at other places.

The major issues remaining are the following.

(i) Distant Units Some units like hostels and the hospital are too far from the TI backbone. Cost-effective ways (using dialup phone lines and SLIP, PPP) should be designed and implemented.

(ii) Subnetting Due to a shortage of IP addresses, subnet masks have been given, which cause some problems to some of the available routing software. This must be avoided by exploring one of the following techniques:

(a) Developing customised special-purpose routing

(b) Routing multiple logical segments on the same physical segment.

(c) Building a 'firewall' – a router that allows use of full address on one side but presents only legal routes to the other side.

(iii) Maintenance, System Administration and Management As the network size and usage grows, effective procedures and staff for network maintenance and management should be available. The idea of forming special interest groups that meet regularly to take stock of the situation will help.

(iv) Network Security Security will become an issue once resources are accessible from distant locations. Kerberos is the solution adopted by MITs Athena project. A project to develop such secure distributed systems will be very useful.

(v) Public-Domain Software While the availability and use of PD-software has been of immense benefit at TL it does need a lot of expertise and experimentation to get things working properly. Standardising these packages and customising them for specific needs of the campus will be another useful project.

QUESTIONS FOR DISCUSSION

1. Comment on the strengths and weaknesses of networking at Technology Institute.
2. Keeping in mind the advancements in technology, how would you proceed differently? Discuss.
3. Comment on the major issues on networking at Technology Institute.

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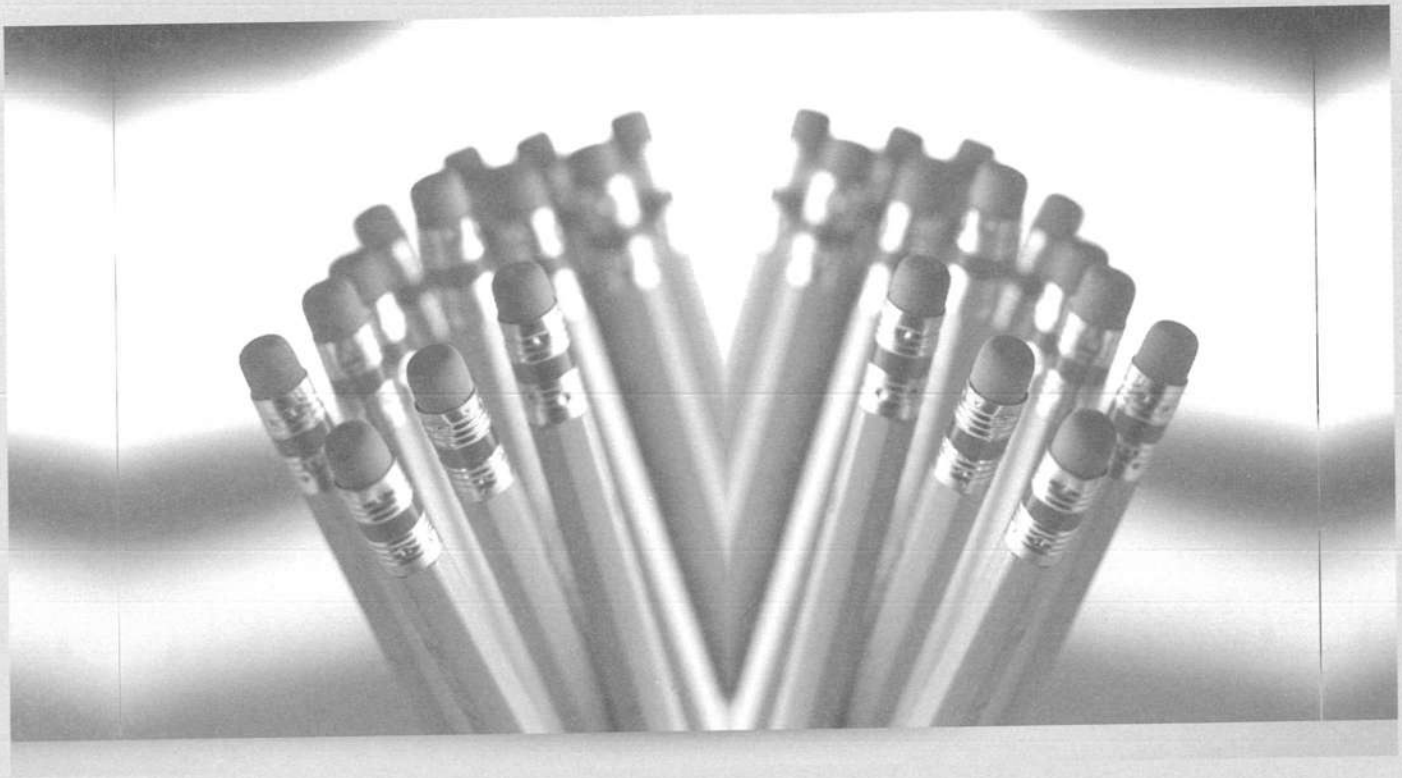
3 Business Applications of IS



Chapter Outline

Chapter 8

e-Commerce

Learning Objectives

After reading this chapter, you should be able to:

- Understand the basic differences between e-business and e-Commerce
- Identify advantages and challenges of e-Commerce system
- Outline the key components of technology infrastructure that must be in place for e-Commerce to succeed
- Discuss the key features of the electronic payment systems needed to support e-Commerce

8.1 INTRODUCTION

The advent of Internet technologies has really revolutionised the business world today. Internet is reshaping the way information systems are being used in business.

New uses of information systems and new business models have become possible because of the Internet, which has eliminated many technical, geographic, and cost barriers that use to obstruct the global flow of information. e-Commerce refers to the use of the Internet and the web to transact business. The global availability of Internet for the exchange of transactions between buyers and sellers has been instrumental in the growth of Electronic Commerce (e-Commerce). e-Commerce as a concept started in 1995 when one of the internet portals known as Netscape.com started to publish advertisements from major organisations on its web portal, which helped in popularised the idea that the web could be used as a new medium for advertising and sales. If we look back at the growth of e-Commerce, it has been phenomenal and much better than many technological innovations such as telephone, radio, and even the television. Unfortunately, this exponential growth in e-Commerce created a market bubble called "Dot-com" bubble, which burst in March 2001. As a result, a large number of dot-com companies failed. This was a major setback for the e-Commerce movement. On the positive side, despite the bubble burst, a few of e-Commerce companies like Amazon, e-bay, and Goggle not only survived but also had a good growth and thus continued the momentum of e-Commerce. By 2006, e-Commerce gained significant ground again and today e-Commerce continues to be the fastest growing form of retail trade in the US, Europe, and Asia. Today, a large number of people are buying and selling their products through e-Commerce. No doubt that for purchasing traditional channels are still way popular, but it is also beyond doubt that e-Commerce continues to grow and to transform the way many companies do business. Another term known as e-business has also become popular because of the fast-changing world of information technology (IT) applications in business.

Different scholars have defined the terms e-Commerce and e-business differently and still many consider these two terms as synonyms that is way often the two terms are used interchangeably. For the sake of clarity, we have used the terms – e-business and e-Commerce as different terms. In a very narrow sense, e-Commerce is the process of buying and selling goods and services electronically, whereas e-business is a much broader concept. e-business, in addition to encompassing e-Commerce, includes both front and back office applications that drive the modern business. In other words, e-business is the use of the information technologies to support electronic Commerce, enterprise communications and collaborations, and web-enabled business processes both within a net-worked enterprise, and with its stakeholders. In this chapter, we will discuss the concepts and applications of e-Commerce like: e-Commerce infrastructure, e-Commerce applications, payment systems and challenges and opportunities in the areas of e-Commerce. Under e-business, we will discuss examples of cross-functional enterprise systems like Enterprise Resource Planning (ERP); Supply Chain Management (SCM); and Customer Relationship Management (CRM) in Chapter 9. Functional information systems, which also fall under e-business, have already been discussed in Chapter 2.

8.2 E-COMMERCE

e-Commerce today, is not just about buying and selling products online as it was perceived a few years before; it rather encompasses the entire online process of developing, marketing, selling, delivering, servicing and paying for products and services transacted through the Internet. e-Commerce broadly includes the following tasks:

- Providing information about a product
- Defining the requirements of the customer
- Performing the purchase transaction
- Electronic delivery of the product (for example, software, music, video or any information-based product)
- Providing customer service electronically.

FOCUS

e-Commerce refers to the use of the Internet and the web to transact business.

It encompasses the entire online process of developing, marketing, selling, delivering, servicing and paying for products and services transacted through the Internet.

It is the Internet that has been the major driving force to make e-Commerce possible. Though e-Commerce provides a number of benefits to the companies, majority of the commercial transactions still take place through the traditional channels. e-Commerce has come a long way in the last decade but there is still a long way to go. The failure of the dot.com companies in mid-2000 did not mean an end of e-Commerce; rather companies have learned a lot about the practical limitations of e-Commerce. Today, a large number of companies, small and large, are using some form of e-Commerce activities. It is maturing and evolving to enable consumers and companies to gain access to worldwide markets. e-Commerce is also used to reduce transaction costs, improve customer services, speed up the flow of information and enhance coordination among manufacturers, suppliers and customers. The number of e-Commerce users and the volume of sales via Internet are increasing in developed as well as the developing countries. Unique features of the internet and web like ubiquity, global reach, universal standards, customisation and social networking are contributing factors for the rapid growth of e-Commerce.

8.2.1 Categories of e-Commerce

On the basis of the nature of the participants in the e-Commerce transactions, e-Commerce applications are divided into three major categories:

(i) **Business-to-Consumer (B2C) e-Commerce** In this type of e-Commerce, business organisations deal with individual customers directly and thus there are no intermediaries, For example, *Amazon.com* sells books, software, and music to individual consumers. Similarly *indiatimes.com* offers a large number of products on their portal directly to the individual consumers.

FOCUS

On the basis of the nature of the participants in the e-Commerce transactions, e-Commerce application are classified as: Business to Consumer, Business to Business, Consumer to Consumer

(ii) **Business-to-Business (B2B) e-Commerce** In B2B e-Commerce, the participants are organisations, example: *Neoforma.com.*

(iii) **Consumer-to-Consumer (C2C) e-Commerce** This category of e-Commerce involves consumers selling directly to other consumers. Customers buy and sell items directly from each other through the website. An example of this is *eBay.com* – a large web auction site that allows people to sell their goods to other consumers by auctioning the merchandise off to the highest bidder.

Besides these three main categories of e-Commerce, Business-to-Government (B2G) and e-Government applications also apply concepts of e-Commerce.

With the advances in the communication technology, websites can be accessed through cell phones and other wireless handheld digital appliances. The use of handheld wireless devices for purchasing goods and services is known as mobile Commerce or m-Commerce.

8.2.2 e-Commerce Sales Life Cycle (ESLC) Model

e-Commerce Sales Life Cycle (ESLC) Model depicts various stages in the sales life cycle a customer undergoes. The e-Commerce system supports each of these stages. In other words, ELSC model describes the customer perspective for the purchases of an item over the Internet. Typically, a customer passes through the following stages:

(i) Searching for the item
(ii) Selection and negotiation
(iii) Purchasing
(iv) Product and service delivery
(v) After sales service

Let us discuss, in brief, each stage of ESLC model.

Figure 8.1, depicts ESLC model diagrammatically.

(i) **Searching for the Item** In this stage, the customer will search for the required items. He will log on to the Internet and visit the websites of various suppliers. From the supplier's home page, the customer can access a product catalog and can search for the required item.

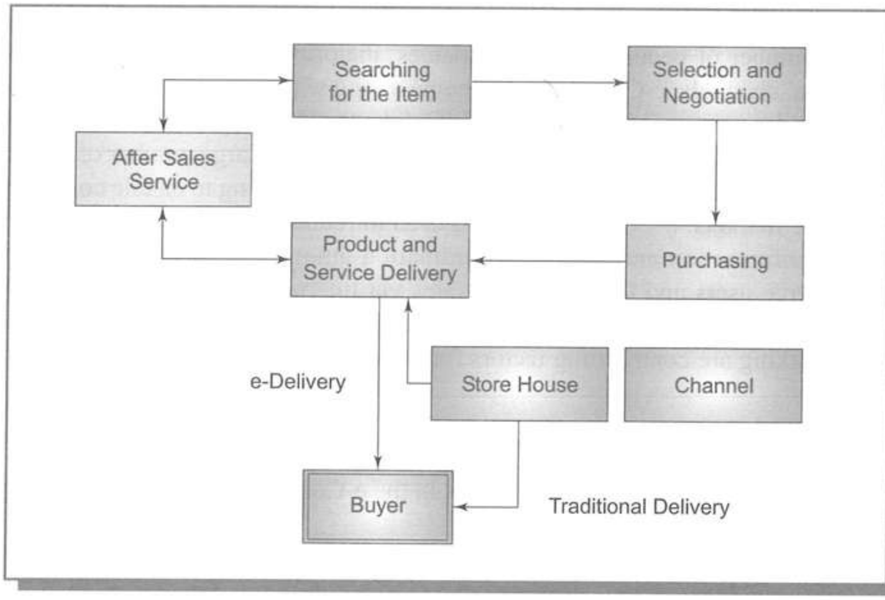


Fig. 8.1 e-Commerce Sales Life Cycle

(ii) Selection and Negotiation After the required items are searched on the Internet, the customer fills out a request-for-quotation form by entering the item codes and quantities needed. The filled out request-for-quotation is entertained by the supplier's web application, and it quotes the price of the selected items along with other terms. After the quotations are received, the customer examines them and selects the item(s) by clicking on the request-for-quotation form. The customer also specifies the delivery date. In addition to the price, the customer may like to consider an item's quality and the supplier's service, and speed of delivery in selection and negotiation.

(iii) Purchasing Having selected the required item and negotiated for it, the customer completes the purchase order by sending a completed electronic form to the supplier. During this stage, a customer may be required to pay electronically through the customer's credit card. Companies take extra care to avoid electronic cash transactions fraud and thus use Secure Electronic Transactions (SET) and Secure Sockets Layer (SSL) communications protocols. These and many other security procedures make purchasing on the Internet easy and safe.

(iv) Product and Service Delivery Many products like software, music pictures and written materials can be delivered using Internet. The customer can download these products directly on their computers. However most of the products cannot be delivered over the Internet, so they are delivered through the traditional methods, like courier, mail, by air or by road. Product delivery may either be by the company or it may be outsourced. In the case of outsourcing, a customer orders for a particular product to a company, but the information for the dispatch of the ordered product is sent directly to the third party, from where the product is delivered to the customer.

(v) After-Sales Services Many after-sales questions are answered through the websites of the companies. Much of the information like how to maintain a piece of equipment, how to use the product, repair services under warranty, etc., can be obtained from the websites.

To conclude, ESLC model advocates that all stages of the Sales Life Cycle should be supported by the e-Commerce system of the company.

8.2.3 e-Commerce Infrastructure

e-Commerce technology infrastructure is the key to successful e-Commerce. A brief overview of the key technology infrastructure is given as below. This has also depicted in Figure 8.2.

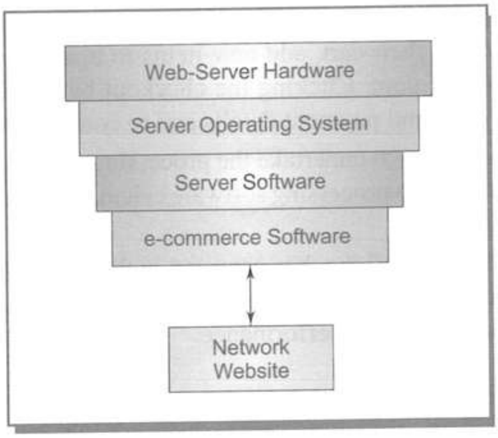


Fig. 8.2 e-Commerce Infrastructure

Hardware

A web-server hardware platform is one of the main e-Commerce technology infrastructure components. The various features of the web-server like the storage capacity and computing power, etc., depend upon the software that runs on the server and the volume of the e-Commerce transactions to be processed. Many a times these requirements are not exactly known in advance, hence the e-Commerce solutions are designed to be highly scalable so that they can be upgraded to meet the requirements. In some cases, the companies may acquire the lease services from the third parties for the e-Commerce web server. The companies may decide this, keeping in view the merits and demerits of both options. The main guiding principle remains that 'there must be adequate hardware backup to avoid a major business disruption in case of a failure of the primary web server'.

FOCUS

The main infrastructure required fro e-Commerce is Hardware and Software.

Software

Software for e-Commerce can be grouped in two parts:

(a) Web-server Software
(b) e-Commerce Software

(a) Web-server Software To perform a large number of functions like security and identification retrieval and sending of web pages, website tracking, website development, and web page development, the website must have web-server software. This software is needed in addition to the web-server operating system.

(b) e-Commerce Software Having located or built a host server, one can start to investigate and install the e-Commerce software. The e-Commerce software must support the following processes:

(i) Catalog Management
(ii) Product Configuration
(iii) Shipping Cart
(iv) e-Commerce Transaction Processing, and
(v) Web Traffic Data Analysis.

Catalog Management is required to deliver customised content to the user's screen. Catalog management software combines different product data formats into a standard format for uniform viewing, aggregating, and integrating catalog data into a central repository.

Product Configuration process supports web-based customer self-service and the mass customisation of a company's product. Web-based product configuration software is used to build the required product online without any help from a sales person. For example, both Dell Computers and CISCO Systems use configuration software to sell build-to-order and network processors to their online customers.

Shopping Cart is a model that is commonly used by many e-Commerce sites to track the items selected to purchase, allowing the buyers to view what is in their cart, add new items to it, and remove the items from it. To order an item, the buyer is required to click that item. Clicking the checkout button displays another screen that usually asks the buyer to fill out billing, shipping and payment details and to confirm the order.

e-Commerce Transaction Processing is required to undertake the processing of data received from the shopping cart and to calculate the cost. e-Commerce transaction processing software calculates the total cost besides connecting participants in the e-Commerce transaction.

Web Traffic Data Analysis is required to analyse all the data captured in the web log file. This analysis is useful to improve website's performance. Website traffic data analysis software processes and analyses data from the web log file to provide useful information to improve website performance.

8.2.4 e-Commerce Applications

e-Commerce finds its applications in diverse areas of business like retail and wholesale, manufacturing, marketing, finance, etc. Given below is a brief description of e-Commerce applications in various areas.

(i) Retail and Wholesale There are a large number of e-Commerce applications in retail and wholesale. e-Tailing, is a popular term, being used for online retailing. It is a direct sale from business to consumer through electronic storefronts, which are designed using electronic catalog and shopping cart model. There are numerous electronic retail websites, selling directly to the consumers. Cybermall, another way to support e-tailing, is a single website that offers many products and services at one web location. An Internet cybermall attracts multiple buyers and sellers together into one virtual space through a web browser. Similarly, e-Commerce sites are used in wholesale buying and selling by different companies.

FOCUS

Retail and wholesale, Marketing, Finance, Manufacturing and Auctions, are the main applications of e-commerce.

(ii) Marketing e-Commerce can also be used in marketing – like collecting data about customer behaviour, their preferences, needs and buying patterns through the web and e-Commerce transactions. The analysis of such information can be used in marketing activities like price fixation, negotiations, tailor promotions, product feature enhancement and relationship with the customers. For example, 'double-click' – an Internet advertising company leverages technology and media expertise to help advertisers use the power of the web to build relationships with the customers.

(iii) Finance Nowadays a large number of e-Commerce applications are also found in the area of finance. Financial companies are applying e-Commerce in a big way. On-line banking enabled the customers to check balances of their saving and loan accounts, transfer money to other accounts, order for checkbooks, demand drafts online, pay their bill through eBanking. Online stock trading is another important application of e-Commerce in the financial stock. Many sites provide access to news, charts, company profiles, and analyst ratings on the stocks.

(iv) Manufacturing e-Commerce is also being applied in supply chain operations of a company. Some of the companies can form an electronic exchange by clubbing together the buying and selling of goods, trade market information, and run backoffice operations, such as inventory control. This approach can speed up the flow of raw material and finished products among the members of the business community, and this will reduce the inventory that is required to be maintained by the company. However, this model has its own limitations, as there may be various issues relating to strategic and competitive issues. Many companies may not trust their competitors and may fear that they may lose trade secrets through participation in such electronic exchanges.

(v) Auctions C2C, which is direct selling among customers including electronic auctions, is another application of e-Commerce. Bidding, which is a special type of auction, allows prospective buyers to place a bid for an item or service. For example, airline companies, nowadays, ask consumers to quote their price for a seat on a specific route on a specified date and time.

8.2.5 Electronic Payment Systems

One of the main threats to e-Commerce has been payments through Internet. With many incidents of computer criminals capturing data about credit card numbers on-line, the customers become suspicious about money transactions. However, the current e-Commerce technology has advanced to a great extent and today, it provides many safeguards in terms of user identifications and encryption. Payments are made in a number of different modes like electronic cash; electronic wallets; smart card; credit card; and debit card, etc. Before we discuss the various methods of online payments, let us briefly discuss the technology involved in e-Commerce payment. It must be clearly understood that there is no absolute security on the Internet. However, the better your security, the greater the challenge to the people who involve themselves in the breach of the security. Authentication technology helps an organisation to confirm the identity of a user who is requesting access to information. The identity of a sender or of a website is verified by a digital certificate, issued by a third party company, which is sent as an attachment to an E-mail message or data embedded in a website. The certifying authority provides a guarantee that the individuals or organisations granted these unique certifications are, in fact, who they claim to be. In other words, digital certificates act as a trust building agents in the transaction, which verifies the identities of both the purchasers as well as the suppliers.

FOCUS

One of the main threats to e-Commerce has been payments through Internet. methods of the online payments are: Electronic Cash, Electronic Wallets, Cards.

Secure Socket Layer (SSL) communication protocol is another Internet technology used to secure sensitive data. This protocol sits above the TCP layer of the OSI model and other protocols, such as Telnet and HTTP, and can be layered on top of it. SSL includes a handshake stage, which authenticates the server and the client, determines the encryption and hashing algorithms to be used, and exchanges encryption keys. The handshake may use public key encryption. Data transfer, that is always encrypted takes place after the handshake stage is complete. This prevents the transaction from any interception by any fraudulent person. Different Internet browsers use their different symbols to denote a secure site. Some websites like *Netcraft.com* provide the information about the security on the website. Let us now briefly discuss can the methods of the online payments.

(i) Electronic Cash Electronic Cash is like hard cash that can be used for online payments. For electronic cash, a customer needs to open an account with a bank after proving his/her identity. In order to withdraw cash, the customer accesses the bank through the Internet and presents a proof of identity in terms of the digital certificate issued by a certification authority. After the bank verifies the customer's identity, it issues electronic cash, which can be stored in the customer's electronic wallet on his/her computer's hard drive, or on a smart card. This cash can be used by the customer for their electronic transactions on those websites that accept electronic cash for payments. Once the goods or services are delivered to the customer, the seller presents the electronic cash to the issuing bank for payments.

(ii) Electronic Wallets An Electronic Wallet is a computerised stored value that holds credit card information, electronic cash, owner identification and address information. It is a convenient method for the customers who want to purchase items online. It provides all customers' information on an e-Commerce site's checkout counter. Instead of entering all details about payments, the customer clicks on the items to be purchased and on their electronic wallet.

(iii) Cards Cards are the most popular media for online buyers. A credit card, such as visa or Master card, has a predefined spending limit based on the credit limit allowed to a user. The user pays off due amount along with interest (as per the terms) to the bank. A charge card, such as American Express, carries no predefined spending limit, and the entire amount charged to the card is due at the end of the billing period. Debit cards are another mode of payments on the Internet. Debit cards operate like cash or a personal cheque. A debit card, which works on the philosophy 'buy now, pay now', allows a customer to spend only what is in his/her bank account. As and when the debit card is used, the money is deducted from the customer's account. These cards have a magnetic strip, in which personal information is read each time the card is swiped to make a purchase. A smart card, on the other hand, has an embedded microchip that provides electronic memory and processing capability. Smart cards can be used for a variety of purposes like credit card number, health insurance data, user's financial information, network identification codes and passwords, etc. Smart cards are better protected from fraud than other card because the smart card information is encrypted and a key to unlock the encrypted information is required to use smart card.

Moreover, there is no external number and no physical signature on the face of the smart card, as is in the case of other cards, which makes a smart card safer.

8.2.6 Management Challenges and Opportunities

There is no denying the fact that Internet technology has provided ample opportunities and ways of doing business electronically; however, it also poses a number of challenges that are taken as threats to e-Commerce. Let us briefly discuss some of these challenges.

New Business Model

"The middle of 2000 has seen a sudden fall of dot com companies, which is termed as 'bubble burst'. Doing business over the Internet is not necessarily more efficient or cost effective than traditional business models. Online retailers may not need to pay for costly storefronts and retail workers, but they require heavy outlays for warehousing, customer service call centres and customer acquisition. Challenges also confront businesses that are trying to use the web to supplement or enhance a traditional business model. Businesses that are unclear about their on-line strategy – and its relationship to their overall business strategy – can waste thousands and even millions of dollars building and maintaining a website that fails to deliver the desired results" (Pinker, Seidmann, and Foster, 2002) In other words the business models, which are being used for e-Commerce are yet to prove their worth.

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Some of the Challenges of e-commerce are: New Business Model, Required Changes in Business Processes, Channel Conflicts, Legal and Regulatory Environment for e-Commerce, Security and Privacy, Managerial Opportunities.

Required Changes in Business Processes

In order to implement e-Commerce applications, organisations need to redesign their business processes. Organisations also need well-defined policies and procedures for sharing data with other organisations.

Channel Conflicts

With the e-Commerce applications in place, there is likelihood of channel conflicts. The sales force and distributors may fear the loss of their revenues as a result of direct buying of the product by the buyers.

Legal and Regulatory Environment for e-Commerce

One of the greatest challenges of e-Commerce is the handling of legal issues. The laws governing e-Commerce are yet to be established. The issues pertaining to legal validity of E-mail contracts, the role of electronic signatures, and the application of copyright laws to electronically copied documents, etc., is still a grey area. The Internet, being global, is being used by different persons in different countries, which can be exploited by the companies. For example, if any good is offered for sale in India via a server in USA to a purchaser in France, it is a complex situation in terms of its legal implications – the basic question is, whose law would apply? The establishment of legal and regulatory environment to may still take a long time.

Security and Privacy

The issue of security and privacy is yet another challenge to the growth of e-Commerce. Because of many incidents of fraud on the Internet, customers fear about the security and confidentiality of the credit card and other personal data that they are required to provide for the e-Commerce transaction, and this leads to lack of trust among buyers, sellers and other partners involved in e-Commerce.

Managerial Opportunities

e-Commerce provides ample opportunities to the organisations. Managers can get many advantages with the use of this technology. For example, they can design new business processes, establish new relationships with the organisation's customers and suppliers, and out even come with new business designs.

The Internet can greatly reduce transaction costs; exchange purchase and sales transactions directly with customers and suppliers, thus eliminating inefficient intermediaries. Organisational communication and coordination can be made more efficient with e-Commerce technologies.

SUMMARY

The advent of Internet technologies has really revolutionised the business world today. Internet is reshaping the way information systems are being used in business. The concept of e-Commerce started in 1995 when one of the Internet portals known as *Netscape.com* started to publish the advertisements from the major organizations on its web portal, which helped popularise the idea that the web could be used as a new medium for advertising and sales. If we look back at the growth of e-Commerce, it has been phenomenal and much better than many technological innovations such as the telephone, radio, and even television. Unfortunately this exponential growth in e-Commerce created a market bubble called "dot-com" bubble, which burst in March 2001. As a result, a large number of dot-com companies failed and this was major setback for the e-Commerce movement. On the positive side, despite the bubble burst, a few of e-Commerce companies like Amazon, e-bay, and Goggle not only survived but also had a good growth and thus continued the momentum of e-Commerce. By 2006, e-Commerce gained a significant ground again and today e-Commerce continues to be the fastest growing form of retail trade in the US, Europe, and Asia.

e-Commerce is the process of buying and selling goods and services electronically, whereas e-business is a much broader concept. e-Business, in addition to encompassing e-Commerce, includes both front and back office applications that drive the modern business. In other words, e-business is the use of the information technologies to support electronic commerce, enterprise communications and collaborations, and web-enabled business processes both within a net-worked enterprise and with its stakeholders. For example, cross-functional enterprise systems like Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Customer Relationship Management (CRM), and Functional information systems. ERP system is an enterprise-wide framework that include Sales and Marketing; Production and Inventory Management, Accounts and Finance, Human Resources, etc.

e-Commerce is not just about buying and selling products online; rather is encompasses the entire online process of developing, marketing, selling, delivering, servicing and paying for products and services transacted through the Internet. e-Commerce Sales Life Cycle (ESLC) Model depicts various stages in the Sales Life Cycle that a customer undergoes and the e-Commerce system supports each of these stages. In other words, ELSC model describes the customer perspective for the purchases of an item over the Internet. e-Commerce technology infrastructure is the key to successful e-Commerce. Thus, organisations should take care of hardware, software and e-Commerce software.

One of the main threats to e-Commerce has been the payments through Internet. With many incidents of computer criminals capturing data about credit card numbers online, the customers become suspicious about money transactions. However, current e-Commerce technology has advanced to a great extent, and it provides many safeguards in terms of user identifications and encryption. e-Commerce provides ample opportunities and ways of doing business electronically; however, there are many challenges, which pose a number of potential threats to e-Commerce.

REVIEW QUESTIONS

1. Differentiate between e-Commerce and e-business. Discuss a few applications of e-Commerce.
2. Discuss Various Categories of e-Commerce. Give at least one example of each category. How has e-Commerce changed consumer retailing and business-to-business transactions?
3. Explain e-Commerce Sales life Cycle (ESLC) model.
4. Briefly discuss e-Commerce infrastructure.
5. Discuss the principal payment systems for e-Commerce.

ASSIGNMENTS

1. You are working for a medium-size company that wishes to sell products Business-to-Consumers (B2C) on the Internet. Find three firms that could be used to host your website. Identify the features, tools, and cost of each firm. Which one would you recommend?

2. Choose one common product available for purchase on the Internet and from local retailers (CD, a specific book). Find at least five items and two retail stores that sell the products. Compare the price of the item, including shipping and taxes. Would you expect the price to be the same? Justify the differences, if any.

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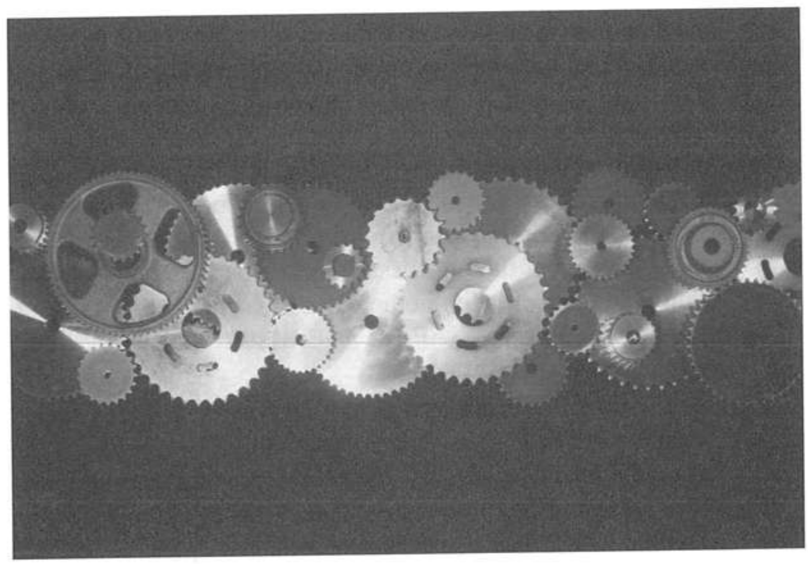
Chapter 9

ERP Systems



Learning Objectives

After going through this chapter, you should be able to:

- Discuss the concept of enterprise resource planning (ERP) system
- Understand the basic concept of Enterprise Information Systems
- Understand the concept of cross-functional enterprise systems
- Understand the concept of customer relationship management (CRM) systems, and supply chain management (SCM) system
- Discuss major application components of each system and understand the major challenges facing these systems

9.1 INTRODUCTION

Enterprise Resource Planning (ERP) System may be defined as a highly integrated information system, which provides information for all the functional areas as well as at all the management levels of an organisation. It may be understood as a computer based system designed to process an organisation's transactions and to integrate the various functions/departments/divisions within an organisation. Thus, ERP System is a set of application software/package that provides operational, managerial, and strategic information for an enterprise.

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Enterprise Resource Planning (ERP) System may be defined as a highly integrated information system, which provides information for all the functional areas as well as at all the management levels of an organisation.

Since the ERP system is an enterprise-wide framework that includes the various functional areas like Sales and Marketing; Production and Inventory Management; Accounts and Finance, Human Resources, etc., it is regarded as the business backbone of an organisation.

ERP Systems serves as a cross-functional enterprise backbone that integrates all the processes of the business and help plan the resources of the organisation. These systems help in focussing on production capacities, logistics management and working out financial implications of each decision rather than just computing costs. The basic philosophy of an ERP system is that business processes are to be integrated at all levels and all the resources of the organisation are to be treated as common resources that are to be used most efficiently to satisfy its customers. As the needs of customers keep changing, ERP systems provide adaptability to these changing needs. ERP systems enable the manager to take an overall view of the business as a whole instead of having a myopic view (or narrow perspective) of business functions, and thus offer the benefits of synergy of various functions in achieving the goals and objectives of the organisation. These systems also offer flexibility to business processes as the process itself, instead of some function in the process, is automated. All the required changes are implemented quickly with ERP systems. For example, SAP-R3, an ERP software package provides more than 700 processes that are automated and integrated with each other.

Figure 9.1 illustrates a typical ERP system. In this system, the sales order processing interacts with the inventory system, work order maintenance and accounts receivable sub-systems. In other words, three important functional areas of a business, namely, marketing, production and finance are integrated. In the system, integration of some other activities like production planning, production scheduling, procurement of raw materials, material resource planning (MRP) has also been achieved.

9.1.1 Evolution of ERP

ERP systems have evolved from the Materials Requirements Planning (MRP) systems of the 1970s and the Manufacturing Resources Planning (MRP II) systems of the 1980s. Assembly operations involving thousands of parts as in automobile manufacture led to large inventories. The need to bring down the large inventory levels associated with these industries led to the early MRP systems that planned the order releases. Such planned order releases ensured proper time phasing and accurate planning of the sub-assembly items, taking into account complex sub-assembly to assembly relationships characterized by the Bill of Materials.

A natural evolution from the first generation MRP systems was the Manufacturing Planning systems (MRP II) that addressed the entire manufacturing function and not just a single task within the manufacturing functions. MRP II went beyond computation of the materials requirement to include loading and scheduling. MRP II systems could determine whether a given schedule of production was feasible, not merely from material availability but also from the other resources point of view. Typically, the resources considered by MRP II systems would include production facilities, machine capacities and precedence sequences.

Both MRP systems and MRP II systems were fairly successful in industry. Thanks to the power of information system-databases, algorithms and their integration, organisations did find real support for efficiently managing the manufacturing function in the eighties.

The nineties saw unprecedented global competition, customer focus and shortened product life cycles. To respond to these demands, corporations had to move towards agile manufacturing of products, continuous improvements of processes and business process reengineering.

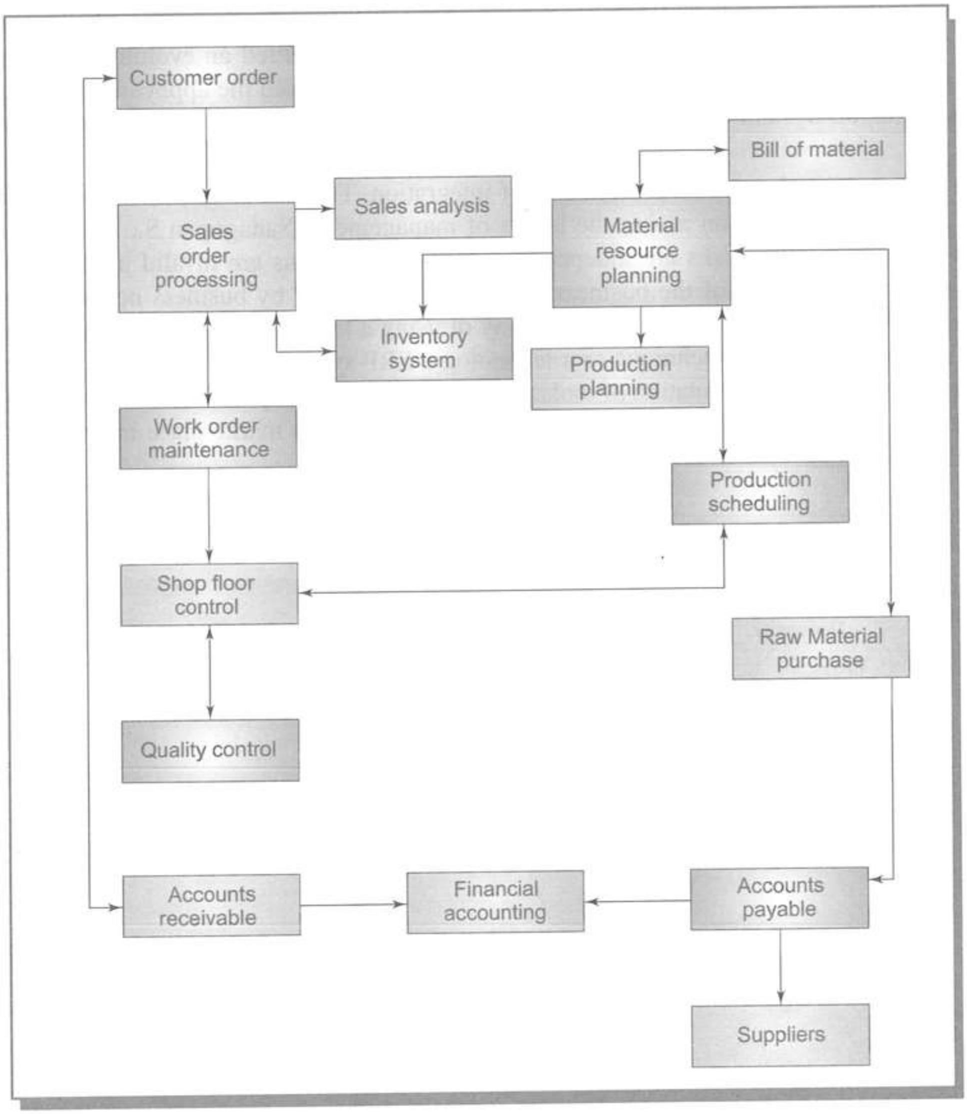

Fig. 9.1 Enterprise Resource Planning System – An Example

This called for integration of manufacturing with other functional areas including accounting, marketing, finance and human resource development. Activity based costing would not be possible without the integration of manufacturing and accounting. Mass customisation of manufacturing needed integration of marketing and manufacturing. Flexible manufacturing with people empowerment necessitated integration of manufacturing with the HRD function. In a sense the 1990s truly called for integration of all the functions of management. ERP systems are such integrated information systems built to meet the information and decision needs of an enterprise spanning all the functions of management.

9.1.2 Information Systems Perspective of ERP

ERP systems can be viewed as a logical extension of the evolution of Electronics Data Processing (EDP), Management Information Systems (MIS), Decision Support Systems (DSS) and Knowledge Based Systems (KBS) over the past four decades. EDP systems concentrated on the efficiency aspect to get mundane things like payroll calculation, inventory reports or census reports generated faster and more accurately. The MIS systems addressed the operational information need through effective measures like exception reporting, insights into processes etc. DSS used extensive modeling tools such as optimisation, simulation and statistical analysis to reveal patterns in the information generated by MIS systems to genuinely support tactical and even strategic decisions. KBS systems went beyond data, information and models to capture the knowledge of the decision maker and to use the captured knowledge to propose far superior solutions. Fortunately, this permitted an evolution of ideas and maturity of computer applications in management. A related development categorised the applications through the tasks addressed Office Automation System (OAS), Transaction Processing (OLTP) and Decision Support System (DSS).

Unfortunately, these approaches missed out the key issue of integration. The EDP, MIS, DSS and KBS based classification assumes a compartmentalisation across the layers of management (Sadagopan S., 1999). The OA, OLTP, DS classification assumes that the tasks are independent. Both assumptions are invalid in the real-world scenario. ERP systems capture the essence of the business processes. It is driven by business needs and not the IT needs. An IT driven solution often attempts to formulate a way of using a technique to solve a known business problem. The emphasis is on the usage of a technique or a technology. ERP systems take a business driven view. They solve the business problem using a combination of tools and implement the best practices using contemporary technology. This explains the phenomenal success of ERP. The ERP in the Indian marketplace is depicted in the Fig. 9.2.

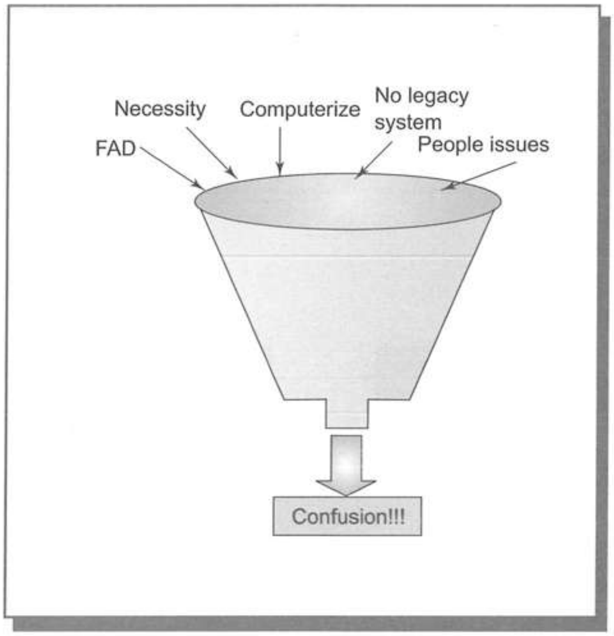

Fig. 9.2 ERP in the Indian marketplace

A few leading vendors of ERP systems and names of the ERP software are listed in Table 9.1.

ERP software suits typically consist of integrated modules of manufacturing, distribution, sales, accounting, and human resource applications. These modules support various processes under each functional area. For example, manufacturing processes that are supported by the manufacturing module are materials requirements planning, production planning, and capacity planning.

Table 9.1 ERP Software Vendors

ERP Software Vendor	*ERP Software Name*
SAP	SAP R/3
Baan	Triton
PeopeleSoft	PeopleSoft
J.D. Edwards	Word Software and one Word
QAD	MFG/Pro
Ross Systems	iRenaissance
Oracle	Oracle Manufacturing

Figure 9.3 presents the major application components in a typical ERP system.

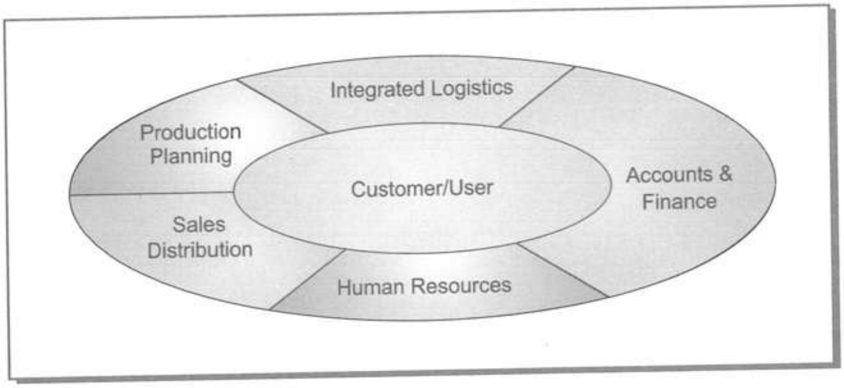

Fig. 9.3 Major Application Components in a Typical ERP System

ERP Life cycle

The different phases of the ERP implementation are given below (Alexis Leon, 1999) and shown in Fig. 9.4

- Pre-evaluation Screening
- Package Evaluation

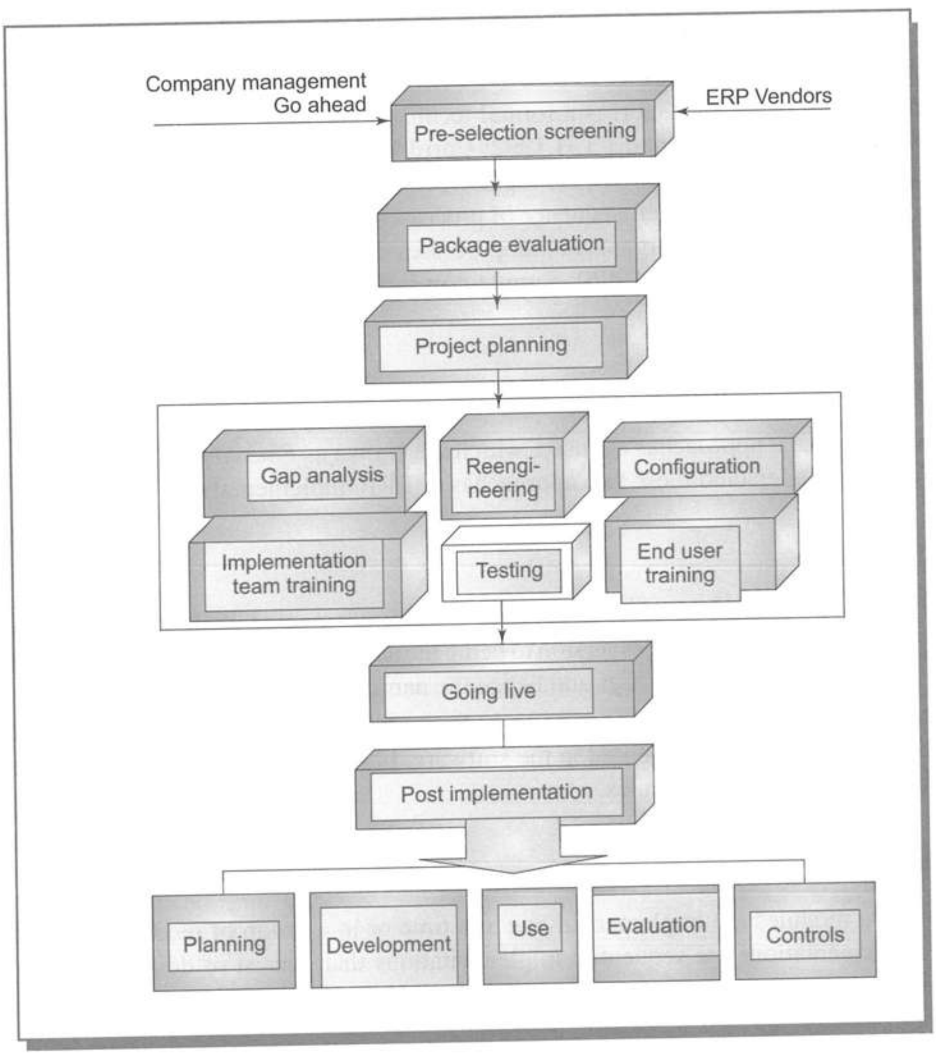

Fig. 9.4 ERP Implementation Life Cycle – different phases

- Project Planning Phase
- Gap Analysis
- Reengineering
- Configuration
- Implementation Team Training
- Testing
- Going Live
- End user Training
- Post implementation

Business Process Reengineering and ERP

Since ERP system is a generic product, designed on the common processes of business, it is used for a large number of organisations. In other words, the business processes are understood and optimised in the design of an ERP System. However, all the organisations do not follow similar business processes. Thus, when an organisation wants to implement the ERP system, its business processes need to be oriented as per the designed processes of ERP package. No doubt the designed business processes of ERP package can be changed to some extent (known as customisation), but it cannot be changed drastically. Otherwise, the purpose of cost effective ERP package would be lost. Thus, to implement an ERP package in an organisation, the organisation is required to modify or change its business processes so as to match with the business processes of the designed ERP package. In other words, change or redesigning of business processes becomes a must, if any organisation wishes to implement ERP package. This process of redesigning the business processes is known as Business Process Reengineering.

Business Process Reengineering or BPR in short is a formal technique to reassess the existing processes and device new processes. (Hammer M,1994; Davenport T.H,1992; Carrd D.,1995; Champy J.,1995; Hansen G.A., 1997). Some of the techniques of reengineering involve the replacement of old processes by new ones, combining processes, redistribution of processes, changing their sequence of processes and in some cases complete elimination of the entire process. Since ERP implements the organisational processes, it is necessary to reengineer the business processes before introducing ERP (Gendron M., 1996). Simple common sense will suggest that only efficient processes need to be implemented using ERP.

ERP Implementation Methodologies

To implement ERP systems, two popular approaches are used, which are known as *Phased Implementation* and *Big-Bang Implementation.* Let us try to understand these two approaches of ERP implementation.

Big-Bang Implementation

In a full big-bang implementation, an entire suite of ERP applications is implemented at all locations, at the same time. Using big bang, the system goes from being a test version to being the actual system used to capture transactions. This transformation takes place only in a matter of days and hence the name 'big bang'.

The big bang approach usually employs a three-step process. In the first step, virtually all relevant processes and artifacts are chosen (or developed) and implemented in the software. In the second step, all modules are tested individually and for their interfaces with other modules.

Phased Implementation

A phased approach is one where modules are implemented one at a time or in a group of modules, often a single location at a time. Phased implementations are sequential implementations that consist of designing, developing, testing and installing different modules.

9.1.3 Technology for ERP

ERP systems that are currently available belong to the client-server era. These systems are built with a clear separation of functional components. The user interface implemented using graphical user interface technique is deployed on client machines. Powerful server machines host the databases and business logic written as server procedures. The databases are built using relational database technology. Business logic is split depending on the product architecture to be executed on the client, server or both.

With suitable communication infrastructure, these systems could be deployed in a distributed environment and business processes may span across multiple geographical locations (Ranjani G., 1999). The technologies deployed have allowed the ERP vendor to meet the requisite objectives. Relational database systems have enabled the vendors to put in the necessary flexibility in terms of business logic and data structure to support parallel business practices. The technology areas that apply to ERP systems are:

- Database systems
- Communication protocols
- User interface framework

9.1.4 Challenges of ERP

In the words of Kalakota and Robinson (2000), 'An ERP implementation is like the corporate equivalent of a brain transplant. We pulled the plug on every company application and moved to people software. The risk was certainly disruption of business, because if you do not do ERP properly, you can kill your company, guaranteed.' The fact cannot be denied that the implementation of ERP system is a complete business transformation which provides a competitive edge over other competitors but the costs and risks are also quite high. There have been different ERP implementation experiences from different companies. Many companies like Hershey Food, Nike, A-DEC, etc; sustained loses running into hundreds of millions of dollars. In the case of FoxMeyer Drugs, a $5 billion pharmaceutical wholesaler, the Company had to file for bankruptcy protection, and then was bought out by its arch competitor McKesson Drugs (Kalakota & Robinson, 2000).

The main reason for the failure of these systems has been lack of understanding of the complexity of the planning, development and implementation required for new ERP system. ERP system should not be regarded as another IT application; rather it is complete business transformation which radically changes the business processes as well as information systems of an organisation. Another typical cause of unsuccessful ERP systems is failure to involve all the affected users in all the stages of ERP system in a hurry.

9.1.5 Actions for Making ERP effective

The problems an enterprise aims to solve by the use of ERP are material shortage, high inventories, poor quality, poor delivery schedules, poor productivity, and poor sales and poor cash management. Procuring and implementing an ERP System can aid in tackling these problems. In order to make Enterprise Resource Planning (ERP) System effective, top management needs to take certain actions (L. Kempster, 1998).

Generally speaking an ERP System implementation fails because of the following problems:

- Lack of top management's commitment to the project
- Lack of training for those who will eventually have to use the system
- Unrealistic master production schedules, and
- Inaccurate data.

Thus to achieve good results from the ERP system, top management has to review the ERP implementation, support the efforts of key people, demand results, get insight into the problems of the enterprise and take pro-active action to enhance the utility of ERP (S. Whang, 1995; W. Gilland, 1995; and H. Lee, 1995).

Similarly S. Sadagopan (1997) and Kevin Parker (1996) describe various factors that make ERP System effective:

- Establish the Need and Set the Stage for ERP

  Apart from stressing the use and implementation of production applications, the action taken had included: scientific numbering parts, materials and assemblies, educating and inculcating a sense of participation in the production department and insisting on getting computer based information. These were some of the actions that made the system effective.
- Set Performance Measures and Review them

  The effect of ERP implementation can be quantified as percentage reduction in inventories or percentage reduction in rejections or reductions in the number of days in the production cycle, etc. These have to be reviewed and the remedial measures have to be effected in the entire production process and the system.
- Assess Value to the Company

  The problem at a factory manufacturing air conditioning plant in U.S.A. was that at installation time the erection engineers found unmatched parts. To overcome this problem, a specific software module called 'Configurator' was developed, which was loaded on the portable computers that the marketing people were carrying with them. With this module, in an interactive session, the marketing person would capture vital information used in the calculation of Bill of Materials (BOM). The modifications of the BOM were then available electronically to the ERP software that the company had implemented. Thus the company was able to reduce customer complaints and delays in commissioning plants. This illustrates that a company which implements ERP has to go beyond the conventional inputs of ERP to reap the full value from its implementation.
- View ERP as an Integrated Process

  The management must see earnings as a vital link in the production process and integrate ERP with the entire process thereby making it more effective.

The fast-changing world of information technology (IT) applications in business are nowadays organisational wide and such organisational wide information systems act as the backbone for the entire organisation and thus all the large organisational wide information systems like Enterprise Resource Planning (ERP) system, Supply Chain Management (SCM) system; and Customer Relationship Management (CRM) system are known as Enterprise Information Systems.

Before discussing the examples of other cross-functional enterprise information system like Supply Chain Management System (SCM) and Customer Relationship Management (CRM) System in detail, let us take a look at the concept of enterprise information system.

9.2 ENTERPRISE INFORMATION SYSTEMS

Today, information technology is being used to develop integrated cross-functional enterprise information systems that cut across the traditional functional areas of a business organisation with an objective to reengineer and improve vital business processes all across the organisation. In fact, these cross-functional enterprise information systems are seen as a strategic way to use IT to share information resources and improve the efficiency and effectiveness of business processes, and develop long-term relationships with the customers, suppliers and other business partners. Thus, instead of having functional mainframe-based legacy systems, organisations are shifting to integrated cross-functional client/server applications, for example ERP, SCM or CRM software systems from SAP, People Soft, Oracle, etc. Such enterprise software focuses on supporting integrated groups of business processes rather than information processing requirements of the respective business function. ERP focuses on the efficiency of a firm's internal production, logistics distribution, HR, and financial processes. CRM focuses on acquiring and retaining profitable customers through marketing, sales and service processes. SCM focuses on developing the most efficient and effective sourcing and procurement processes with suppliers for the products and services needed by a business. Knowledge management (KM) applications focus on providing a firm's employees with tools that support group collaboration and decision support (Sawhney Mohan, and Jeff Zabin, 2001).

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Information technology is being used to develop integrated cross-functional enterprise information systems that cut across the traditional functional areas of a business organisation with an objective to reengineer and improve vital business processes all across the organisation.

Having already discussed Enterprise Resource Planning (ERP) System, let us now discuss Customer Relationship Management (CRM) System and Supply Chain Management (SCM) System.

9.2.1 Customer Relationship Management (CRM) System

With the change of business focus from sales to marketing, companies now strive to provide maximum satisfaction to their customers. In order to achieve customer satisfaction objective, they try to focus on the customers and to build a long-term relationship with them. Managing customer relationship is a two-way process, in which the organisation and all of its employees who need to interface with the customers get a complete access to every customer at every touch point and across all channels; and also the customers get all the required information about the company and of its products without much effort. Though the concept of CRM has been practised for long, but today because of environmental pressures, organisations, in order to survive and grow in cut-throat business environment, are forced to follow it much more seriously. Further, to appreciate the importance of the CRM concept, let us look at some of the facts given by Kalakota and Robinson (2001).

- It costs six times more to sell to a new customer than to sell to an existing one.
- A typical dissatisfied customer will spread the word to 8–10 people about his or her experience.
- A company can boost its profits 85 per cent by increasing the annual customer retention by only 5 per cent.
- The odds of selling a product to a new customer are 15 per cent, whereas the odds of selling a product to an existing customer are 50 per cent.
- 70 per cent of complaining customers will do business with the company again if it quickly takes care of a service snafu.

The above data further proves a point that besides acquiring new customers, providing better services and support, retaining existing customers are much more important for companies that require a major business strategy.

Customer Relationship Management (CRM) is a broad approach to doing business. It is holistic in that it encompasses all aspects and functions of a company, focusing on managing the relationship between customer and company just as much between company and customer. CRM requires a two-way street and exchange of information just as much as of goods and services. CRM is an approach which combines people, process, and technology that allows the organisations to understand their customers and retain the most profitable ones.

In the present business scenario, extremely demanding customers and technology have introduced the new dimension of customer relationship management. A comprehensive CRM system can automate every aspect of a company's relationship with its customers, from all the activities needed to target customers through those for product development, sales, service, and retention. But smart companies sharply focus their CRM implementations, carefully choosing which segment of cycle and which segment is to be automated.

CRM is an iterative process that turns customer information into positive customer relationship. The process cycle of CRM is shown in Figure 9.5.

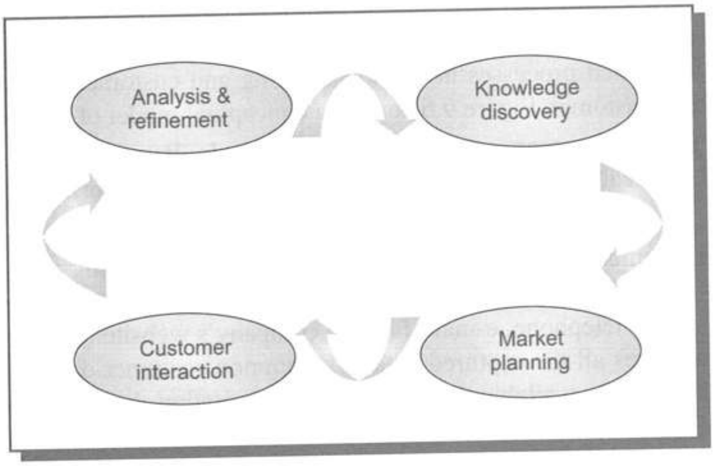

Fig. 9.5 The Process Cycle of CRM

CRM is the new mantra, which uses intelligent methods in the form of data mining techniques to get better insights of customer needs. The CRM cycle (Rigby and Ledingham, 2004) consists of five process stages:

- Target and Marketing
- Development of Offerings
- Sales
- Superior Experience
- Retention and Winback

From an operational standpoint, CRM links business processes across the supply chain from back-office functions through all touch points, enabling continuity and consistency across customer relationship. From an analytical standpoint, CRM is a host of analytical data tools that enables banks to fully understand customer segments, assess and maximize lifetime value of each customer, model 'what-if' scenarios, predict customer behavior's, and design and track effective marketing campaigns. The investments made for CRM can pay off any organisation by:

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CRM is an iterative process that turns customer information into positive customer relationship.

- Restoring the personal-service connotation that was previously unavailable.
- Fostering greater long-term loyalty through relationship building.
- Maximising lifetime value of each customer through cross-selling.
- Enabling immediate action to retain the most valuable customers.
- Identifying high-risk customers and adjusting service accordingly.
- Enabling the bank to fulfill customer needs at the right time with the right offer.
- Increasing the rate of return on marketing initiatives.

Whereas, from a strategic standpoint, CRM mobilises resources around customer relationships rather than product groups, and fosters activities that maximise the value of lifetime relationships. For example, many banks like ICICI, HDFC, and Standard Chartered, etc., have implemented CRM to excel in business and to give customised services to their customers.

Customer relationship management (CRM) may be defined as an integrated sales, marketing and service strategy that focuses on managing all of the ways that an organisation deals with its existing and potential new customers. It uses information technology to create a cross-functional enterprise system that integrates and automates many of the customer-related processes in sales, marketing and customer services.

Thus, CRM consolidates all this information to provide a unified view of a customer across the organisation. Such information was not available in the past, as the organisations used to follow a highly compartmentalised functional approach to the business processes and did not share much of the information relating to the customers. Nowadays, CRM tools integrate all the customer-related processes of an organisation and consolidates customer information from multiple channels like retail stores, telephone, e-mail, Internet, Extranet, etc., so that a consistent and consolidated information may be provided to the customers. Majority of the questions pertaining to the customers, which are analysis based, are provided by CRM systems so as to formulate strategies and business policies.

In other words, CRM system is an integrated cross-functional information system that includes a set of tools to integrate and automate customer-related processes in sales, marketing and customer services to provide fast, convenient and reliable services to its customer. Figure 9.6 depicts a conceptual model of a typical CRM system.

Some of the leading vendors of CRM systems are Siebel systems, Oracle, PeopleSoft, SAP AG. Some of the major applications components of a typical CRM system are given in Figure 9.7. Let us briefly discuss each of these components.

(i) Customer Interface: This component of CRM system assists sales, marketing, and service employees in capturing and tracking all data about the existing and prospective customers. Such information is captured from the customer touch points, such as telephone, e-mail, fax and company's website (Internet), retail stores and any personal contact. CRM system stores all the captured data in a common customer database that integrates all customer account information and makes it available throughout the organisation through Internet or Intranet for sales, marketing and service CRM applications.

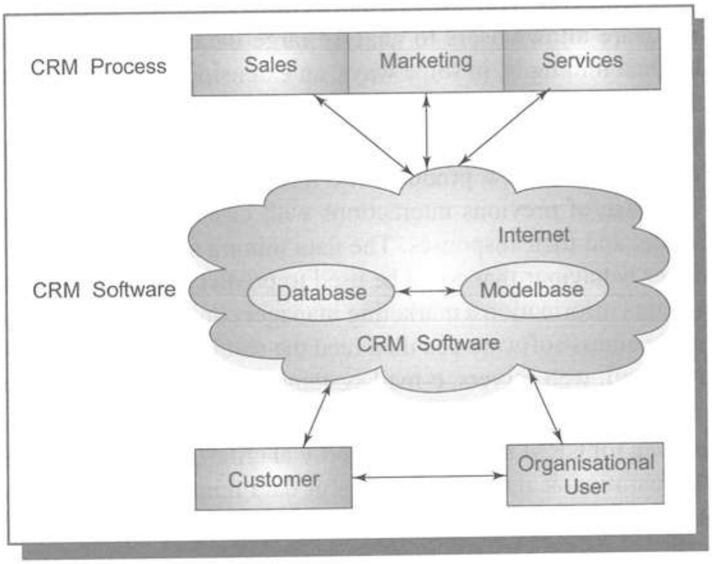

Fig. 9.6 A CRM System

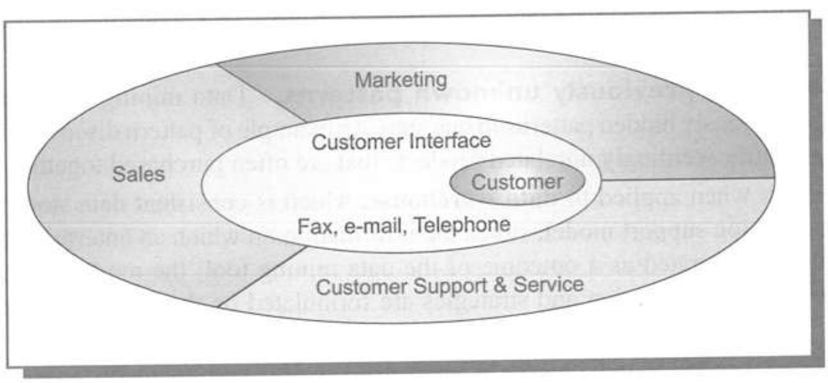

Fig. 9.7 Application Components in a Typical CRM System

(ii) Sales: CRM system provides the software tools and information to all sales people, which is required to support and manage the sales activities. It gives them real-time access to a single common view of the customer in order to provide reliable and consistent information.

(iii) Marketing: The CRM system helps marketing professionals capture and manage customer response data in the CRM database and analyse the customer and business value of a company's marketing campaigns.

(iv) Customer Service and Support: CRM system also provides service people with software tools and real-time access to the customer database. It helps in managing the requests for services by the customer. To handle specific types of requests, CRM system also allocates the services to various business professionals. On the basis of levels of their authority, calls can be routed to the customer support people through call centre software. Web-based self-service enables customers to resolve their problems on-line.

CRM model base includes analytical tools like data mining tools and other analytical marketing software, and CRM database consists of a customer data warehouse and CRM data marts.

9.2.2 Data Mining for CRM

Data mining attempts to formulate, analyse and implement basic induction processes that facilitate the extraction of meaningful information and knowledge from unstructured data. Data mining extracts patterns, changes, associations

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Data mining attempts to formulate, analyse and implement basic induction processes that facilitate the extraction of meaningful information and knowledge from unstructured data.

and anomalies from large data sets. The scope of data mining includes theoretical work on the principles of learning and mathematical representations of data to building advanced engineering systems that perform information filtering on the web. Data mining software allows users to analyse large databases to solve business decision problems. Data mining is, in some ways, an extension of statistics, with a few artificial intelligence and machine learning twists thrown in.

Data mining is not a business solution, it is just a technology. For example, consider a catalog retailer who needs to decide who should receive information about a new product. The information operated on by the data mining process is contained in a historical database of previous interactions with customers and the features associated with the customers, such as age, zip code, and their responses. The data mining software would use this historical information to build a model of customer behaviour that could be used to predict which customers would be likely to respond to the new product. By using this information a marketing manager can select only the customers who are most likely to respond. The operational business software can then feed the results of the decision to the appropriate touch point systems (call centers, direct mail, web servers, e-mail systems, etc.) so that the right customers receive the right offers.

Data mining is not a universal panacea for CRM success but its critical criteria include tools selection, business objective matching, data discovery, preparation & delivery. Successful data mining in a CRM environment is far more than the application of algorithms to data. Data mining supports CRM mainly in the following two ways.

- **Automated prediction of trends and behaviours.** Data mining automates the process of finding predictive information in large databases. Questions that traditionally required extensive hands-on analysis can now be answered directly from the data quickly. A typical example of a predictive problem is targeted marketing.
- **Automated discovery of previously unknown patterns.** Data mining tools sweep through databases and identify previously hidden patterns in one step. An example of pattern discovery is the analysis of retail sales data to identify seemingly unrelated products that are often purchased together.

Intelligent mining algorithms when applied to **data warehouse,** which is consistent data store that serves as physical implementation of a decision support model, stores the information on which an enterprise needs to make strategic decisions. The model is generated as a outcome of the data mining tool; the model is then interpreted for the purpose of the business problem solution and strategies are formulated on the basis of which, actions are taken.

Data warehousing provides architectures and tools for business executives to systematically organise, understand and use their data for decision-making. Data warehouse systems play an important role in today's competitive, fast-evolving world. Organisations are moving from a situation where they looked at what happened to a situation, where they can influence what will happen. This is possible only by gaining insights into the business processes by applying data mining to a data warehouse. Data mining algorithms comb the database for the hidden patterns. Data mining process consists of the following sequence of steps (Han and Kamber, 2004):

1. **Data Cleaning** To remove noise and inconsistent data.
2. **Data Integration** Where multiple data sources may be combined.
3. **Data Selection** Data relevant to the analysis task are retrieved from the database.
4. **Data Transformation** Data are transformed or consolidated into forms appropriate for mining by performing summary or aggregation operations.
5. **Data Mining** Process where intelligent methods are applied in order to extract data patterns.
6. **Pattern Evaluation** To identify the truly interesting patterns representing knowledge based on some interestingness measure. Patterns are selected on interestingness basis.
7. **Knowledge Presentation** Visualisation and knowledge representation technique are used to present the mined knowledge to the user.

The steps are represented in the pictorial form in the Figure 9.8. The first three steps namely data cleaning, data integration, and data selection are the pre-processing steps, before the application of the data mining tool on the data warehouse. This is to prepare the database for the application of the tools for mining the data.

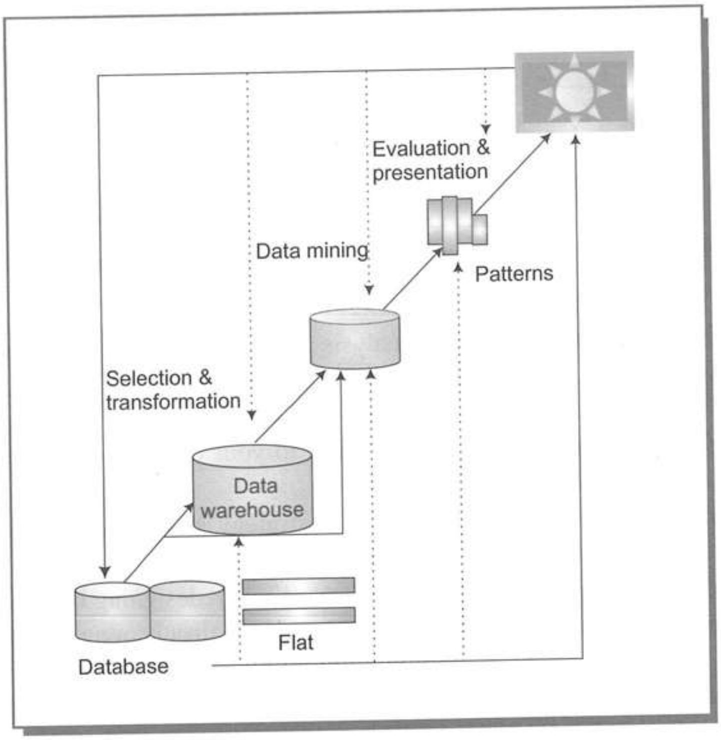

Fig. 9.8 Data Mining Process

9.2.3 CRM Architecture

CRM systems include data warehouse as its technology support and when intelligent data mining tools are applied on the data warehouse maintained by the company (to store all the details about the customer behaviour), hidden patterns are generated and predictions can be made. CRM is more than just a set of technologies; it is a process. This fact will be of significant importance to information technology professionals who will be asked to support CRM with information and applications. Furthermore, it is intended to be a repeatable process to ensure ongoing, continually improving, and consistent results. Major components of CRM Systems (Lin, 2003) are exhibited in the Figure 9.9.

9.2.4 Challenges of CRM

It is beyond doubt that a business organisation may get a lot of benefits with the implementation of CRM systems. However, it has been revealed by surveys that over 50 per cent of CRM systems did not produce the results that were promised and 20 per cent of the business surveyed supported the fact that CRM implementations had actually damaged long-standing customer relationships. Still in another survey of senior management satisfaction with 25 management tools, CRM ranked near the bottom in user satisfaction, even though 72 per cent expected to have CRM systems implemented shortly (Rigby, 2002). The failure or dissatisfaction with CRM systems can be attributed to the lack of understanding and planned implementation of CRM systems. Customer solutions cannot be automatic and generated with the buying of CRM systems; rather implementation of such systems is possible through planning and proper training of the users. CRM systems is a business strategy for which business process redesigning in sales, marketing and customer service processes are required, thus CRM system is to be regarded as a business transformation project and not merely an IT application. The following CRM implementation framework can be adopted by the organisations.

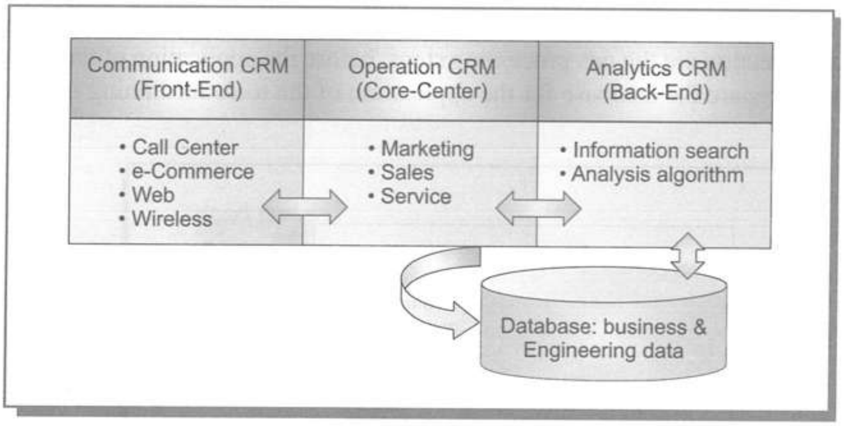

Fig. 9.9 CRM Architecture

- *Understand your Business and Customer*: Make an analysis of the services and products you want to offer to your customer; and how does your customer use your products and services?
- *Do SWOT Analysis*: Understand your company's strengths, weaknesses, opportunities, and threats in terms of sales, marketing and services infrastructure with relation to your competitors to acquire support and retain your customers.
- *Define CRM System Strategy for Your Organisation*: CRM strategy should be aligned to your business strategy. CRM systems should be integrated with other applications.
- *Make Your Organisation Business Process Reengineer Ready*: While redesigning business processes, adopt a customer's view, not the product view, customers must not be at disadvantage because of BPR of an organisation.
- *Plan Implementation of CRM System*: Implementation of CRM System should not be taken as panacea for all customer problems; the implementation of CRM system must be a slow and target-based process. Systems should be implemented in increments rather than in a great hurry and in one go.
- *Top Management Support*: CRM systems must get the support from the top management on a continuous basis.
- *Develop a Performance Scorecard*: If you can't measure, you will not be able to control and improve the project and thus you must develop concrete measurement goals so as to ensure its success.

9.2.5 Supply Chain Management (SCM) System

Supply Chain Management has become increasingly important in the last few years. SCM is now regarded as a competitive tool and is regarded not mere a technology issue, rather a business strategy, that creates many new and innovative opportunities for organisations. With the business paradigm shift from manufacturing to customer value, the question is no longer about manufacturing costs and producing high quality product; rather the question is about delivering the new value proposition, i.e. what the customer wants, when he wants and where it is wanted at the lowest possible cost. Meeting this challenge entails a campaign that besides process re-engineering, quality improvement, etc., also requires fusing company's internal systems to those of its suppliers, partners, and customers. Thus, companies require integration of their systems not only from within but also it has to go a step further and integrate the processes with the processes of other companies. SCM system is more outward-facing, focussing on helping the organisation's relationship with suppliers. In simple terms, SCM is managing the supply chain. The supply chain is a network of organisations and business processes for procuring materials, transforming raw materials into finished goods and distributing these products to the customers Figure 9.10.

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Supply Chain Management is regarded as a competitive tool and it is a business strategy that creates many new and innovative opportunities for organisations.

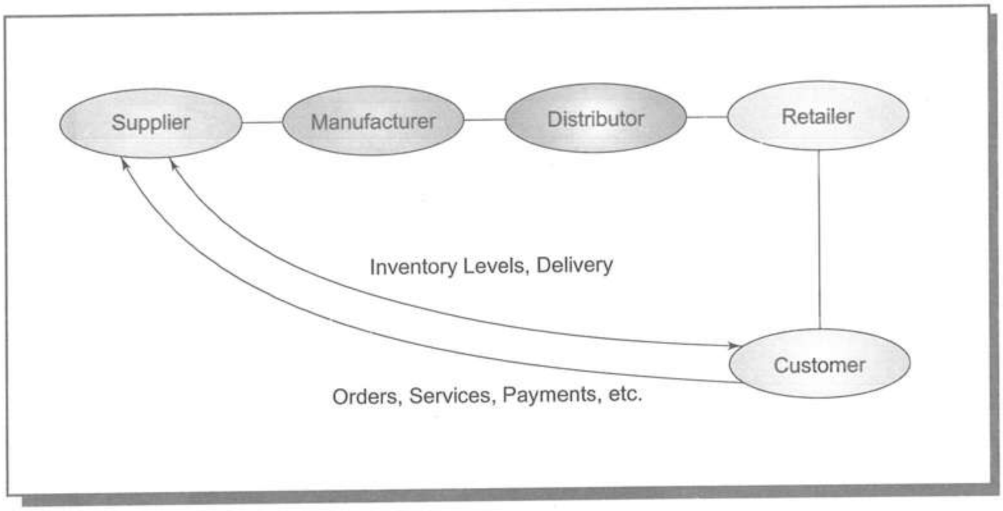

Fig. 9.10 Concept of Supply Chain Management

Supply Chain Management System makes Supply Chain Management more efficient by helping companies coordinate, schedule, and control procurement, production, inventory management and delivery of products and services.

Supply chain management system is a cross-functional inter-enterprise system (involving more than one organisation) that uses information technology to help support and manage the linkages between company's processes involved in buying, making, and moving a product. It integrates supplier, manufacturer, distributor and custom logistics processes to improve manufacturing efficiency and distribution effectiveness.

Supply chain management systems are developed using Internets, Extranets or specified supply chain management software. Supply chain management systems can provide the following benefits to the organisations:

- The organisation would be able to decide when and what to produce, store, and move.
- Orders can be communicated quickly.
- Organisations can track the status of orders.
- Inventory availability can be checked and inventory levels can be monitored.
- Inventory, transportation, and warehousing costs can be reduced.
- Shipments can be tracked.
- Production can be planned based on the actual plan.
- Any changes in the product design can be communicated quickly.

The basic components of the supply chain management systems are shown in Fig. 9.11

9.2.6 Challenges of SCM System

As SCM systems provide the companies with benefits of managing strategic relationships with their suppliers besides other benefits like faster, more accurate order processing, reduction in inventory levels, lower transaction and materials costs, etc., these systems are viewed as a major business strategy by the organisations. These benefits of SCM are mainly aimed at helping an organisation achieve agility and responsiveness in meeting the demands of their customers and the needs of their business partners. However, development of SCM systems is a complex and difficult application of information technology to business processes, which poses a number of challenges. Organisations, before planning for SCM systems, must understand the causes of problems in supply chain management. Several reasons may be attributed to such problems. For example a lack of proper demand for planning knowledge, tools and guidelines is a major source of SCM failure. Demand forecasts, which are not accurate, will lead to major production, inventory and other business problems. Inconsistent or wrong data, due to lack of integration with ERP of the organisation is another common cause of SCM problems. Similarly, lack of adequate collaboration among

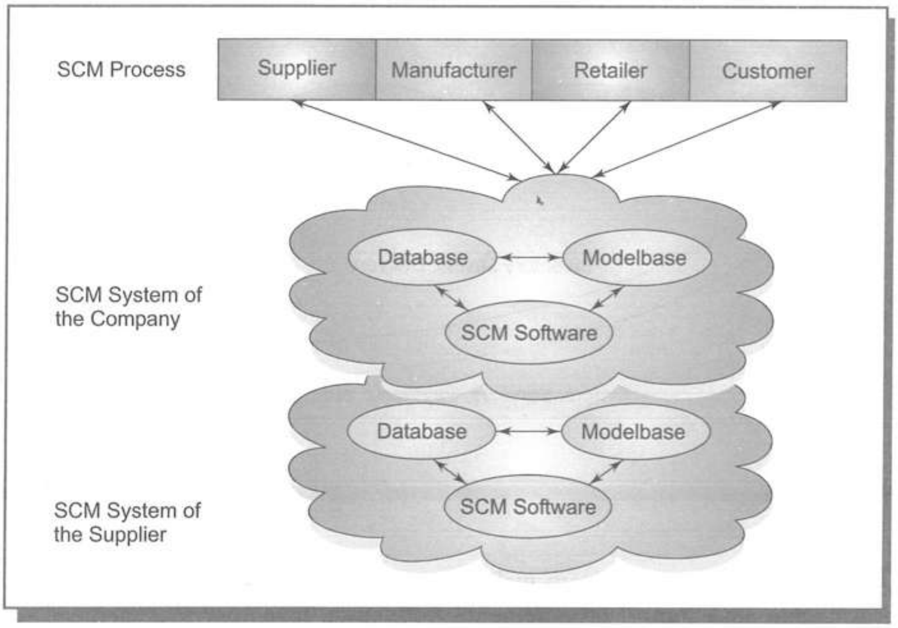

Fig. 9.11 A Typical SCM System

marketing, production and inventory within a company, and with suppliers, distributors, and others will adversely affect SCM system.

The following SCM implementation framework, suggesting guiding steps, can be adopted by organisations.

- *Understand Your Business and Supplier*: Make an analysis of the linkages of the supply chain of your organisation and understand what is required out of your supply chain.
- *Define SCM System Strategy for Your Organisation*: SCM System strategy must be aligned to your business strategy. SCM systems are inter-enterprise systems and hence must be fused with the SCM systems of your suppliers' systems.
- *Make Your Organisation Business Process Re-engineer Ready*: In the process of SCM systems, many processes of the organisations are required to be redesigned and a proper readiness of the organisation for the same is required.
- *Plan Implementation of SCM System*: The implementation of SCM system should be planned and made clear to each person involved in the SCM process.
- *Top Management Support*: SCM system, in order to be successful, must be provided top management support.
- *Develop a Performance Scorecard*: Even before the implementation of SCM system starts, supply chain measurement issues should be understood with the selected supplier of SCM system.

SUMMARY

ERP serves as a cross-functional enterprise backbone that integrates all the processes of the business and help plan the resources of the organisation. These systems helps in focussing on production capacities, logistics management and working out financial implications of each decision rather than just computing costs. The basic philosophy of an ERP system is that business processes are to be integrated at all levels and all the resources of the organisation are to be treated as common resources that are to be used most efficiently to satisfy its customers. As the needs of customers keep changing, ERP systems provide adaptability to these changing needs. ERP systems enable the manager to take an overall view of the business as a whole instead of having a myopic view of business functions, and thus offer the benefits of synergy of various functions in achieving the goals and objectives of the organisation. These systems also offer flexibility to business processes as the process itself, instead of some function in the process, is automated. The fast-changing world of information technology (IT) applications in business is now popularly known as Enterprise Information Systems. These systems are organisational wide information systems and act as the backbone for the entire organisation and thus all the large organisational wide information systems like Enterprise Resource Planning (ERP) system; Supply Chain Management (SCM) system; and Customer Relationship Management (CRM) system are known as Enterprise Information Systems. The challenge for Enterprise Information Systems is to quickly merge the information from a variety of diverse sources into a sales force that can provide the customer with the comforts of a shopping environment with which they are already familiar.

Customer Relationship Management (CRM) is defined as an integrated sales, marketing and service strategy that focuses on managing all the ways that an organisation deals with its existing and potential new customers. It uses information technology to create a cross-functional enterprise system that integrates and automates many of the customer-related processes in sales, marketing and customer services. The goal of e-CRM is to serve the same essential purpose of customer service in any business. That is, understand who the customers are and what they want.

In the present business scenario, extremely demanding customers and technology have introduced the new dimension of customer relationship management. A Comprehensive CRM system can automate every aspect of a company's relationship with its customers, from all the activities needed to target customers through those, for product development, sales, service and retention. But smart companies sharply focus their CRM implementations, carefully choosing which segment of cycle is to be automated.

Although CRM has been practiced for long, but today because of environmental pressures, organisations, in order to survive and grow in the cut-throat business environment, are forced to follow it much more seriously. CRM is found important because of the following well established reasons:

- It costs six times more to sell to a new customer than to sell to an existing one.
- A typical dissatisfied customer will spread the word to 8–10 people about his or her experience.
- A company can boost its profits up by 85 per cent by increasing the annual customer retention by only 5 per cent.
- The odds of selling a product to a new customer are 15 per cent, whereas the odds of selling a product to an existing customer are 50 per cent.
- 70 per cent of complaining customers will do business, the company again if it quickly takes care of a service snafu.

The above data further proves a point that besides acquiring new customers; providing better services and support; retaining the existing customers are much more important for the companies that require a major business strategy.

Supply Chain Management (SCM) system is a cross-functional inter-enterprise system (involving more than one organisation) that uses information technology to help support and manage the linkages between a company's processes involved in buying, making, and moving a product. It integrates supplier, manufacturer, distributor and custom logistics processes to improve manufacturing efficiency and distribution effectiveness.

REVIEW QUESTIONS

1. What is Enterprise Resource Planning System? Discuss the concept and challenges of ERP.
2. Differentiate between Enterprise Information systems and e-Commerce. Discuss a few applications of Enterprise Information systems.
3. 'CRM System is an integrated cross functional information system'. Justify the statement. Give conceptual model of a typical CRM system.
4. Describe the main challenges being faced by CRM.
5. What is meant by Supply Chain Management? Discuss the main components of supply Chain Management.

ASSIGNMENT

1. Find a few softwares, which are specifically designed for CRM and for SCM. What features do these softwares provide? How many customers/suppliers can these softwares handle? Find out the cost of these softwares.

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Chapter 10

Decision-Support Systems

Learning Objectives

After going through this chapter, you should be able to:

- Understand the concept of decision-making and identify the categories of specific decisions you make
- Describe various methods for choosing among alternatives
- Appreciate the relevance and role of information and that of MIS in decision-making
- Understand the concept, application and technology of DSS

While understanding 'management' as a component of management information system, we have advocated that decision-making is the essence of management. In other words, whatever a manager does in an organisation, he/she does it through decision-making. That is why, decision-making is regarded as the core of managerial functions. MIS assists every manager/decision-maker in providing the required information, which is a vital and essential input in any kind of decision-making.

Decision-making, is no longer based on the creativity, judgement, intuition, and/or experience of a manager or rule of thumb approach; rather today's manager has to operate, under ever-increasing complexities of business as well as that of management. It is more difficult to make decisions for several reasons. For example, the number of available alternatives is much larger than ever before because of improved technology and communication systems. Second, any wrong decision may be very costly because of the complexity and magnitude of operations, automation and the chain reactions that it can cause in an organisation. Third, the environment today is more dynamic, and finally, the ever-increasing competition, forces the managers to act fast and take quick decisions.

The important factors and their effect on decision-making are listed in Fig. 10.1.

Factors	Effect
• More complexity in IT	More alternatives
• Increased organisational complexity	High cost of wrong decisions
• Presence of Globalisation, Less political stability, high government intervention	More uncertainty
• More changes, fluctuations	Need for quick decisions

Fig. 10.1 Factors affecting Decision Making

In order to cope with such a situation, today's manager must understand the decision-making process, decision situations, application of new tools and techniques, and the applications of computerised support systems in their decision-making. Let us first discuss the concept of decision-making.

10.1 DECISION-MAKING: A CONCEPT

Literally speaking, decision making has been taken from the word 'decide', which is a Latin word meaning 'to cutoff' or to come to a conclusion. Decision may be regarded as a 'choice', whereby a decision-maker comes to a conclusion about a given situation. A decision represents a course of behaviour selected from a number of (more than one) possible alternatives. Decision-making, on the other hand, is a process of selecting one optimum alternative from among alternatives of a course of action. Thus, a decision is an end or the final product of the decision-making process. However, the decision should not be mistaken here as an end in itself, rather it is regarded as a means for action. Decisions are not static and have to be responsive to varying situations. In fact, decision-making means, choosing one course of action rather than another and finding an appropriate solution to a new problem posed by a dynamic world. It is implied that decision-making envisages two or more alternatives from which a final decision can be made. However, if there is no option, i.e. only one alternative is available, there is no decision to be made. In organisations, some of the decisions can be made easily with a minimum of mental effort but in most cases, decision-making becomes a complex issue, broader than merely making a commitment after evaluating alternatives. It involves the entire process of establishing goals, defining activities, searching for alternatives and developing plans. It includes all the activities of coordinating, information processing, problem solving and evaluating that usually precede a decision.

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Decision making has been taken from the word 'decide', which is a Latin word meaning 'to cutoff' or to come to a conclusion.

10.2 SIMON'S MODEL OF DECISION-MAKING

Decision-making, in organisations, is regarded as a rational process. Herbert A. Simon has given a model to describe the decision-making process. The model comprises of three major phases, namely,

(i) Intelligence,
(ii) Design, and
(iii) Choice.

The explanation for these three phases is as follows.

10.2.1 Intelligence Phase

In this phase, the decision-maker scans the environment and identifies the problem or opportunity. The scanning of environment may be continuous or intermittent. For example,

(i) a production manager reviews the daily scrap report to check for problems relating to quality control (continuous scanning).
(ii) a sales executive periodically visits key customers to review possible problems and to identify new customer needs (intermittent scanning).

Scanning of environment need not always be conscious. It may, sometimes, even be an unconscious one. For example, each time the user of a scooter/car starts the engine, he/she consciously or unconsciously listens for any undesirable noise to detect possible engine problems. Thus, we see that, intelligence activities result in dissatisfaction with the existing state or identification of potential rewards from a new state.

Intelligence phase of the decision-making process involves:

(a) Problem searching, and
(b) Problem formulation.

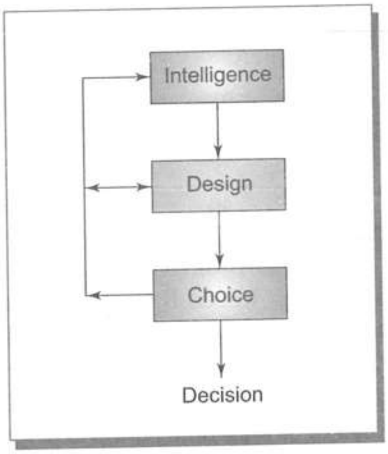

Fig. 10.2 Decision-making Process

Problem Searching

'Problem' is defined as the 'difference' between something that is expected and reality.

Desired/Expected – Actual/Reality = Difference (Problem)

In actual practice, the reality or actual is compared to some standard (some model of what is desired). Differences are measured and are evaluated to determine whether there is any problem or not. Various types of models can be used to compare reality. Some of them are:

(i) Planning model,
(ii) Historical models based on extrapolation,
(iii) Models used by other people in the organisation,
(iv) Extra organisational models in which expectations are derived from competition, customers and consultants, etc.

To illustrate problem searching, we may take the example of a Sales Manager who has set a sales target of Rs. 5 lakh in one particular month (Standard or a Model), and he could achieve only Rs. 4 lakh worth of sales for that particular month (Reality). Thus, the difference between a standard/model and reality, i.e. of Rs. 1 lakh is a problem which worries the manager.

Problem Formulation

When the problem is identified, there is always a risk of solving the wrong problem. To avoid such risk, it is very important that the problem is well-understood and clearly stated. Many a times, the process of clearly defining the problem is sufficient. In other cases, we have to simplify the problem by determining its boundaries, breaking it down into smaller manageable sub-problems or focusing on the controllable elements. In problem formulation, establishing relations with some problem solved earlier or an analogy proves quite useful.

Design Phase

In this phase, the decision-maker identifies alternative courses of action to solve the problem. Inventing or developing various alternatives is a time-consuming and crucial activity as the decision-maker has to explore all possible alternatives and he cannot take a risk of missing any alternative, as the missed-out alternative might be the best one. Developing alternatives is a creative activity which can be enhanced by various aids such as brain-storming, checklists, analogies, etc.

Choice Phase

At this stage, one of the alternatives developed in design phase is selected and is called a decision. For selecting an alternative, a detailed analysis of each and every alternative is made. Methods for choosing among alternatives is discussed later. Having made the decision, it is implemented. Simon's model of decision-making suggests three phases and the flow of activities is from intelligence to design to choice. However at any phase, the decision-maker may return to a previous phase. For example, the decision-maker in the choice phase may reject all alternatives and return to the design phase for developing more alternatives. This has been depicted in Fig. 10.2.

10.3 TYPES OF DECISIONS

Organisational decisions differ in a number of ways. These differences affect the development of alternatives and the choice among them. They also affect the design of information system support for decision activities. The following bases are important to classify decisions.

10.3.1 Purpose of Decision-making

On the basis of the purpose of the decision-making activities, Robert B. Anthony (1965) has differentiated organisational decisions into three categories, namely, strategic planning decisions, management control decisions and operational control decisions.

Strategic planning decisions are those decisions in which the decision-maker develops objectives and allocates resources to achieve these objectives. Decisions in this category are of long-time period and usually involve a large investment and effort. Such decisions are taken by strategic planning level (top level) managers. Examples of such decisions may include introduction of a new product, acquisition of another firm, etc.

Management control decisions are taken by management control level (middle level) managers and deal with the use of resources in the organisation. Analysis of variance, product mix, planning decisions, fall in this category of decisions.

Operational control decisions deal with the day-to-day problems that affect the operation of the organisation. For example, production scheduling decisions and inventory control decisions like the product to be produced for the day or the items and their quantities to be ordered are operational control decisions. Such type of decisions are normally taken by managers at the operational level (bottom level) of the management hierarchy in the organisation.

Because of the overlapping nature of some decisions, the lines of demarcation classifying decisions in these categories are not very concrete and thus these decision types should not be taken as discrete ones, rather they form a continuum for classifying decisions.

10.3.2 Level of Programmability

Simon (1965) on the basis of the level of the programmability of a decision, proposed two types of decisions: programmed and non-programmed, also known as structured and unstructured decisions (Gorry and Scott Morton, 1971). However, there is no distinct line of demarcation between the two types of decisions, rather, they exhibit as continuum for the classification of decisions.

Programmed/Structured Decisions

Programmed or structured decisions are those decisions, which are well defined and some specified procedure or some decision rule may be applied to reach a decision. Such decisions are routine and repetitive and require little time for developing alternatives in the design phase. Programmed or structured decisions have traditionally been made through habit, by operating procedures or with other accepted tools. More modern techniques for making such decisions involve operations research (OR), mathematical analysis, modelling and simulation, etc. Decisions of this kind can be delegated to lower levels in an organisation or can be automated. For example, inventory reorder decisions fall under this category.

Non-programmed/Unstructured Decisions

Decisions which are not well-defined and have no pre-specified procedure or decision rule are known as unstructured or non-programmed decisions. These decisions are novel ones, which may range from one-time decisions relating to a crisis (such as a catastrophe at the location of the unit) to decisions relating to recurring problems where conditions change so frequently and to such an extent that decision rules cannot be specified. For these decisions, sufficient time has to be spent in the design phase. Unstructured decisions tend to be solved through judgement, intuition and the rule of thumb. Modern approaches to such decisions include special data analysis on computers, heuristic techniques, etc. Decisions of this kind are usually handled by strategic planning level managers. Because of their unstructured nature, these decisions cannot be delegated to lower levels and are difficult to automate. For example, introduction of a new product, planning for R&D are unstructured decisions.

Many decision situations in the real world are either unstructured or structured ones. However, decision situations, which do not fall within any of these two extremes, are known as semi-structured decisions (decisions which fall somewhere between the structured and unstructured continuum).

Over time, as technology (decision-making techniques) advances, and provides more programming to non-programmed decisions, we experience a tendency to move towards the more programmed extreme of the continuum. For example, the EOQ decision, which was considered a non-programmed decision in the past, is classified as a programmed decision today.

The above discussion on different classes of decisions, based on Anthony and Simon are illustrated in Table 10.1.

Table 10.1 Different Classes of Decisions

Class	*Operational Control*	*Management Control*	*Strategic Planning*
Structured	Order processing Accounts receivable	Budget analysis	Warehouse location
Semi-structured	Inventory control Production scheduling	Analysis of variance	Introduction of new product
Unstructured	Cash management Long-term forecast	Budget formulation	R&D Planning

10.3.3 Knowledge of Outcomes

Another approach of classifying decisions is the level of knowledge of outcomes. An outcome defines what will happen if a decision is made or course of action taken. When there are more than one alternative, the knowledge of outcome becomes important. On the basis of the level of knowledge of outcomes, decision-making can be classified into three categories.

(i) Decision under certainty,

(ii) Decision under risk, and

(iii) Decision under uncertainty.

Decision Under Certainty

Decision-making under certainty takes place when the outcome of each alternative is fully known. There is only one outcome for each alternative. In such a situation, the decision-maker is required to compute the optimal alternative or outcome. Various optimisation techniques may be used for such decisions.

Decision Under Risk

Decision-making under risk occurs when there is a possibility of multiple outcomes of each alternative and a probability of occurrence can be attached to each outcome. Such a decision-making is also similar to decision-making under certainty, where instead of optimising outcomes, the general rule is to optimise the expected outcome. The decision-maker is assumed to be rational. For example, confronted with a choice between two actions, one offering a *2* per cent probability of profit of Rs. 1,00,000 and the other an 80 per cent probability of a profit of Rs. 10,000, the rational decision-maker will choose the second alternative because it gives a higher expected value.

	Outcome × Probability = Expected Value
S1	1,00,000 × 0.02 = 2,000
S2	10,000 × 0.80 = 8,000

Decision Under Uncertainty

Decision-making under uncertainty takes place when there are a number of outcomes for each alternative and the probabilities of their occurrence are not known. Optimisation criteria cannot be applied for making decisions under uncertainty because there is no knowledge of the probabilities. Under such a situation, different people take decisions applying different decision rules. Some may assign equal probabilities to all the outcomes for each alternative, so as to treat the decision-making as a decision-making under risk. Whereas others may adopt different criteria, such as to minimise regret, Maximax and Maximin criteria. These criteria are explained later in this chapter.

10.4 METHODS FOR CHOOSING AMONG ALTERNATIVES

A decision-maker makes use of various methods for choosing among alternatives. These methods generally assume that all alternatives are known. Given below is a brief explanation of some of these methods.

10.4.1 Decision Theory or Decision Analysis

The decision theory (decision analysis) refers to the techniques for analysing decisions under risk and uncertainty. In the process of decision-making, the decision-maker wants to achieve something which may be called his goal, purpose or objective. The decision-maker may choose one particular alternative, which is called strategy of the decision-maker, from among various alternatives. All alternatives and outcomes are assumed to be known. There are certain factors which affect the outcome for different strategies. But these factors or conditions, also called 'states of nature', are beyond the control of the decision-maker. The strategy (alternative) along with the state of nature determines the degree to which the goal is actually achieved. A measure of achievement of the goal is called the 'Pay-off'.

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The decision theory (decision analysis) refers to the techniques for analysing decisions under risk and uncertainty.

The pay-off matrix is used as a method of presenting data in decision-analysis. A pay-off matrix is a good representation of the decision-problem because the alternatives or strategies available to the decision-maker may be represented by rows and conditions (states of nature) by columns. Each cell, which is an intersection of a strategy and a state of nature, contains the pay-off. This has been shown in Fig. 10.3.

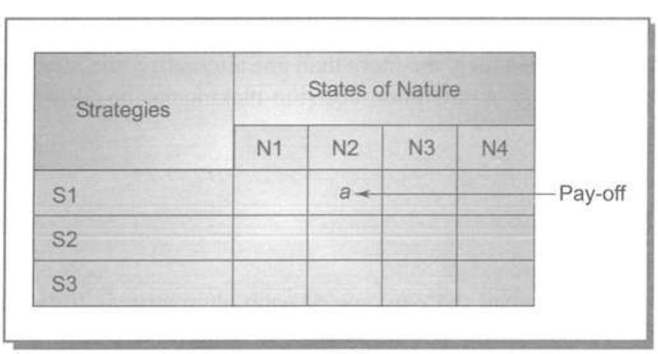

Fig. 10.3 Pay-off Matrix

If the state of nature is known with certainty, the decision-maker is required only to select the strategy that provides him the highest pay-off.

Let us explain the concept of the pay-off matrix by taking an example.

Assume that a marketing manager of a computer manufacturer is to choose from three alternatives.

1. Modify the existing PC to improve its design and processing power.
2. Launch a new PC having latest technology.
3. Do nothing, i.e. leave the PC as it is.

There are three states of nature that affect the pay-off from each of the alternative strategies. These states of nature are:

(i) A competitor may launch a new PC with latest technology.

(ii) The government may impose high excise duty on the manufacture of PCs and reduce excise to minimum on laptops to encourage the use of laptops.

(iii) Conditions will remain the same as they are.

The various pay-offs (profit or loss) from the combination of a strategy and a state of nature are given in the pay-off matrix in Fig. 10.4.

	States of Nature		
Strategies	Same conditions 0.40	New competitor 0.40	Govt. Ban 0.20
(S1) Modify	7	5	–5
(S2) New Product	10	3	–13
(S3) Do Nothing	5	1	–2

Fig. 10.4 Pay-off Matrix

The probabilities that each state of nature could occur are also shown in the figure. It can be seen that there are three states of nature whose probabilities of occurrence is known. This problem situation is called decision under risk. The probabilities represent the likelihood of occurrence of the specific states of nature, either based on historical data or on personal judgement of the decision-maker. Now to make a decision under such a situation, a rational decision-maker will compute the expected value of each alternative. The expected value is determined by multiplying each pay-off by the probability of occurrence of the state of nature (given in columns) and summing these values across all states of nature (across the rows). In the above example, the expected value (EV) of each strategy is:

$$\text{EV of S1} = (7)(0.40) + (5)(0.40) + (-5)(0.20)$$

$$= 2.8 + 2.0 - 1.0 = 3.8$$

$$\text{EV of S2} = (10)(0.40) + (3)(0.40) + (-13)(0.20)$$

$$= 4.0 + 1.2 - 2.6 = 2.6$$

$$\text{EV of S3} = (5)(0.40) + (1)(0.40) + (-2)(0.20)$$

$$= 2.0 + 0.4 - 0.4 = 2.0$$

The maximum expected value 3.8 lakh is found to be of the option to modify and if the decision is made based on the expected value objective function, the strategy S1, i.e. to modify the existing PC will be selected.

As already mentioned, in decision-making under risk, the probabilities of various states of nature are assumed to be known. However, in the case of decision-making under uncertainty, the probabilities of the various states of nature are not known to the decision-maker and thus, he cannot apply the maximisation/minimisation of expected value criteria as in the case of decision under risk. In such a decision problem, the following decision rules/criteria, depending upon the attitude of the decision-maker, may be applied.

(i) Maximax rule or criterion of optimism,
(ii) Maximin rule or criterion of pessimism,
(iii) Criterion of minimise regret, and
(iv) Criterion of rationality.

In order to understand the above criteria, let us take the earlier example, assuming no knowledge of probability. The pay-off matrix is given in Fig. 10.5.

Fig. 10.5 Pay-off Matrix (where probabilities of states of nature are not known)

Strategies	States of Nature		
	Same conditions	New competitor	Govt. Ban
(S1) Modify	7	5	−5
(S2) New Product	10	3	−13
(S3) Do Nothing	5	1	−2

(i) Maximax or Criterion of Optimism

In this case, the decision-maker is of optimistic attitude and thus would select the strategy which will provide him the greatest (max) pay-off under the most favourable or the best condition (max). In the above example, the decision-maker will select strategy S2 which will give him a maximum pay-off of Rs. 10 lakh for launching a new PC and for the same conditions (see Table 10.2).

Table 10.2

Strategy	*Maximum or the Best Pay-off*	
S1	7	
S2	10 ←	Maximum
S3	5	

(ii) Maximin or Criterion of Pessimism

As the name of the criterion indicates, the decision-maker is of pessimistic attitude and thus will select the strategy which will give him the highest pay-off (max) if the worst condition (min) occurs. Here, the decision-maker, being of pessimistic view, will not like to take any risk and thus will think about the safest position in the worst situation. Thus, the decision-maker will select strategy S3 since in the worst situation (government ban), he will sustain the minimum loss (Rs. 2 lakh) due to this decision. This is shown in Table 10.3.

Table 10.3

Strategy	*Worst or Minimum Pay-off*	
S1	− 5	
S2	− 13 ←	Minimum pay-off
S3	− 2	

(iii) Criterion of Regret

Under the criterion of regret, a decision-maker selects the strategy which minimises the maximum regret for each decision. The decision-maker might experience regret if he has not selected the appropriate strategy in terms of the particular states of nature that may actually take place, which is the difference between the pay-off he actually receives and the pay-off he could have received for the best strategy, had he known the state of nature that was going to occur. The regret is the difference between the highest pay-off for a state of nature and the other pay-off for the same state of nature regret matrix (see Table 10.4) and may be computed by subtracting the value in each entry in the column from the highest value in the column. The decision-maker would select that strategy which will give him the minimum of such maximum regrets.

Strategies	*States of Nature*		
	Same Conditions	*New Competitor*	*Govt. Ban*
(S1) Modify	10 – 7 = 3	5 – 5 = 0	–2 – (–5) = 3
(S2) New product	10 – 10 = 0	5 – 3 = 2	– 2 – (–13) = 11
(S3) Do nothing	10 – 5 = 5	5 – 1 = 4	– 2 – (–2) = 0

Table 10.4

Strategy	*Maximum Regret*	
S1	3	← Minimum of maximum regrets
S2	11	
S3	5	

In this case, the minimum regret is Rs. 3 lakh. The decision-maker, therefore, should select S1 strategy of modifying the product. Though this is the minimum regret, if all other strategies available to a decision-maker are taken into account, Rs. 3 lakh is the maximum regret he may experience for strategy S1. It is clear that depending upon the state of nature, this regret may be less (as in the case of new competitor).

(iv) Criterion of Rationality

Criterion of rationality is also known as Laplace Criterion, which assumes equal probabilities of various states of nature. Thus, it is considered a rational approach of decision-making. Once equal probabilities are attached to the states of nature, it becomes a decision problem under risk and the expected pay-off for each strategy is calculated. The strategy which has the greatest expected pay-off is selected.

In our example, the expected pay-off for each strategy is given in Table 10.5. As there are three states of nature, the probability of each state is assumed to be equal to 1/3.

Table 10.5

Strategy	*Expected Pay-off*	
S1	(1/3)(7 + 5 – 5) = 2.3	← Highest EV
S2	(1/3)(10 + 3 – 13 = 0	
S3	(1/3)(5 + 1 – 2) = 1.3	

Thus, as per the criterion of rationality, strategy S1 should be selected, because of the greatest pay-off expected. Except criterion of rationality, all other criteria are based on the attitude of the decision-maker. Thus, there is no best criterion, rather under uncertainty, a strategy becomes relevant, depending upon the criterion of the decision-maker. In the above example, the following strategies may be selected.

Strategy	*Criterion*
S1	Regret criterion and Laplace criterion
S2	Maximax
S3	Maximin

10.4.2 Utility

It has been observed that in decision analysis, the various pay-offs are measured in monetary value (Rupees), but some of the factors like goodwill, image of an organisation, perception of quality, advertising effects, etc. (qualitative in nature), are

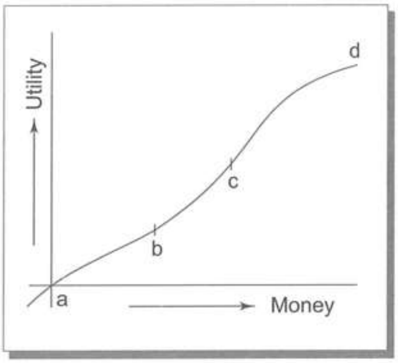

Fig. 10.6 Utility Functions

required to be considered. These need not be measured in monetary value. For this reason, another measure, called Utility, having Utiles as its units is used. Utility function for money is diagrammatically shown in Fig. 10.6.

FOCUS: Utility is a measure having Utiles as its units is used.

It can be inferred from the shape of the curve that the relation is linear (Re. 1 = 1 utile, Rs. 2 = 2 utiles, etc.) over a certain range (ab) but then rises rapidly (bc position of the curve). This means that a small amount of money has small utility but large amount of money has much more utility (larger than the utility computed from a set of small amounts). In other words, Re. 1 = 1 utile but Rs. 5,00,000 in one payment is larger than 5,00,000 utiles for Re. 1. Further, the behaviour of the curve shows that it flattens out (cd position of the curve), which means the utility gets limited with more money. This behaviour of the curve can be explained by the law of diminishing returns. The utility concept finds various applications in organisational decision-making as it helps the decision-maker to decide about the non-monetary factors.

10.4.3 Decision Tree

FOCUS: Decision tree is a graphic representation of a sequence of decisions and actions.

Decision tree is a graphic representation of a sequence of decisions and actions. It is an important method for presenting the analysis. The analysis is called a 'decision tree' because it resembles branches of a tree. The root of the tree is the starting point of the decision sequence. The particular branch to be followed depends on the conditions that exist, and the decision to be made (Fig. 10.7). The decision tree helps both in structuring the problem, that is to understand the process logic of a problem as well as in its analysis. Let us explain it with examples.

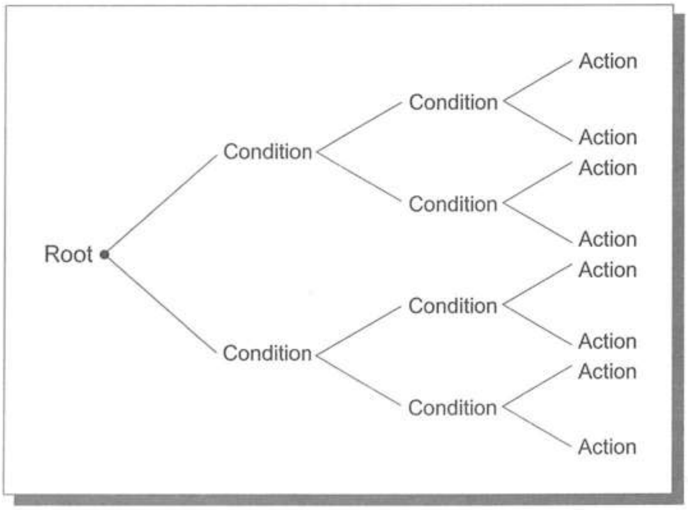

Fig. 10.7 Decision Tree Sequence

(i) *Problem Structuring*

Consider the case of a computer firm that offers the following discount policy to its customers.

If the payment is made within 10 days,

3% discount is allowed on orders above Rs. 10,000;

2% on orders up to Rs. 5,001 to Rs. 10,000;

1% on orders up to Rs. 5,000.

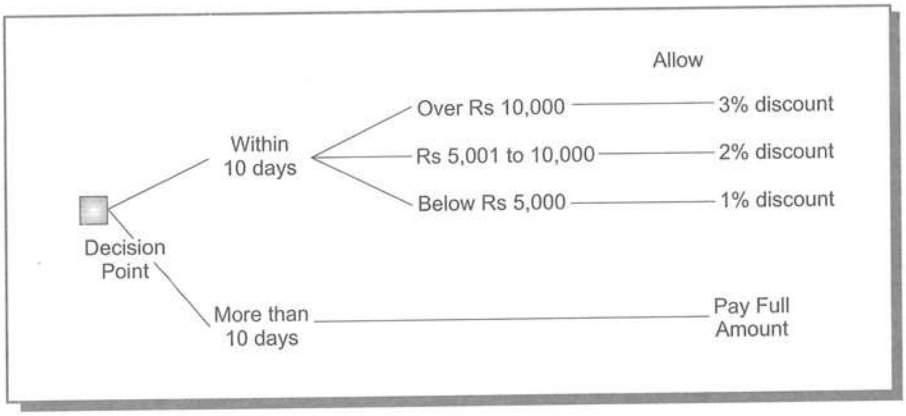

Fig. 10.8 Decision Tree for Discount Policy

However, if the payment is made in more than 10 days, no discount is allowed.

The above discount policy can be portrayed with the following decision tree.

(ii) *Problem Analysis*

Suppose, XYZ company wants to make distribution channel decisions for marketing of its products. There are two alternative channels available to the company.

(a) Direct sales, and

(b) Selling agent.

The company may have high or low market penetration and market share. The probabilities and net gains are as follows.

Channel	*High Penetration*	*Low Penetration*
Direct Sales	0.60	0.40
Net Gains	Rs. 40 lakh	Rs 30 lakh
Selling Agent	0.80	0.20
Net Gains	Rs. 45 lakh	Rs 20 lakh

The decision tree and the analysis is as follows.

Expected Pay-off for Direct Sales-(0.60)(40) + (0.40)(30) = 36 lakh

Expected Pay-off for Selling Agent-(0.80)(45) + (0.20)(20) = 40 lakh

Decision: As selling through agent would give a higher pay-off, the company should select this channel for marketing its products.

Though the above example is a simple one, it gives a fairly good idea of making an analysis using a decision tree. However, when a large number of decisions are to be made and each decision has a bearing on the subsequent decision, the procedure of roll-back is adopted. In the rollback procedure, the decision-maker starts at the tips or ends of the branches and works backward to calculate the expected pay-off for all the branches of all the nodes of the tree. The choice that maximises the expected pay-off on the whole, is found by analysing the possible outcomes at each decision point working backwards till the start (decision point) of the decision tree is reached.

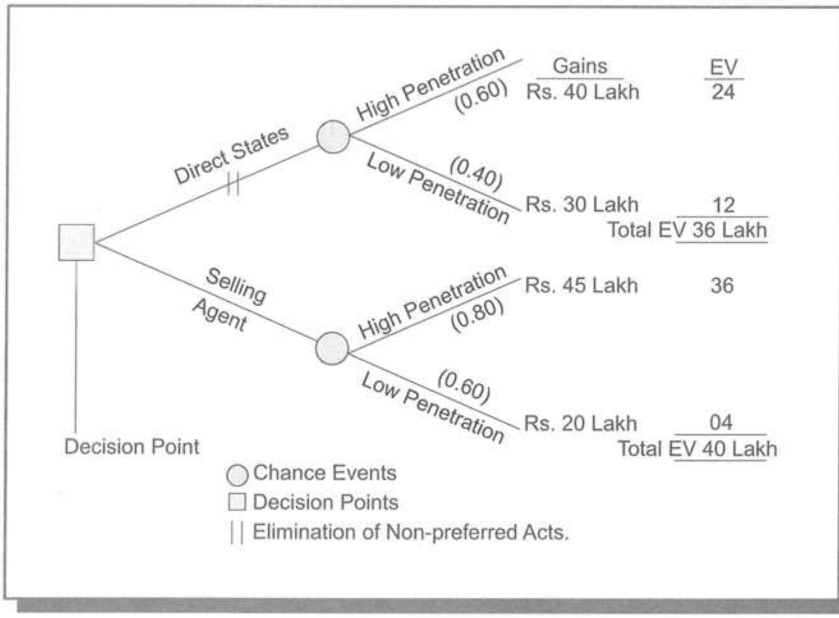

Fig. 10.9 Decision Tree – An Example

10.4.4 Optimisation Techniques

> **FOCUS** Modern management science offers a number of optimisation techniques for reaching a decision. These techniques assume that all alternatives and their outcomes are known.

Modern management science offers a number of optimisation techniques for reaching a decision. These techniques assume that all alternatives and their outcomes are known. The decision-maker is required to calculate the optimal alternative for his objective function. Various techniques which are used under this category include Linear Programming, Integer Programming, Dynamic Programming, Queuing Models, Inventory Models, etc.

10.5 DECISION-MAKING AND MIS

Having understood the process and concept of decision-making, let us now discuss the role of an information system in providing information to support decision-making in an organisation. We will also explore the relevance of this knowledge of decision-making for the design of an information system.

10.5.1 Information Support for Decision-Making Process

Simon's model of decision-making proposes three stages in the decision-making process. MIS plays its role in all the three stages. Given below is a brief description of these three stages of the decision-making process and the role of MIS.

Intelligence Stage

In this stage, an information system may provide information about internal as well as external environments. Internal information is generated from the functional areas, whereas external information is collected from various sources, such as databases, newspapers, government reports, personal contacts, etc. Availability of a large amount of information makes it necessary to scan the environment and data sources to get the relevant information. Thus, information systems can be used to scan the business environment of an organisation.

> **FOCUS** The role of an information system in providing information to support decision-making in an organisation is very important.

In order to get the required information in the intelligence phase of decision-making, MIS must be designed so as to answer pre-specified as well as *ad hoc* queries (unique, unscheduled, situation-specific) made by the decision-maker. In other words, information system design may have various models (like historical planning and extra organisational) and a query language capability (decision support system capability).

Design Stage

At this stage, various alternatives are developed and evaluated. In the case of structured decisions, information systems can support by quantifying and automating a decision-making process. On the other hand, for semi-structured to unstructured decisions, information systems can support such decision-making by providing:

(i) the ability to make *ad hoc* queries for information in the organisational databases, and

(ii) the ability to reach a decision in an interactive process (decision support system capability).

Thus, information systems should be designed to incorporate various models of business operations and advanced statistical, optimisation techniques, etc., so that these could be used to manipulate information already collected in the intelligence stage to develop and evaluate various alternatives.

Choice Stage

It is the choice stage in which a course of action is selected and feedback is collected on the implemented decision. Information systems can provide summarised and organised information to the decision-makers at this stage. Several models may be used to select the most appropriate alternative and thus help decision-makers select the best course of action. Information systems can also help the decision-maker monitor the successful implementation of a decision by providing feedback. During the process of decision-making, if the decision-maker chooses to return to any of the preceding stage for more information, such information support is again provided by the information system. An information system, to support the choice stage of the decision-maker, should have optimisation models and suggestion models.

10.5.2 Techniques Used in Decision-Making

Before we discuss the importance of DSS, let us also have a brief look at some of the techniques, which are often used in decision-making support. These techniques that follow complex approaches, are discussed, in brief, here:

(i) *Simulation:* In this approach, a mathematical model of the situation is created. Main decision variables are defined and the model is operated under different assumptions or with different starting conditions to help explore alternative paths for the real situation.

(ii) *Optimisation:* In optimisation technique, a mathematical model of the situation is developed. The model is designed so that optimisation techniques can be used to search for optimal values of decision variables.

(iii) *OLAP and Data Mining:* It uses statistical techniques to analyse business results and find hidden relationships.

(iv) *Expert Systems:* Here an expert's view of an area of knowledge in terms of facts and rules are summarised and then the facts and rules to a particular situation are applied to help someone else decide what to do.

(v) *Neural Networks:* It starts with a large set of coded examples that represents the range and frequency of possibilities in the situation being studied. Neural networks apply automated statistical 'learning' techniques to find the statistical parameters that best present correlations between groups of characteristics within the trading set.

(vi) *Fuzzy Logic:* In this approach, decision processes are controlled using logic systems that replace 'either – or' logic with logic based on relative degrees of inclusion in sets.

(vii) *Case-based Reasoning:* This approach creates a database of examples that may help in making decision. Adds another example to the database when the database does not cover a new situation.

(viii) *Intelligent Agents:* In this technique, decision parameters are specified for a computerised 'agent' that searches one or more databases to find a specific answer, such as the lowest price for a particular mobile set.

10.6 DECISION SUPPORT SYSTEMS – WHY?

Having discussed the conceptual framework for decision-making, let us now understand the need for computerised decision support systems. These systems have become necessary for today's manager because of the following reasons:

(i) *Fast Computation:* A decision-maker can perform a large number of computations very quickly and that too at a low cost with the help of computer support systems. Today, in majority of the decisions, time is the essence.

(ii) *Enhanced Productivity:* Support systems can enhance the productivity of support staff and also enable the group members to discuss the problems among themselves at a distance.

(iii) *Data Transmission:* Sometimes the data, which may be stored at different locations, may be required to be transmitted quickly from distant locations. Computer support systems can search, store, and transmit the required data quickly and economically.

(iv) *Better Decisions:* Computer support systems can help a decision-maker in arriving at a better decision. For example, more alternatives can be evaluated, risk analysis be performed quickly, and views of experts from different places can be collected quickly and at a lower cost.

(v) *Competitive Edge:* Decision support systems enable the users to get a competitive edge over their competitors as these systems enable organisations to change their operations frequently, re-engineer processes and structures, empower employees and innovate. Decision support technologies can create useful empowerment by allowing people to make good decisions, even if they lack some knowledge.

In view of the above-stated reasons, decision support systems are important tools in the hands of decision-makers, which come handy especially in their semi-structured to unstructured problems.

10.7 DECISION SUPPORT SYSTEMS: A FRAMEWORK

Decision Support Systems like MIS, have also been defined differently by different people and thus there is no universally accepted definition of DSS. It was in the early 1970s, when Scott Morton put forward the concept of DSS and defined DSS as an interactive computer-based system, which helps decision-makers utilise data and models to solve unstructured problems, and thereafter many other scholars like Little (1970), Alter (1980), Moore and Chang (1980), Keen (1980), etc., have defined the concept in different ways. However, the focus of all these definitions has been on the 'what' aspect, i.e. what a DSS does and 'how' aspect, i.e. how the objectives of DSS can be achieved. For the purpose of this book, we understand the definition of DSS as follows:

> **FOCUS**
> DSS is an interactive computer-based system, which helps decision-makers utilise data and models to solve unstructured problems.

A Decision Support System is a specialised kind of information system, which is an interactive system to supports in the decision-making process of a manager in an organisation, especially in semi-structured and unstructured situations. The system utilises information, models, and data manipulation tools to help make decisions in semi-structured to unstructured situations.

10.7.1 Components of Decision Support System

A Decision Support System comprises of three main components.

(i) a database;

(ii) model base; and

(iii) software providing interactive dialogue facility for the manager.

(i) **Database** The data in the database typically is a combination of master files (internal corporate data) and data from external sources.

(ii) **Model Base** The second component of the DSS is a library of models to manipulate and analyse the data in the desired ways. The model base might include econometric models to forecast demand by industry and simulation models of the corporation.

(iii) **Dialogue Box** A user interface is the third component. Through this, the user can communicate with the DSS. The physical interface generally consists of a terminal hooked up to the mainframe computer, either directly or by telephone. Micro-computers with modems are being used ever more frequently for this interface. These elements are illustrated in Fig. 10.10.

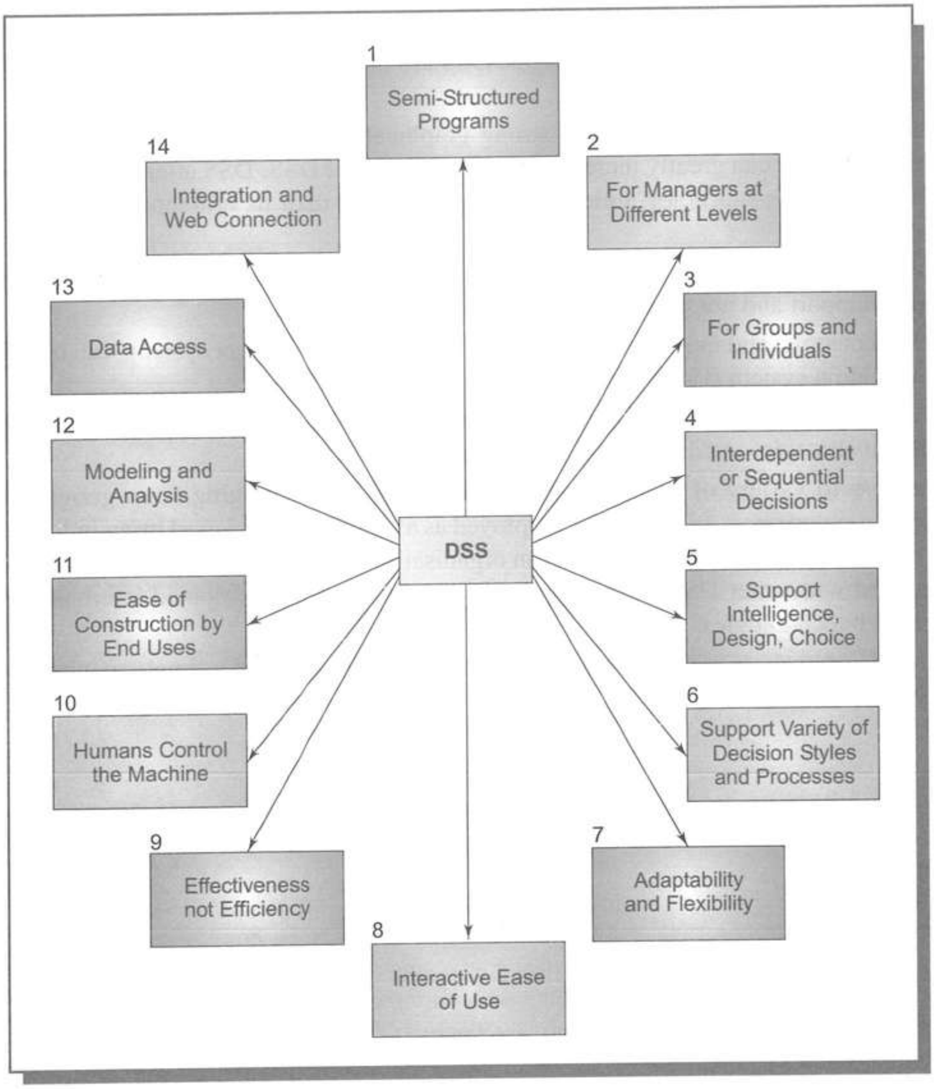

Fig. 10.10 The Ideal Characteristic and Capabilities of DSS (Turban et al., 2001, p. 99)

10.8 CHARACTERISTICS AND CAPABILITIES OF DSS

Different scholars have defined the characteristics and capabilities of DSS differently. Given below are the major DSS characteristics and capabilities, as suggested by Turban et al.:

1. DSS provide support for decision-makers mainly in semi-structured and unstructured situation by bringing together human judgements and computerised information. Such problem cannot be solved (or cannot be solved conveniently) by other computerised systems or by standard quantitative methods or tools.
2. Support is provided for various managerial levels, ranging from top executives to line managers.
3. Support is provided to individuals as well as to groups. Less-structured problems often require the involvement of several individuals from different departments and organisational levels or even from different organisations.
4. DSS provide support to several interdependent and/or sequential decisions. The decision may be made once, several times, or repeatedly.
5. DSS support all phases of the decision-making process: intelligence, design, choice, and implementation.
6. DSS support a variety of decision-making processes and styles.

7. DSS are adaptive over time. The decision-maker should be reactive, able to confront changing condition quickly, and be able to adapt the DSS to meet these changes. DSS are flexible, and so user can add, delete, combine, change or rearrange basic elements.
8. Users must feel at home with DSS. User-friendliness, strong graphical capabilities, and an English-like interactive human machine interface can greatly increase the effectiveness of DSS. DSS attempt to improve the effectiveness of decision-making (accuracy, timeliness, quality) rather than its efficiency (the cost of making decisions).
9. The decision-maker has complete control over all steps of the decision-making process in solving a problem. A DSS specifically aims to support and not to replace the decision-maker.
10. End users should be able to construct and modify simple systems by themselves. Larger systems can be built with assistance from information system (IS) specialists.
11. A DSS usually utilises models for analysing decision-making situations. The modeling capability enables experimenting with different strategies under different configurations.

The DSS should provide access to variety of data sources, formats, and types, ranging from geographic information system (GIS) to object-oriented ones. A DSS can be employed as a stand alone tool used by an individual decision-maker in one location, or it can be distributed throughout an organisation and in several organisations along the supply chain. It can be integrated with other DSS and/or applications, and it can be distributed internally and externally, using networking and Web technologies.

These characteristics allow decision-makers to make better, more consistent decisions in a timely manner, and they are provided by DSS major components.

SUMMARY

Decision-making is an essence of management. In other words, whatever a manager does, he/she does it through decision-making and MIS assists every manager in providing the required information, which is a vital and necessary input in decision-making. Decision-making is a process of selecting one optimum alternative from various alternatives. Thus, decision is the end result of the decision-making process. Simon has suggested three phases of the process of decision-making. They are Intelligence, Design and Choice phase. Though the flow of activities is from intelligence to design to choice, at any phase, a decision-maker may return to a previous phase. Organisational decisions vary in a number of ways. On the basis of the purpose of decision-making, these decisions may be classified into three classes, namely, strategic planning decisions, management control decisions and operational control decisions. Level of programmability can be another basis for categorising decisions into two main classes, i.e. programmed and non-programmed decisions. These decisions are also known as structured and unstructured decisions, respectively. Decision can also be categorised into three classes, namely, decision under certainty, decision under risk and decision under uncertainty on the basis of knowledge of outcomes. Selection of an alternative requires a method or a combination of methods to be employed. A decision-maker must know about these methods. Some of the important methods include decision theory or decision analysis, utility, decision tree and optimisation techniques. MIS plays a pivotal role in providing information at each and every phase of decision-making.

Decision Support systems are important tools in the hands of decision-makers, which come handy especially in their semi-structured to unstructured problems. A Decision Support System is a specialised kind of information system, which is an interactive system to supports in the decision-making process of a manager in an organisation, especially in semi-structured and unstructured situations. The system utilises information, models, and data manipulation tools to help make decisions in semi-structured to unstructured situations. A DSS can be employed as a stand alone tool used by an individual decision-maker in one location, or it can be distributed throughout an organisation and in several organisations along the supply chain. It can be integrated with other DSS and/or applications, and it can be distributed internally and externally, using networking and Web technologies.

REVIEW QUESTIONS

1. Differentiate between a 'decision' and a 'decision-making process'. Illustrate Simon's model of decision-making.
2. Give various bases for classifying decisions. Which is the most widely used basis? Why?
3. A decision problem involves four strategies, namely, A, B, C and D. There are three possible states of nature. On the basis of the following pay-off matrix, make the decision and provide pay-off using each of the following decision rules.

   Maximax, Maximin, minimise regret, expected value with equal probabilities.
4. With a suitable example, give an application of decision analysis, utility and decision tree. Discuss the advantages and disadvantages of each method.
5. Discuss the relevance and role of MIS in various phases of decision-making.
6. What is a decision-support system? Discuss its components, characteristics and capabilities.

ASSIGNMENTS

1. An example of each type of decision is given in the text for classification system of decisions; name a different example of a decision for each class.
2. Assume you are to take the following decisions.
   (a) Hire Siridhar as Vice-President for your company.
   (b) Develop a new product.
   (c) Purchase a computer system for your department.

   Identify the activities, which may have preceded the choice. Also classify each activity as either intelligence or design.
3. Build a DSS using Microsoft-Excel. Take a real-life example.

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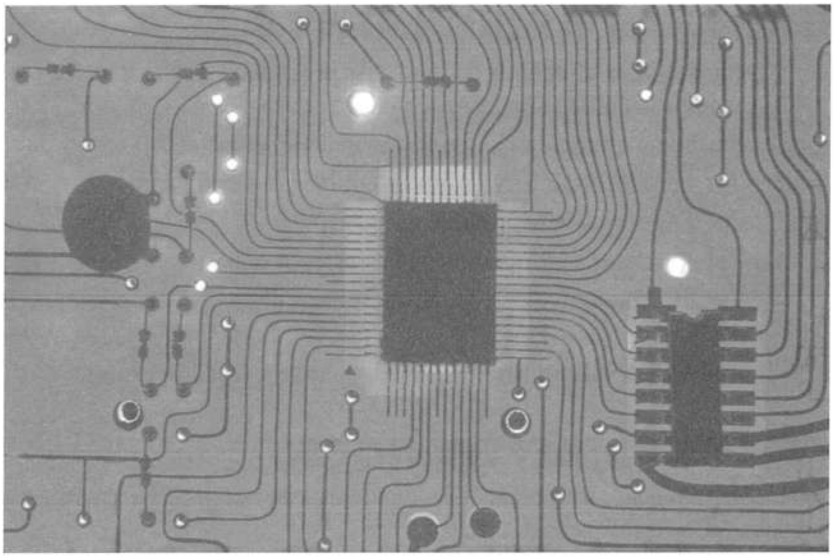
Chapter 11

Business Intelligence and Knowledge Management System



Learning Objectives

After going through this chapter, you should be able to:

- Understand the meaning of business intelligence and its benefits to organisations
- Know the concepts of data mining and online analytical processing
- Identify needs for knowledge management in organisations
- Explain the challenges in knowledge management and its benefits to organisations

11.1 BUSINESS INTELLIGENCE

Business Intelligence (BI) may be defined as knowledge – knowledge about your customers, your competitors, your business partners, your competitive environment and your own internal operations. This knowledge, in turn, enables the organisation to make effective decisions and decisions having strategic implications for the business. In other words, BI enables an organisation to extract the right meaning of information to take creative and important steps to get the competitive advantage. Thus, BI is much more than just a list of the products or services you deal with. It can combine the product information with the advertising strategy information and customer demographics information to help you determine the effectiveness of various advertising media on demographic groups segmented by income or by any other variable. As we know that data is a by-product of business transactions. In a business organisation, especially in the large organisation, numerous transactions take place and thus a lot of data is generated. Now-a-days, organisations collect and store this data electronically in database and data warehouses. Besides data generated from internal transactions, organisations collect data from external sources as well. With proper software tools, organisations can process this data to know trends, patterns and unknown facts and thus can know more about customers and suppliers, and, therefore, can make better decisions. Information technology also enables organisations to organise stored knowledge and garner knowledge from vast amount of unstructured data. As the purpose of BI is to improve the timeliness and quality of the input for decision making, it helps the managers to understand the

> **FOCUS**
> Business Intelligence (BI) may be defined as knowledge - knowledge about your customers, your competitors, your business partners, your competitive environment and your own internal operations.

- internal capabilities of the organisation,
- trends and future directions in the markets,
- external environment like economic, political, social, technological and demographic environment, and
- behaviour of the competitors.

In other words, BI encompasses both internal and external information, which is stored in various database. An organisation may have separate database for different applications. For trends, knowing internal capabilities and to understand the behaviour of the competitors, organisations transfer information from various databases into a common data repository known as a data warehouse.

11.1.1 Data Warehouse and Data Mining

A **data warehouse** is a logical collection of information, gathered from many different database and thus a data warehouse may be called as a large database containing historical transactions and other data. To illustrate this concept, let us take an example of a departmental store dealing in buying and selling grocery items. The data warehouse would deal with **granular** data, information in its raw form. Within the data warehouse, each transaction may be recorded. Table 11.1 shows transactions for a small portion of specific date (12 May 2010).

The purpose of data warehouse is permanent storage of detailed information. Data entered into a data warehouse needs to be processed to ensure that it is clean, complete, and in the proper format. Data warehouses are intended as permanent storage facilities. Many a times, a data warehouse is subdivided into smaller repositories called data marts. A **data mart** is a subset of a data warehouse, in which only the required portion of the data warehouse information is kept.

Table 11.1 Data Warehouse (an example)

Key	*Date*	*Customer ID*	*Name*	*City*	*Product*	*Item No*	*Quantity*	*Lot No*	*Price*	*Source*
1001	12510	FA456	Inderjeet	Patiala	Sugar	E019	5	AXY002	35.00	Raj Trading
1001	12510	KF459	Ashok	Jalandhar	Dal	A001	2	TBA247	98.50	Shivam
1001	12510	FC476	Amrit	Amritsar	Dal	A059	5	AB682	78	Mittal & Co
1001	12510	SF356	Darshan	Patiala	Besan		2	NN432	48	Raj Trading
1001	12510	FA457	Raj	Gurdaspur	Atta	B008	10	SF431	17	Raj Trading
7340	12510	C241	Balwant	Sangrur	Tea Leaves	A007	0.250	RT694	89	Raj Trading

However, data warehouses or data marts in themselves are of no use. To make data warehouses useful, organisations must use BI tools to process data from these huge database into meaningful information. There database are used for **data mining** and **online analytical processing (OLAP).** As discussed in Chapter 9, data mining and OLAP software are integrated into CRM systems to collect business intelligence about customers. This knowledge, in turn helps organisations acquire and retain its customers.

The organisations that develop business intelligence (BI) tools create interfaces that help the managers to quickly grasp business situations. Such an interface is simple to understand and interpretation by the managers becomes easy. One of such interface is called **dashboard,** because it looks similar to a car dashboard. Visual images like speedometer-like indicators for periodic revenues, profits, and other financial information; plus bar charts, line graphs, and other graphical representations are used in dashboards. Figure 11.1 shows a sample of dashboards.

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A **data warehouse** is a logical collection of information, gathered from many different databases.

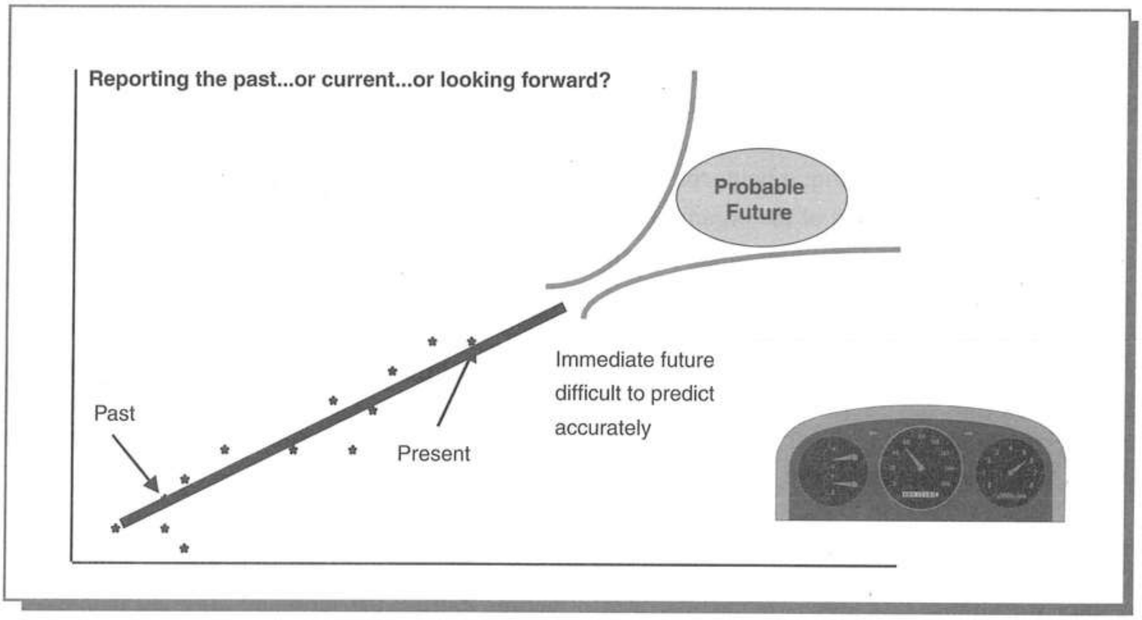

Fig. 11.1 Sample of dashboards

Data mining queries are more advanced and sophisticated than those of traditional queries. For example, a typical traditional query may be: 'What is the relationship between the amount of product A and the amount of product B that an organisation sold over the past week?' Whereas in the data mining, the manager would be interested to know the products that would be in demand in the coming weekend and thus the query from the data mining may be 'Find out the products most likely to have the maximum demand on the coming weekend.' This query meant for data mining would find patterns that would otherwise not be known through observation. Thus, data mining queries go one step beyond the traditional queries. While data has traditionally been used to see whether this or that pattern exists, data mining allows you to ask *what* patterns exist. In simple words, data mining lets the manager ask that he would not otherwise ask. The combination of data-warehousing techniques and data-mining software makes it easier to predict future outcomes based on patterns discovered within the historical data.

Data mining has four main objectives:

- *Sequence* or *path analysis:* Finding patterns where one event leads to another;
- *Classification:* Finding whether certain facts fall into predefined groups;
- *Clustering:* Finding groups of related facts not previously known;
- *Forecasting:* Discovering patterns in data that can lead to reasonable predictions.

As discussed in Chapter 9, data mining supports CRM mainly in following two ways:

- ***Automated prediction of trends and behaviors.*** Data mining automates the process of finding predictive information in large database. Questions that traditionally required extensive hands-on analysis can now be answered directly from the data quickly. A typical example of a predictive problem is targeted marketing.
- ***Automated discovery of previously unknown patterns***. Data mining tools sweep through databases and identify previously hidden patterns in one step. An example of pattern discovery is the analysis of retail sales data to identify seemingly unrelated products that are often purchased together.

Intelligent mining algorithms when applied to **data warehouse** which is consistent data store that serves as physical implementation of a decision support model, stores the information on which an enterprise needs to make strategic decisions. The model is generated as an outcome of the data mining tool, the model is then interpreted for the purpose of the business problem solution and strategies are formulated on the basis of which, actions are taken.

Data warehousing provides architecture and tools for business executives to systematically organise, understand and use their data for decision-making. Data warehouse systems play important role in today's competitive, fast-evolving world. Organisations are moving from a situation where they looked at what happened to a situation where they can influence what will happen. This is possible only by gaining insights into the business processes by applying data mining to a data warehouse. Data mining algorithms comb the database for the hidden patterns. Data mining process consists of the following sequence of steps (Han and Kamber, 2004):

1. *Data Cleaning*: To remove noise and inconsistent data.
2. *Data Integration*: Where multiple data sources may be combined.
3. *Data Selection*: Data relevant to the analysis task are retrieved from the database.
4. *Data Transformation*: Data are transformed or consolidated into forms appropriate for mining by performing summary or aggregation operations.
5. *Data Mining*: Process where intelligent methods are applied in order to extract data patterns.
6. *Pattern Evaluation*: To identify the truly interesting patterns representing knowledge based on some interestingness measure. Patterns are selected on interestingness basis.
7. *Knowledge Presentation*: Visualizations and knowledge representation technique are used to present the mined knowledge to the user.

The steps are represented in the pictorial form in the Fig. 11.2. The first three steps namely data cleaning, data integration, and data selection are the pre-processing steps, before the application of the data mining tool on the data warehouse. This is to prepare the database for the application of the tools for mining the data.

Having discussed the concept of data mining, let us now understand the concept of on-line analytical processing (OLAP).

11.1.2 On-line Analytical Processing (OLAP)

On-line analytic processing (OLAP) systems are multidimensional databases. These systems allow analysts to display data in one or more of a number of different dimensions, such as time, geographic region, product, organisational department, customer, or other factors. The data used by OLAP applications usually comes from a data warehouse. While data warehouse focuses on storing huge amount of data efficiently, OLAP systems are designed to make this data easy to analyse. In simple terms, OLAP is an extension of the structured query language (SQL) framework to accommodate queries that are not feasible on relational database.

An OLAP application would focus more on analysing trends or other aspects of organisational operations. It may obtain much of its information from the data warehouse. The OLAP application extracts granular information that is of interest to the users being supported, aggregates this information, and makes the information easily accessible on a number of dimensions. Data mining analytics go beyond OLAP, as it provides abilities for discovering insights that are computer-driven and not end-user driven. Data analytics software like SPSS, SAS, Minitab and Systat are using statistical tools to a large extent providing the organisations a user-friendly environment in data processing and timely decision-

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On-line analytic processing (OLAP) systems allow analysts to display data in one or more of a number of different dimensions.

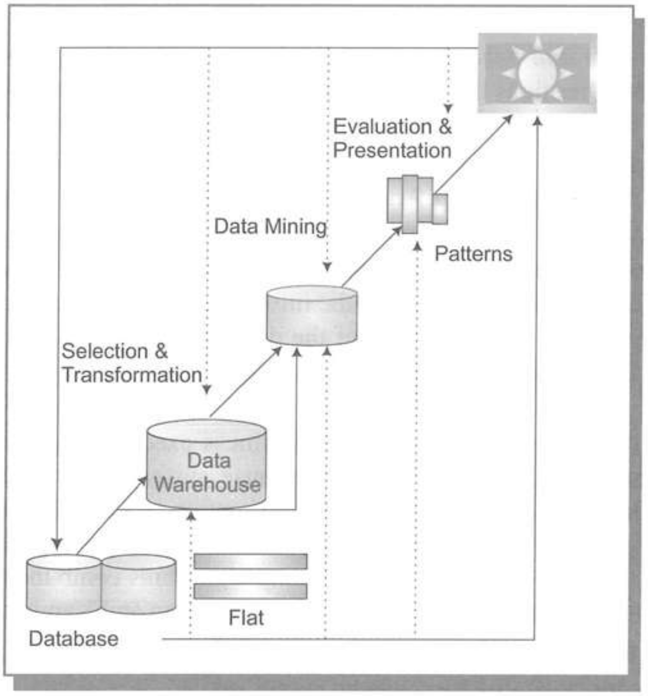

Fig. 11.2 Data Mining Process

making.

Drilling down is a process in which one starts with a table that shows broad information and gradually retrieves tables of more specific information. For example, the OLAP application lets you receive the information in numbers of employees or as their percentages in each region, department, or organisational units within the department.

Business intelligence is a way to truly understand markets, competitors, and processes. Software technology such as data warehouses, data marts, and data mining or on-line analytical processing (OLAP) makes it possible to sift through data to find out trends and patterns that can be used by the organisation to improve profitability. Business intelligence finds its application in a large number of areas, for example in marketing, banking, human relations management, insurance, credit card management etc. Marketing managers are required to study the buying patterns so as to target the potential buyers. Similarly bankers are required to find profitable customers and patterns of fraud. Some of the Business intelligence applications are discussed here.

Business intelligence Applications in Business

Business intelligence is used in diverse areas of business. Let us discuss some of the applications of business intelligence in business.

Retailing

Retailers in general and grocery stores in particular, can get valuable predictive information from data mining. Grocery stores generate huge amount of data that require automated tools for analysis. Now-a-days, data mining tools can be employed on this data stored in data warehouse to find the likings, disliking, shopping behaviour and other patterns, etc., and thus become very effective in formulating and implementing retailing strategies.

Customer Relationship Management

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Some of the applications of Business intelligence in business are:
Retailing, Customer Relationship Management, Credit card Management, Insurance, Telecommunications, Telemarketing and Human Resource Management.

Customer Relationship Management (CRM) allows businesses to identify the profitability of specific customers and to increase chances of retaining them. This can be achieved by having all relevant information readily available that is needed for planning, development and selling of the products. It is also equally important to know the factors that motivate the customers so as to provide the customer with the right product, at the right price and at the right place.

Credit Card Management

Data mining can also be used in credit card management. From a large number of credit card users, banks can find out the most profitable customers and also can target its credit card campaign to the right set of potential customers. Data warehouses provide information that allows issuers more accurately predict what the customer is interested in, as well as the customer's potential value to the issuer.

Insurance

The insurance industry can also find useful applications of data mining tools to detect frauds and to market its products. By linking names, telephone numbers, streets, birthdays, and other information with slight variations, patterns indicating fraud can be identified. Consolidating data internal and external to the insurance company creates a data mart that can be used for advanced search.

Telecommunications

In the last two decades, telecommunication industry has seen a new revolution. With so many players, it has really become difficult to retain the customers. The phenomenon of a customer switching carriers is referred to as chum, a fundamental concept in telephony as well as in other fields. Analysis using data mining can reduce this customer churn to a great extent.

Telemarketing

Telephone providers are among the many marketing operations utilising telemarketing. Data mining can be used on the collected data to determine segments based on common characteristics, like the set of customers who respond to new promotions; the set of customers who respond to discounts; or the set of customers who respond to new product offers. Once segments have been defined, on-line analytic processing tools can be used to explore in greater depth.

Human Resource Management

In the human resources field, this analysis can lead to identification of individuals who are liable to leave the company unless additional compensation or benefits are provided. A firm might know that 20 per cent of its employees use 80 per cent of services offered, but may not know which particular individuals are in that 20 per cent. Business intelligence provides a means of identifying segments so that programs can be devised to cut costs and increase productivity. Data mining can also be used to examine the way in which an organisation uses its people. It can help determine whether the most talented people are working for those business units with the highest priority or where they will have the greatest impact on profit. (Roberts, 1999).

11.2 KNOWLEDGE MANAGEMENT SYSTEM

We have realised that business organisations need business intelligence or knowledge to compete in this competitive world. When knowledge (experience based know-how) is being regarded as a key asset, it becomes not only important rather essential that organisations must devote sufficient time and financial resources to manage this resource carefully and thus a proper knowledge management system must be in place. Knowledge management system, in its broadest sense may be defined as a strategy, a framework, combination of activities, or a system that is designed to help organisation create, capture, analyse, apply and reuse knowledge to improve its performance and to achieve competitive advantage. In simple words, a core aspect of knowledge management (KM) is 'getting the right knowledge to the right people at the right time in the right format.' Let us try to understand the basic terminology involved in knowledge management.

In simplest terms, knowledge is aggregation of what is known, the body of truth, information and experience gathered by a person. It starts with data (raw facts), which is processed and converted into information by putting it into context and further converting the information into knowledge by combining it with experience and judgement. Thus, knowledge is at the highest level in a hierarchy with information at the middle level, and data to be at the lowest level. The concept of knowledge has been shown in Fig. 11.3.

> **FOCUS**
> KMS, is a system that is designed to help organization create, capture, analyze, apply and reuse knowledge to improve its performance and to achieve competitive advantage.

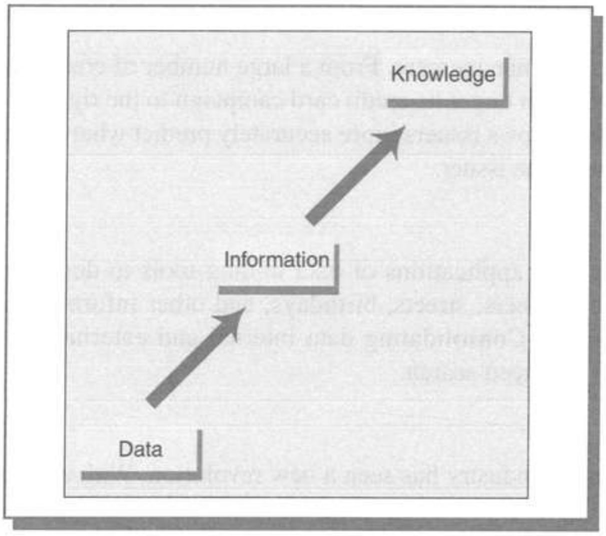

Fig. 11.3 Knowledge hierarchy

When a pattern relation exists amidst the data and information, the pattern has the potential to represent knowledge. It only becomes knowledge, when one is able to realise and understand the pattern and their implications. Thus, one needs to understand that

(a) collection of data is not information
(b) collection of information is not knowledge
(c) collection of knowledge is not wisdom
(d) collection of wisdom is not truth

Further knowledge can be divided into two parts, namely, explicit knowledge; and tacit knowledge. While *explicit knowledge* is always tangible, transferable and can be documented, (for example databases, text books, formulae and equation etc.); *tacit knowledge* may be intangible or in unconscious mind, non-transferable or personal, and exists in the minds of persons, for example, experiences, know-how, perceptions and insights, etc.

The ultimate aim of KM is to avoid reinventing the wheel and leverage cumulative organisational knowledge for more informed decision-making. Information Technology (IT) is recognised as a key enabler of KM. Without the capabilities of IT in terms of both storage and communication, leveraging of knowledge resources would hardly be feasible.

It is often argued that knowledge cannot be managed, because knowledge is a personal attribute, which is elusive to manage. But at the same time, the other school of thought says that though knowledge is difficult to be controlled, capturing and sharing knowledge can be encouraged and facilitated and the environment with in which knowledge flourishes can certainly be managed.

Managing knowledge involve creating the following:

- *Right conditions* need a culture of trust, openness, sharing and learning;
- *Right means* need a systematic approach ,tools and processes ofr exchanging knowledge; and
- *Right actions* where people instinctively seek, share and apply expensive, best practice, know-how and new ideas.

The tracks of knowledge management have been identified as

Management of information **i.e.** knowledge equals to objects that can be identified and handled in information system; and

Management by people knowledge consists of processes, complex set of dynamic skills , know-how etc that is constantly changing.

The concept of knowledge management has been illustrated in Fig. 11.4.

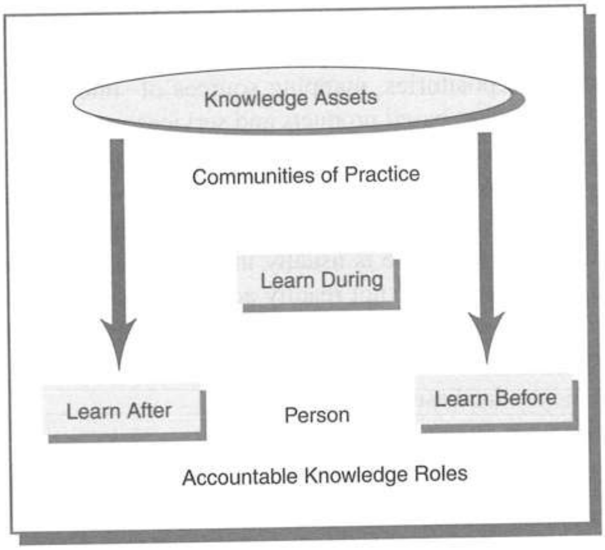

Fig. 11.4 Knowledge Management Model

The components of the model are discussed as below:

- A *Knowledge Asset:* It is validated knowledge, captured and stored for reuse. Knowledge assets often contain the context behind the activity, recommendations for how to do the activity in future, a list of people with relevant experience, stories from the past and valuable reusable documents.
- *Learning Before:* Knowledge is accessed at the start of a project or a piece of work, to ensure that you start the work with a full knowledge base. You can learn before through accessing knowledge assets, interviewing experts or holding a peer assist.
- *Learning During:* New knowledge is identified and collected during implementation, while work is in progress, so that operational plans can be changed immediately as new knowledge becomes available. The after-action review is a good process for learning during.
- *Learning After: Upon* completion of a task or at the end of a project cycle, the knowledge is collected from all those who took part and collated for future use. A retrospect is a suitable process for learning after.
- *Communities of Practice:* These are networks dedicated to sharing knowledge among practitioners, in order to help them practice better. These practitioners can be professionals within the organisation, or in several organisations, or they can be armatures who form a community that is not work-related at all. The members of community share a common sense of purpose and desire to share work-related knowledge and experience.
- *Accountable Knowledge Roles* They are represented by the face with in the business activity cycle at the bottom of the model picture. Individuals need to be identified who can take responsibility for making sure that knowledge management processes are applied and that knowledge is captured, collated, validated, stored and reused.

To facilitate the leveraging of knowledge, organisations can use *Knowledge Management Systems* (KMSs) that are defined as a class of information systems applied to managing organisational knowledge. That is, they are IT-based systems developed to support and enhance the organisational processes of knowledge creation, storage/ retrieval, transfer and application (Alavi and Tiwana, 2002). The technologies for the knowledge management system include intranets and extranets, search and retrieval tools, content management and collaboration tools, data warehousing and mining tools, and groupware and Artificial Intelligence (AI) tools like expert systems and Knowledge Base Systems (KBS). The concept of coding and transmitting knowledge in organisations is not new: training and employee development programmes, organisational policies, routines, procedures, reports and manuals have served this function for many years. What is new and exciting in the KM area is the potential offered by modern IT (e.g. the Internet, intranets, browsers, data warehouses, data filters and software agents etc.) to systematise, facilitate and expedite organisation, wide KM (Alavi and Leidner, 1999). The critical role for IT lies in its ability to support communication, collaboration and the search for knowledge, and its ability to enable collaborative learning. Examples of IT-based knowledge management systems include, creating an intranet, data warehousing, implementing decision-support tools, implementing groupware to support collaboration, creating networks of knowledge workers, creating knowledge repositories, mapping sources of internal expertise, establishing new knowledge roles, and launching new knowledge-based products and services.

Information that can be gleaned from stored data is knowledge, but many a times, organisations may not have all the information in its stored data. The knowledge that is not maintained in information systems is typically of the type that cannot be extracted from readily captured data at websites or other electronic means of transactions. It is accumulated through experience. The experience is usually in the minds of the employees, on paper notes, on discussion transcripts, and in other places that are not readily accessible to the employees of the organisation. Therefore, knowledge management is a great challenge. Knowledge management is the attempt by organisations to put procedures and technologies in place to do the following:

- Transfer individual knowledge into databases.
- Filter and separate the most relevant knowledge.
- Organise that knowledge in databases that allow employees easy access to it or that 'push' specific knowledge to employees based on pre specified needs.

11.2.1 Knowledge Management Strategies

There are a number of strategies that can be formulated and implemented for the knowledge management systems in the organisations. Let us discuss these strategies:

What knowledge to share: The knowledge sharing program may be limited to a specific function, such as sales and marketing, or research or a specific area of expertise such as engineering. The question of 'What to Share' includes not only the type of knowledge but also its quality.

With whom to share knowledge: Knowledge sharing programs may aim at sharing with either an internal or an external audience. Internal knowledge sharing programmes aim at making the existing business work better, faster or cheaper by arming the front-line staff of an organisation with higher quality more up-to-date and easily accessible tools. External knowledge sharing poses greater risks than internal sharing programs – raising complex issues of confidentially.

How will knowledge be shared: In this strategy, the organisations need to decide about the principal channels by which knowledge will be shared? It may include face-to-face, with the help desks, by telephone, by fax, through email collaborative tools on the web, or may be some combination of these mentioned strategies.

Why will knowledge be shared: Knowledge management is undertaken for supporting the business of the organisation and thus knowledge should be shared to increase speed, lower the cost of operation, and accelerate innovation and to increase the client base.

However, one needs to understand that different organisation may have its unique needs and problems, and thus an organisation must understand its needs and problems before formulating a strategy. It must be made sure that a knowledge management strategy must address the real needs and issues.

SUMMARY

EBI enables an organisation to extract the right meaning of information to take creative and important steps to get the competitive advantage. Thus, BI is much more than just a list of the products or services you deal with. It can combine the product information with the advertising strategy information and customer demographics information to help you determine the effectiveness of various advertising media on demographic groups segmented by income or by any other variable. As we know that data is a by product of business transactions. In a business organisation, especially in a large organisation, numerous transactions take place and thus a lot of data is generated. Now-a-days, organisations collect and store this data electronically in database and data warehouses. Besides data generated from internal transactions, organisations collect data from external sources as well. With proper software tools, organisations can process this data to know trends, patterns and unknown facts from this data and thus can know more about customers and suppliers, and therefore can make better decisions. Information technology also enables organisations to organise stored knowledge and garner knowledge from vast amount of unstructured data.

A **data warehouse** is a logical collection of information, gathered from many different database and thus a data warehouse may be called as a large database containing historical transactions and other data. The purpose of data warehouse is permanent storage of detailed information. Data entered into a data warehouse needs to be processed to ensure that it is clean, complete, and in the proper format. Data warehouses are intended as permanent storage facilities. Many a times, a data warehouse is subdivided into smaller repositories called data marts. A **data mart** is a subset of a data warehouse, in which only the required portion of the data warehouse information is kept. However, data warehouses or data marts in themselves are not of any use. To make data warehouses useful, organisations must use BI tools to process data from these huge database into meaningful information. There database are used for **data mining** and **online analytical processing (OLAP).**

Knowledge management system, in its broadest sense may be defined as a strategy, a framework, combination of activities, or a system that is designed to help organisation create, capture, analyse, apply and reuse knowledge to improve its performance and to achieve competitive advantage. In simple words, a core aspect of knowledge management is 'getting the right knowledge to the right people at the right time in the right format.' Let us try to understand the basic terminology involved in knowledge management. To facilitate the leveraging of knowledge, organisations can use *Knowledge Management Systems* (KMSs) that are defined as a class of information systems applied to managing organisational knowledge. As every organisation may have its unique needs and problems. A knowledge management strategy must address the real needs and issues.

REVIEW QUESTIONS

1. Describe data warehouse, a data mart and online analytical processing. Briefly discuss the data warehouse architecture.
2. Describe the process of knowledge discovery and discuss the roles of data warehouse and OLAP in this process.
3. Elaborate the concept of Data mining. Discuss the major characteristics and applications of data mining in business.
4. What is meant by knowledge management? How would you create and maintain knowledge base. Answer by taking a suitable example.
5. Discuss the main challenges to implement knowledge management in organisations. Discuss main technologies of knowledge management.

ASSIGNMENTS

1. Visit an organisation in your locality and study its business intelligence and knowledge management systems. How would you improve its existing knowledge management systems?
2. Study knowledge management initiative in an organisation and evaluate the reasons for its success or failure.

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CASE STUDY 1

KNOWLEDGE MANAGEMENT SYSTEMS AT ANIL CONSULTANCY

Anil Consultancy is a software services and consulting company having its headquarters in Pune. It is the leading provider of services like - information technology and business process outsourcing in the country as well as to Global clients.

Anil Consultancy was established in year 1961 and happens to be a pioneer in the Indian IT industry. From the year 1970, Anil Consultancy started exporting their services. Their first international order was from Germany. They were given assignment of writing code for Heavy machines for some UK-based clients. This experience helped Anil Consultancy bag their first onsite project, a data centre for eight banks, which catered to more than one million customers in the US.

In the year 1984, Anil Consultancy set up its first software R&D centre. During early 1990s, the IT outsourcing industry of India grew tremendously because of two main reasons- the Y2K bug and launch of Euro (unified European currency). It was Anil Consultancy who pioneered 'new model' for Y2K conversion. They also developed software tools which led to automation of the conversion process and enabled other third-party developers as well as clients to make use of it.

Vision

Global Top 10 by 2012

Mission

To help customers achieve their business objectives, by providing innovative, best-in–class consulting, IT solutions and services.

To make it a joy for all stakeholders to work with us.

Values

Leading change, Integrity, respect for the individual, Excellence, Learning and sharing.

HUMAN RESOURCES (HR) FUNCTION AT ANIL CONSULTANCY

Human resources (HR) function is working closely with senior management, business segments, line management and functional leaders in Anil Consultancy. It is responsible for the following activities:

- **Employee services:** Employee services are important part of HR services. HR department study the industry trends and use the communication and feedback from employees to continuously improving the services. These services go a long way in employee-company relationship as these promotes organizational citizenship and generate respect and admiration in employees about the company.
- **Talent management:** Talent management is one of the core functions for the HR department. Talent management involves arranging specially requested training programs on demand from employees to improve their competencies. It covers the appraisal process and payroll issues. It involves regularly updating the new competencies acquired by the employees.
- **Workforce management:** It basically consists of workforce management and global recruitment system. It is responsible for allocating resources to the project teams. Resource management groups handle the request for team members. Global recruitment system is responsible for attracting and hiring new talent from the other companies. They use employee referrals to contact the resources. They also create database of people who apply for job and screen them for project requirements. IT involves taking service of the consultancy firms to get access to new resources.

As part of providing an IT solution to reach the strategic goals of the company, company has developed a project Kinfo, the official portal of Anil Consultancy. The outcome of Kinfo was a cohesive network and method for deploying all internal processes, together with HR, finance, and project management. Kinfo included J2EE based customized module using rule engines, workflow services, and SOA based on the ERP suite.

It is single sign-in portal with a personalized log-in and password for all Anil Consultancy employees. It connects over 80000 Anil Consultancy employees in 49 countries to a single platform. It is one-stop solution for all the issues related to employees. On one platform, it tackles issues related to employee services, finances, career plans, infrastructure and administrative issues. The employees of Anil Consultancy can connect to any other employee anywhere in the world and can share knowledge. The biggest achievement of this software is efficient flow of information. It contains a bulletin board which shows latest happenings in the company. Employees can get information regarding the latest social and corporate events taking place in the Anil Consultancy. Employees can be informed about the policy changes.

One more important aspect of Kinfo is knowledge management. It contains links to technical and managerial resources. It helps employees improve their knowledge by continuously updating link to make latest additions accessible to the employees. It also allows employees to update their competency details on-line so that they don't miss out on opportunities.

It is a complete portal for all internal processes like payroll, appraisal, travel plans, exit etc. It is a time-efficient and cost – efficient solution to the unproductive internal processes of the company.

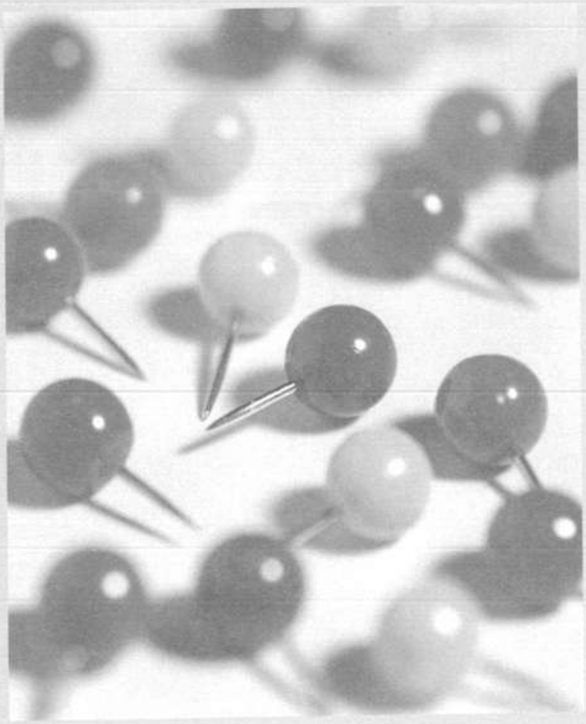
QUESTIONS FOR DISCUSSION

(1) Comment on the Knowledge management System at Anil Consultancy.

(2) If you are invited as a consultant, how would you improve the Knowledge Management System at Anil Consultancy? Discuss.

Part

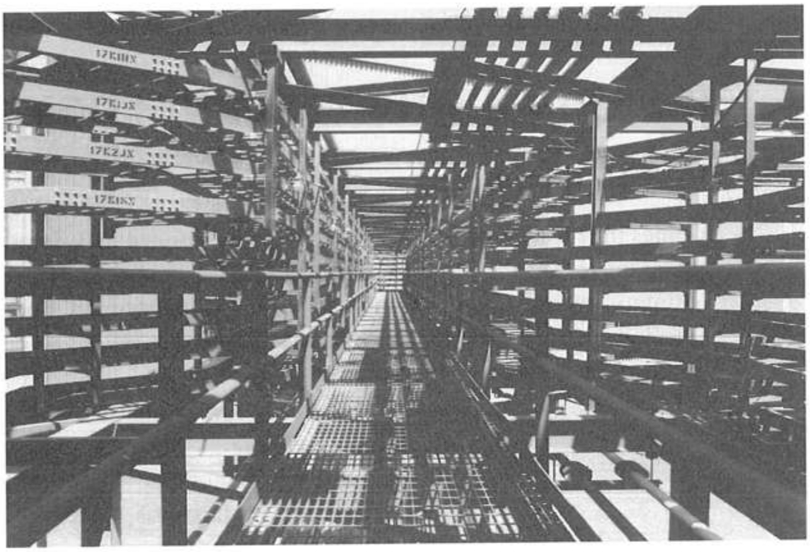
4 Management of Information Systems



Chapter Outline

Chapter 12

Information System Planning



Learning Objectives

After reading this chapter, you should be able to:

- Understand the need, importance and related terminology of IS planning
- Identify the stage(s) of IS planning in an organisation
- Explain the four-stage model of IS planning
- Discuss different methodologies for conducting strategic information system planning

12.1 INFORMATION SYSTEM PLANNING: WHY?

There is no need to emphasise the importance of planning, suffice it to say that planning is vital to success. Organisations that plan their information systems (IS) tend to achieve better results than organisations that do not, yet studies reveal that many organisations either do not plan or do it unsystematically. The business organisations today are quite dynamic and exist in an ever-increasing competition. Accordingly, they have to develop and update their information systems in a systematic way. This requires an overall plan for the information system in the organisation. The IS plan is a comprehensive one which is derived from the organisational strategic plan. The information system plan generally includes the goals, objectives and structure of information systems, the available information system resources and future developments which may affect the plan. There are a wide variety of methodologies for information system planning. These methodologies have been discussed in the later part of this chapter. A plan, articulates the actions that organisations feel are necessary to achieve their goals. Thus, a plan acts as a basis for action. Before we study IS planning, let us briefly take a look at the planning terminology.

> **FOCUS**
> Organisations that plan their information systems tend to achieve better results than organisations that do not.

12.2 PLANNING TERMINOLOGY

12.2.1 Mission

It states the basic purpose for which an organisation exists. In other words, the mission statement is a broad, enduring statement giving the organisations 'reason for being'. It answers the basic questions, 'What is our business?' and distinguishes one organisation from similar organisations. For example, the mission of an oil organisation is stated as follows: 'To stimulate, continue and accelerate efforts to develop and maximise the contribution of the energy sector to the economy of the country'.

Similarly, the General Electric Corporation of the United States, declared about two decades ago. 'We are in energy business', despite the fact that the company's main activity was manufacturing and selling electrical goods. This explains that the company in defining its business, keeps future in view and this gives a broad statement of its mission.

> **FOCUS**
> Strategic Planning Includes: Mission, Objectives, Strategies and Policies.

12.2.2 Objectives

Objectives are the desired future positions and destinations the organisation intends to reach in order to fulfil its mission. For example, to raise the average ROI to 20 per cent per annum may be one of the objectives of an organisation. Sometimes, the terms 'objectives' and 'goals' are differentiated by experts on the basis of generality and specificity. Thus, where objectives are understood in generic terms, goals are regarded as specific, time-based points of measurement that the organisation intends to meet in pursuit of its broad objectives. Goals are stated to the maximum possible extent in quantitative terms. The emphasis is on measurement of progress towards the attainment of objectives. For example, if a firm has 20 per cent ROI as its objective, it might establish a schedule indicating earnings and investment positions necessary to attain its objective. However, objectives and goals have overlapping connotation because of which these two terms are used interchangeably.

12.2.3 Strategies

A strategy is a general direction in which an objective is to be sought. For example, if an objective is to increase earnings per share, it can be attained through action in many directions – new products, acquiring small companies, selling more in existing or new markets and even disinvestment of losing propositions. Each of these then will be termed as a strategy.

12.2.4 Policies

A policy is a general guideline that directs and constrains decision-making within an organisation. In other words, a policy is a statement of intended behaviour for the organisation. Policy limits the scope of alternatives to be considered in decison-making in the implementation of a strategy. For example, if the strategy calls for dropping a product-line, the policy spells out the criteria under which the product-line becomes a candidate for disposition. Policies are implemented by rules and procedures, which are more specific statements than direct decision-making.

12.3 INFORMATION SYSTEM PLANNING

Information system planning, essentially involves

(i) identification of the stage(s) of IS in the organisation;

(ii) identification of the applications of organisational ISs;

(iii) evaluation of each of these applications, based on established evaluation criteria;

(iv) establishing a priority ranking for these applications; and

(v) determining the 'optimum' architecture of IS for serving the top-priority applications.

Nolan stage model helps identification of the stage(s) of the IS in the organisation, whereas IS planning methodologies provide assistance in other activities of the IS planning process.

12.4 THE NOLAN STAGE MODEL

Richard Nolan (1974) has discussed a framework for IS planning, popularly known an Nolan stage model. The basic premise of the model is that any organisation will move through stages of maturity with respect to the use and management of IS. While progressing, an organisation must go through each stage of growth before it can move to the next stage. In fact Nolan stage model is a contingency model that helps managers diagnose the stage(s) of IS in an organisation and thus provides a set of limits to planning. The model has been called contingency model because it states: IF these features exist THEN the information system is in this stage.

The Nolan stage model has identified four stages of information system growth. A brief description of these stages is given below:

Stage 1

The first growth stage is known as *initiation* stage. In this stage, the technology is placed in the organisation. A few applications in the organisation are computerised. There are only a small number of users. This stage is characterised by minimum planning.

Stage 2

This growth stage is called *expansion* or *contagion* stage. During this stage rapid and uncontrolled growth in the number and variety of IT applications takes place. Many users adopt computers in solving their IT-related problems.

Stage 3

This stage is known as *formalisation* or *control* stage because in this stage, organisations gain control over the technology's resources by implementing formal control processes and standards. Thus, organisations are able to apply cost-effectiveness criteria. However, controls sometimes become barriers in attaining potential benefits.

Stage 4

Nolan has described this growth stage as *maturity* or *integration* stage, as by this stage organisations gain sufficient experience and maturity in IS/IT applications. In this stage, applications are integrated, controls are adjusted. Planning is well-established. That is why this growth stage sometimes is also called the stage of perfection.

The shape of the IS growth curve is similar to sigmoid or S curve. The S curve, which describes the growth phenomenon in organisations and organisational activities, is widely applied to the marketing of products. Figure 12.1 portrays the four stages of information system growth.

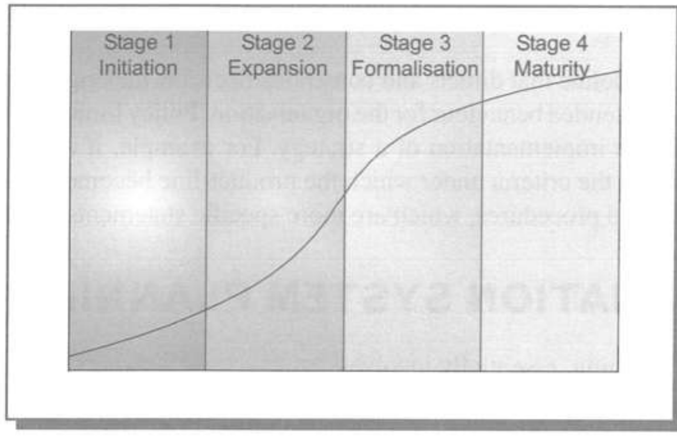


Fig. 12.1 Stages of Nolan's Growth Model

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
Growth Process	Initiation	Contagion	Control	Integration	Data Administration	Maturity
IS organisation	specialised for technology learning	users' need-based programs	middle-management	user/IS account teams	data administration	data resource management
Application portfolio	cost reduction applications	large no. of applications	restructuring of existing applications	database technology	integration of applications	total integration, effective information flows
Planning and control	less	more/less	formalised	tailored systems	shared data systems	data resource strategic planning
User awareness	'hands off'	superficially enthusiastic	arbitrarily held accountable	accountability learning	effective accountable	acceptance of joint user and IS accountability

(*Source:* Adapted from Richard L. Nolan's paper on Managing the Crisis in Data Processing, Harvard Business Review, March-April, 1979, pp. 115–26).

Fig. 12.2 Stages of Growth Model – Six Stages Discussing the Features for Growth Processes at Each Stage of Growth

Nolan in the year 1979 enhanced his earlier model to six stages (see Fig. 12.2) and advocated that four stages were not enough to describe the proliferation of IT in an organisation and thus added Stage 5 and Stage 6.

Stage 5

This is the stage of *data administration*. This stage features a new emphasis on managing corporate data rather than IT. Thus, in this stage, controls are further lowered to encourage development of systems which contribute to strategic advantage to the organisation.

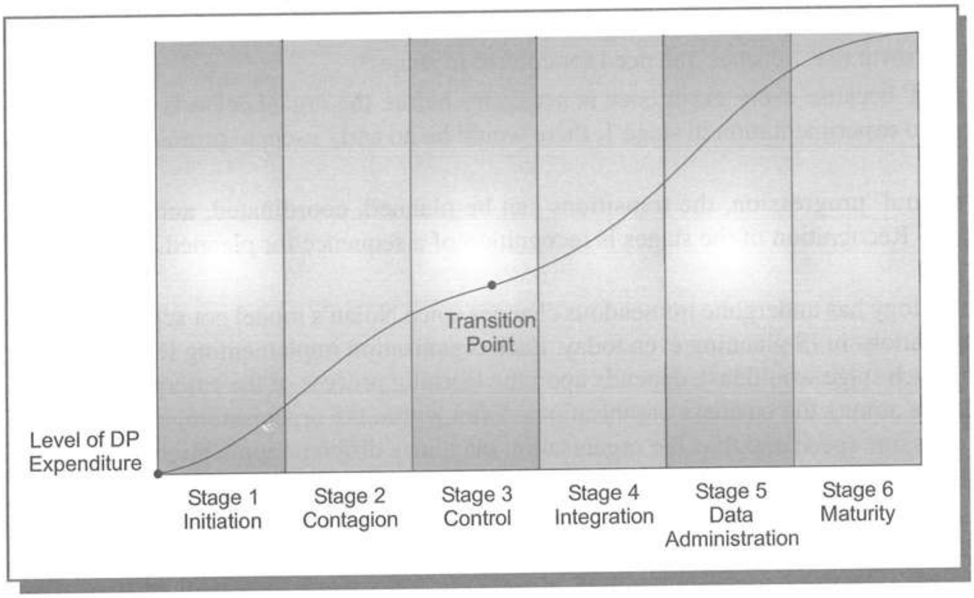


Fig. 12.3 Six Stages of Nolan's Enhanced Model

Stage 6

In the enhanced growth model, this stage is termed as the *maturity* stage. This stage indicates that the application portfolio is complete and matches the objectives of the organisation. Thus, planning and development of IS in the organisation is embedded into the business development. Figure 12.3 portrays the six-stage growth model.

In this six-stage model, the IS growth curve takes the shape of a double 'S', which indicates that the investment will rise sharply in the first two stages and would stablise by the end of the third stage. Again the investments will increase in the fourth stage only to take a steady shape at the last stage of the growth curve, i.e. maturity stage.

Nolan also proposed an alternative model without a maturity stage. He suggested that major changes in technology lead to repetition of the stages of growth. In such cases, organisations experience a repeat of the characteristic S-cuve as illustrated in Fig. 12.4.

Thus, the major changes in the technology eliminate the maturity stage. New technology leads the organisation to start on a new growth curve. It may be noted that the start point is not zero, but nor is it a smooth continuous progression.

Nolan's model is based on certain assumptions. These assumptions are as follows.

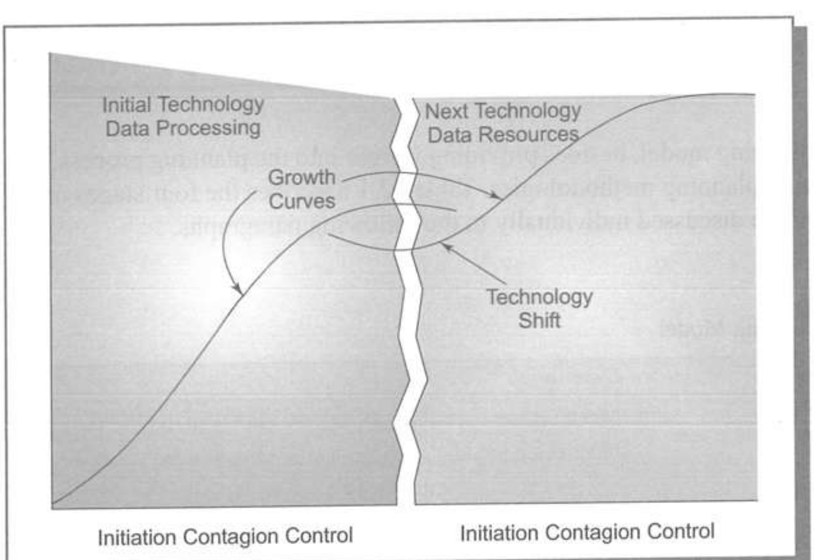


Fig. 12.4 Stages of Growth Model – Repeating Stages

(i) Organisational learning permits the movement through stages. The experimentation of stage 1 leads to the growth stage 2. It is the growth that 'teaches' the need for control in stage 3.

(ii) Stages cannot be 'skipped' because every experience is necessary before the organisation is ready for the next stage. So if there is no experimentation in stage 1, there would be no early users to promote contagion, i.e. stage 2, and so on.

(iii) Although there is a 'natural' progression, the transitions can be planned, coordinated, and managed to allow painless movement. Recognition of the stages is recognition of a sequence for planned and managed change.

No doubt, information technology has undergone tremendous changes since Nolan's model got acceptance. But it finds its validity in many applications in IS planning even today. Each organisation implementing IS has to move through these stages. How long each stage would last, depends upon the learning process of the enterprise, as there may be both slow and fast learners among the business organisations. Even within the organisation, all application sub-systems may not grow at the same speed and thus the organisation may have different applications in different stages. For example, accounting may be in stage 3 while marketing may still be in stage 2.

The model can be applied both in diagnosing the current stage of growth the organisation is in and in planning changes to move in a controlled way to the next stage. In other words, this model helps managers to be proactive. Second, the model helps minimising the risks associated with IS planning as it is important as well necessary that every new technology be absorbed in the organisation before it can offer its benefits to the users. Mere implementation of new IT is no solution to the problems of any organisation. It may even aggravate the problem further. The process of absorption of IT is evolutionary and not revolutionary.

12.5 THE FOUR–STAGE MODEL OF IS PLANNING

A wide variety of techniques are being applied for IS planning. However, organisations select these techniques based on the persuasive power of IS developers rather than on a sound logic. The main reason of selecting wrong techniques is attributed to the non-identification of the stage the information system of the organisation is in. A four-stage model of IS planning, which is an enhancement of the three-stage model developed by Bowman et al. (1983), has been depicted in Fig. 12.5. This model describes the four generic planning activities, namely, strategic planning, requirement analysis, resource allocation and project planning.

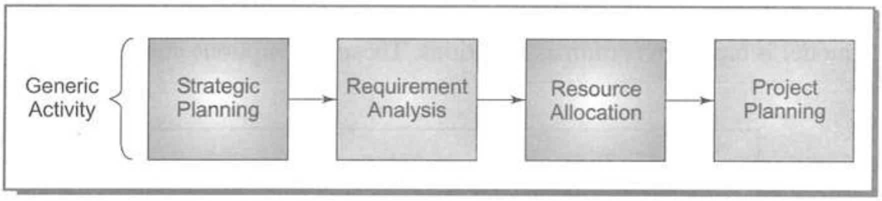


Fig. 12.5 Four-stage Model of IS Planning

The four-stage IS planning model, besides providing insight into the planning process, reduces confusion about the selection of competing planning methodologies. Table 12.1 describes the four stages of IS planning model. The four stages of the model are discussed individually in the following paragraphs.

Table 12.1 Four Stages of IS Planning Model

IS Planning Activity	*Description*
Strategic Planning	Matching the overall organisational plan with the IS Plan.
Information Requirement Analysis	Identifying broad, organisational information requirements.
Resource Allocation	Allocating resources for IS development and operation.
Project Planning	Formulating a plan giving resource requirements for specific IS projects and schedules.

12.5.1 Strategic Planning

As the name indicates, in the IS strategic planning stage, objectives, goals and strategies of information systems are aligned with the objectives, goals, and strategies of the organisation. The following techniques are used at this stage:

(i) Derivation from the organisational plan,
(ii) The strategic information system grid,
(iii) Strategic fit with organisational culture,
(iv) Strategy set transformation.

Derivation from the Organisational Plan

In this technique, IS objectives, goals and strategies are derived from the objectives, goals and strategies of the organisation. An analysis is made of each objective, goal and strategy in the plan to find out the required information system support, which becomes their basis. For example, the objective of an organisation may be to pay salaries to all the employees by the seventh day of every month. The derived IS plan may be to provide information support for processing payroll of all the employees before the due date.

Strategic Information System Grid

This technique, known as McFarlan-McKenney strategic grid, provides four types of IS planning situations, arranged in the form of a grid. The strategic grid defines the strategic importance of the existing information system applications to the business and the strategic importance of the IS applications to be planned for development. The four cells of the grid represent the position of the IS activity relative to the business organisation. The strategic importance grid has been portrayed in Fig. 12.6.

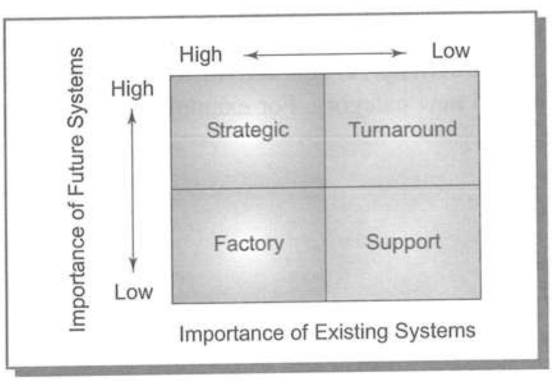


Fig. 12.6 The Strategic Importance Grid

The strategic cell of the grid indicates the critical role of the information systems in the existing competitive strategy and in the future strategic directions of the organisation. Information systems are part of new strategic directions. The factory cell indicates the vital position of the existing information systems. However, they are not considered part of the future strategic directions. The *support* cell points out that IS applications are useful in supporting the organisational activities. In this stage, IS applications are not regarded as vital or critical, rather they are oriented towards the traditional data processing systems. *Turnaround* is understood as a state of transition from 'support' to 'strategic' stage. This cell indicates that the organisation has had only support applications, but is now planning for IS applications vital to strategic success of the organisation. The strategic grid helps in analysing the current and future IS applications, and thus acts as a diagnostic tool. The grid is diagnostic because it helps understand the role of IS in the organisation. The position in the grid explains the needed level of top management involvement. However, the grid explains what is happening rather than what should happen.

Strategic Fit with Organisational Culture

In this technique, the organisational culture is understood and the information systems are developed in such a way that these fit into the organisational culture. This helps to avoid the risk of IS failures because of resistance from the employees. In order to understand the culture, planners may collect relevant cues from top-management behaviour, incidents in the organisations, subjects and order of agenda, rituals, etc.

Strategy Set Transformation

This approach has been proposed by William R. King, in which the overall organisational strategy is viewed as an IS set consisting of objectives, goals and strategies. Strategic IS planning is the process of converting the organisational strategy set into an IS strategy set.

12.5.2 Information Requirement Analysis

After the strategic planning stage, in which goals, objectives and strategies for IS are formulated, is over, the second phase of the IS planning model starts and is known as information requirement analysis stage. This stage does not deal with the detailed information requirement analysis; rather current and future needs for IS to support decision-making and operations of the organisation are assessed. This stage of the model ensures that various ISs and databases are integrated and a master plan for IS development is formulated.

To undertake information requirement analysis, the following steps are followed:

(i) Define underlying organisational requirements.
(ii) Develop sub-system matrix.
(iii) Define and evaluate information requirements for organisational sub-systems.
(iv) Prioritisation of Information Systems.

The following paragraphs give a brief description of these steps.

Define Underlying Organisational Sub-systems

In the first step, underlying organisational sub-systems are defined. This is done to sub-divide requirement determination by major organisational activity. These sub-systems are identified by having discussions with the managers of the organisation, which is an iterative activity. As new activities are considered, they are either included in the already defined category or identified as a new category. For example, the major processes for a computer training institute may include:

(i) Advertising,
(ii) Accounts Receivable,
(iii) Training Schedule,
(iv) Faculty Administration,
(v) Computer Maintenance,
(vi) Appraisal,
(vii) Credit,
(viii) Audit,
(ix) Course Material Inventory,
(x) Legal Activities, etc.

Develop Sub-system Matrix

The second phase of the organisational information requirement analysis is to relate specific managers to organisational sub-systems. The matrix thus prepared is known as *manager by process* or *manager sub-system matrix* (Fig. 12.7). The sub-systems in the left column of the matrix are the same as those developed in step 1.

The matrix is developed by reviewing the major decision responsibilities of each middle to top manager and relating them to specific sub-systems. This step helps clarify responsibilities of each manager responsible for each sub-system.

Organisational Sub-systems	Manager 1	Manager 2	Manager n
Advertising	X		0
Accounts receivable		X	
Training schedule			X
Faculty administration			X
Computer maintenance			
Appraisal	X		
Audit		X	
Course material inventory			X
Legal		X	
Credit			

Fig. 12.7 Manager by Sub-system Matrix

Define and Evaluate Information Requirements for Organisational Sub-Systems

In this phase, information requirements of each sub-system are obtained. For obtaining information requirements, managers with major decision-making responsibilities for each sub-system are interviewed in groups. As it may be difficult for the managers to define and recall their information requirements during an interview because of the human limitations in processing an information. It therefore becomes necessary to provide some help in the process of the managers' recall of his information requirements. Commonly used approaches, namely, Business System Planning (BSP), Critical Success Factors (CSF), and Ends-Means Analysis are used for framing questions to be asked from the managers for getting their information requirements. The questions which are derived from these three approaches indicate three different ways of thinking about requirements. The three sets of questions are given as follows:

(i) What decisions do you take and what information do you need for your decision-making? (Business Systems Planning approach)

(ii) State the factors which are critical to the success of your area of activity. What information do you need to get success in these factors? (Critical Success Factor approach)

(iii) What are the outputs (ends) from your sub-system and what information do you require to measure effectiveness in achieving the outputs? (Ends-Means Analysis)

Prioritization of Information Systems

Having identified the need for information system applications for the entire organisation, the next step of IS planning model is the prioritisation of IS applications. As IS resources are limited, and not all applications can be developed at once, it becomes important to identify which applications are to be developed and in what order. While the applications are identified on the basis of information requirement analysis, the sequence of prioritised applications is determined on the basis of value of IS and the organisational readiness, also known as feasibility analysis. Thus organisational readiness is seen in terms of

- People issues
- Data issues
- Integration/Links with other systems/external links
- Technology/Infra issues
- Other Issues

For example, let us take a case of an educational institute, in which the following applications of IS have been identified to be developed.

- Online admissions
- Online academics (registration, course outline, electives, attendance, quizzes, feedback, results, etc)
- Online placements
- Online administration (Fee, complaints, Salary)

- Online MDP/Consultancy
- Online research
- Online leave accounting
- Online library

To determine the prioritization of these identified IS applications, the following matrix as shown in Figure 12.8 is employed.

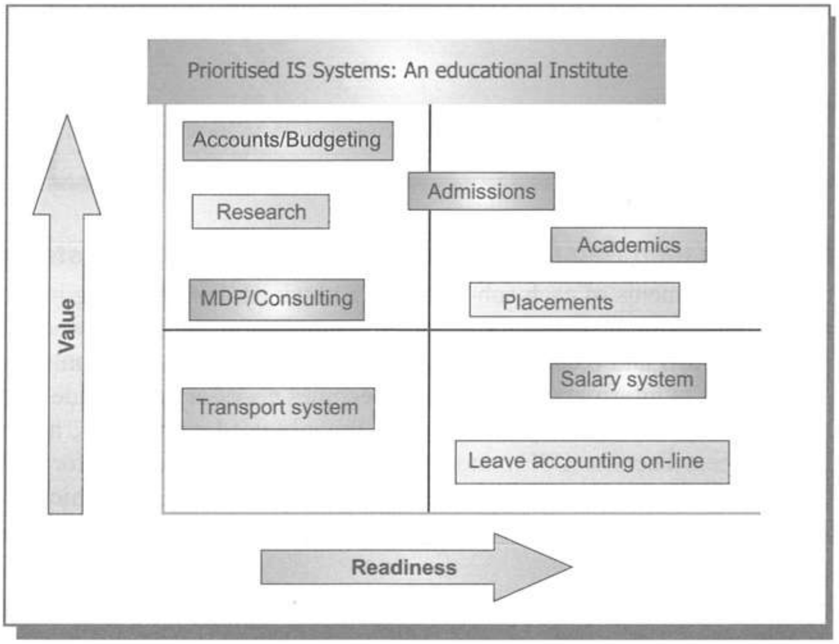


Fig. 12.8 Prioritization of IS applications

The following matrix as shown in Figure 12.9 demonstrates the readiness/risk analysis for various variables, namely, people issues; data issues; integration with other systems/technology/infra issues/miscellaneous issues, etc. For each of the information system application like online academics; online admissions; online placements, etc., the readiness for each of the IS application can thus be described as highest, medium or low. Having determined the readiness of the IS applications, the sequence of prioritization case be found as depicted in Figure 12.10.

Readiness/Risk Analysis

The sequence of the applications may be determined as per the following criteria.

Info System	*People Issues*	*Data Issues*	*Integration/links with other Systems*	*Technology/Infra Issues*	*Misc Issues*	*Readiness*
Online academics						
Online admissions						
Online placements						

Fig. 12.9 Readiness/Risk Analysis

12.5.3 Resource Allocation

This stage provides the framework for personnel planning, technology procurement and budgeting to provide services to users. There have been a number of methods for allocating scarce resources. Some of the generally used methods are briefly discussed here.

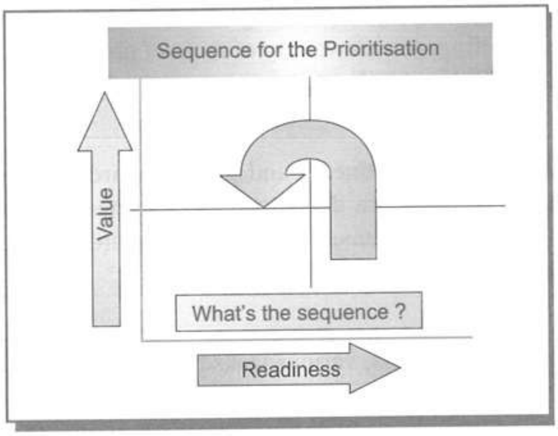


Fig. 12.10 Sequence of Prioritization

Return on Investment (ROI)

This is a cost-benefit analysis technique, which is used in a variety of planning applications. This technique is used in IS projects as each IS project may be considered as having quantifiable economic costs and quantifiable economic benefits, on the basis of which return on the investment can be calculated. A decision rule based on ROI is to select projects that have the highest ROI. However, the costs and benefits of IS projects are variable, complex, interrelated and difficult to estimate, which makes the ROI technique less popular for IS planning (also see Chapter 12).

Charge Out

It is an accounting procedure for charging the costs of IS resources to its users. The users may be charged in two ways. In one of the methods, a standard cost is *allocated to different* users of the organisation for the IS services rendered. In this, the user has no control over the costs as the costs are directly allocated by the IS department to all the sub-systems of the organisation. This method, primarily, is used to aid in internal planning and control of IS costs. In the second method, users are charged for information services but to the extent information service are rendered. Thus, in this method, users can control costs by reducing services or by choosing alternative methods or suppliers. This method, though has significant advantages but it suffers from a limitation, i.e. it promotes local rationality than justification for the entire organisation.

Portfolio Approach

This approach works on the premise that IS projects should be evaluated not only individually but as part of a portfolio of projects that has an overall impact on the organisation. Thus, the IS application portfolio should have a balanced approach in terms of project risk, support for strategic directions and appropriate applications as per the stages of growth of the various organisational sub-systems.

Steering Committees

An alternative to single-executive decisions (such as an IS executive) is a steering committee, which may have executives from major functions in the organisation. The committee would decide about the allocation of IS resources, keeping in view, the interest of the entire organisation. Such a committee facilitates coalitions and builds support for the allocations and the resulting plan. However, this technique of resource allocation may be time-consuming and may overlook an 'IS needy' but less powerful group.

12.5.4 Project Planning

Having decided the requirements of IS applications and the sequence in which these applications are to be implemented in the organisation, management needs to take a decision whether to develop these applications in-house; get them developed from the vendors (outsource/offshore development) or get the services of application service provider (ASP).The various strategies for acquisition of ISs have been discussed in Chapter 18. The last stage of the four-stage model of MIS planning is project planning which provides an overall framework for system acquisition planning, scheduling and controlling. A wide variety of tools of project management are available which include milestones; critical path method (CPM); and Gantt charts.

Milestones

In milestone planning techniques, all project requirements and problems are not anticipated in advance; rather these techniques allow projects to evolve as they are developed. Milestones or checkpoints are established to allow periodic reviews of progress so that the management may assess if a project needs more resources, requires adjustments, or if it should be abandoned.

Critical Path Method (CPM)

In this method, commonly known as *network analysis*, various tasks required to complete a project are represented in the form of a network chart. The method establishes sequential dependencies and relationships among the tasks. In this method, the longest path in terms of time determines the total time required to complete the project and this longest path is termed as the critical path. Any delay of tasks in the critical path would result in a corresponding delay in the overall project (see Fig. 12.11).

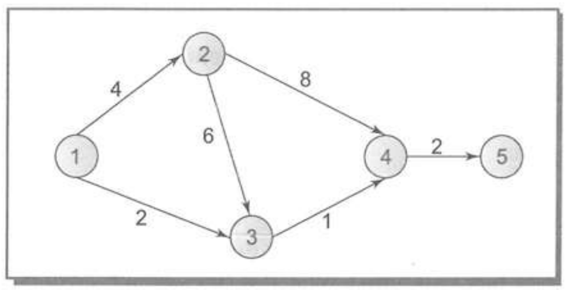


Fig. 12.11 A Network Showing Critical Path

Gantt Chart

This is also another planning technique like CPM which provides definitions of tasks to be performed and specifies when they are to start and finish. However, like a CPM chart, a Gantt Chart does not establish sequential dependencies. Figure 12.12 illustrates a simple Gantt Chart.

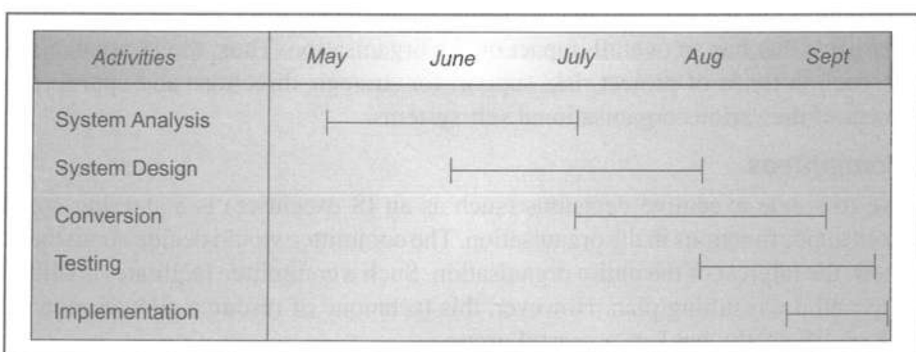


Fig. 12.12 Gantt Chart

12.6 SELECTING A METHODOLOGY

The four-stage planning model provides an insight into the IS planning issues. To determine IS planning, the organisation should determine the extent to which each stage of IS planning has been accomplished. This can be done by analysing major activities and outputs as per the four-stage planning model. It is only after IS planning needs are

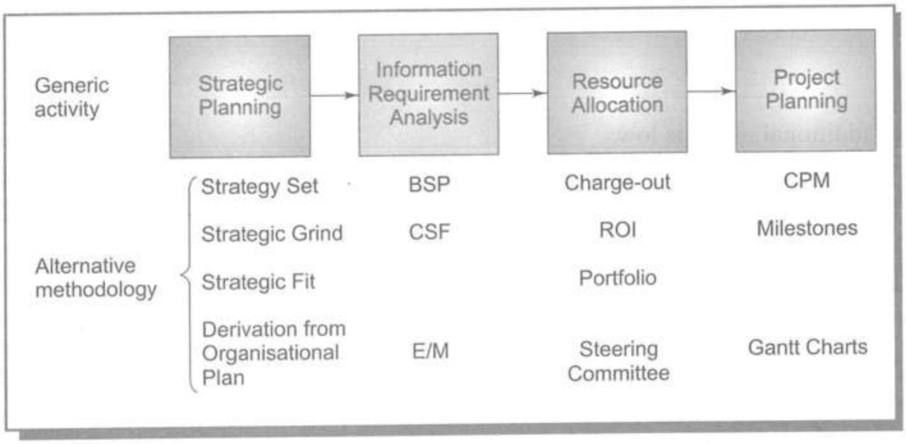


Fig. 12.13 Four-Stage Model with Alternative IS Planning Methodologies

determined that appropriate methodologies should be selected. Figure 12.13 illustrates each of the methodologies, that have been discussed, relating to particular stages of the IS planning process. Following the model avoids confusion about competing planning methodologies which otherwise may be operating in the organisation. For example, an organisation may view its IS function as making minimal contributions to strategic organisational objectives. To find a solution to this problem, the organisation may start a charge out system (resource allocation planning), whereas some other organisation with similar problem may conduct a business system planning study (information requirement analysis activity). These activities may result in improved IS services, but the planning model suggests that both the organisations are not following the appropriate methodologies for resolving this problem. An organisation that follows the planning model will not use resource allocation methodology or information requirement analysis activity methodology; rather it may adopt strategic planning methodology, which may be more appropriate in this situation.

> **FOCUS**
>
> IRM is a concept that focuses on the information, its availability and its usage.

12.6 INFORMATION RESOURCE MANAGEMENT (IRM)

Nowadays, information is, viewed as a resource of the organisation and not as a by-product of transaction processing. Information is also seen as a resource of the entire organisation, not of just the department that generates or receives it. Such a thinking has given birth to a new concept which is known as Information Resource Management (IRM).

IRM is a concept that focuses on the information, its availability and its usage. The emphasis of IRM is on the efficient management of information. The organisations, which adopt IRM concept, view information as a key resource and invest in information technology to gain a competitive advantage. In this approach, organisations ensure the availability of the required information to all the users. Thus, the IRM is a perspective; it is also an approach to organising and integrating the diverse elements of an information system. In other words, IRM's focus is on management of these elements and the information of the organisation in a coordinated manner. In managing information, IRM takes the perspective that information as a resource of the entire organisation, has value and should be managed in much the same way in which other resources are managed. IRM advocates applying normal resource management techniques to information.

Information, when compared with other resources of the organisation like money, men, machine, and materials, shows the following similarities:

(i) It has a cost.
(ii) It has a return on investment.
(iii) It requires organisation for its efficient use.
(iv) It has an opportunity cost.

However, information is different from other resources in the following terms.

(i) It can be reused.

(ii) It is intangible.

(iii) The marginal cost per additional usage is low.

Many organisations now have an information centre. Because this is a new type of information activity, there is as yet little agreement about its activities and purposes. All information resources of an organisation should be under the overall umbrella of IRM. These should include the following.

(i) Business data processing

(ii) Information System development

(iii) Data management

(iv) Networking

(v) Office automation and word processing

(vi) End-user computing

(vii) Information centre management.

However, most of the information centres today, are created primarily to assist end users acquire and develop their own computing systems.

The task of the IRM function is to integrate and coordinate the above-mentioned activities. In other words, IRM is an all-encompassing, information-focused concept that involves no less than organising all aspects of the information activities and flows. Nowadays many organisations, having realised the significance of IRM, have started according a higher position to the chief information officer, who reports directly to the chief executive officer of the organisation.

12.7 ORGANISATION STRUCTURE AND LOCATION OF MIS

Location of MIS in the organisation structure is another area which is quite often overlooked but it is an important issue that deserves the attention of the management. For proper discharge of its functions, MIS must be suitably located in the overall structure of the organisation. This requires proper planning at the organisational level.

The exact location in the organisation and the authority granted to the MIS function is, of course, a function of the type of business the firm is in and how important the information resource is to its operation. In banking, transportation and many other industries, data processing and MIS pervade all areas of the business. Alternative assignments of the MIS function are discussed here.

(a) As Part of Financial Department

In this form of MIS organisation, MIS manager is placed under the charge of the Financial Controller or Chief Accounts Officer of the organisation. This is because historically, financial applications were the first to be computerised and to be systematised. This form of organisation structure is shown in Fig. 12.14(a).

(b) MIS Under the Direct Control of the Chairman/Chief Executive

In this type of organisation, MIS is put under the direct supervision of the Chairman of the organisation. It is done in view to accord more importance to this function, and thus to get acceptance from other functional areas within the organisation. The organisation structure representing MIS function under the direct control of the chairman has been given in Fig. 12.14(b).

(c) MIS as a Distinct Function

In this type of MIS organisation, MIS is given equal status as enjoyed by other traditional functional areas in an organisation. This type of organisation structure has been shown in Fig. 12.14(c).

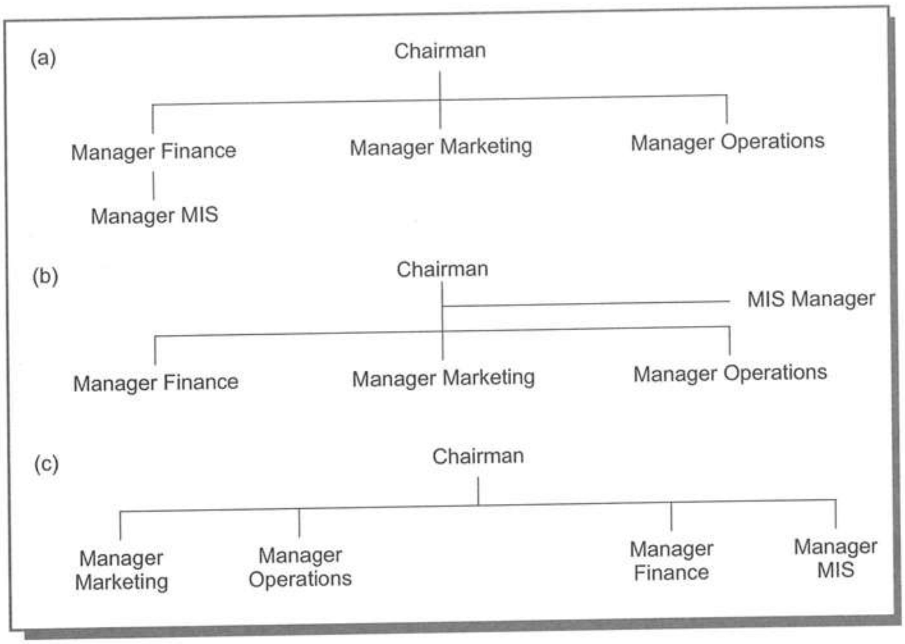


Fig. 12.14 Organisation Structure and Locataion of MIS (a) Not Recommended at Any Time (b) Recommended for Early Stages of Development (c) Recommended for Eventual Permanent Organisation

SUMMARY

An information plan, today, is recognised as a vital component of good IS management. In the past, IS planning followed only a piecemeal approach, which over the years has evolved to a more structured approach. There are a wide variety of approaches to organise for planning. An important principle for IS plan is that it should meet organisational needs and must have management support. Nolan stage model, which is a contingency model, describes the direction of change as organisations adopt IT and develop policies and procedures to benefit from it. The four-stage model of IS planning provides a good framework to identify the stages of planning and the role of IS methodologies in various stages, namely, strategic planning, information requirement analysis, resource allocation and project planning.

In the strategic planning stage, which includes derivations from the organisational plan, information grid, strategic fit and strategy set transformation, any one or a combination of methodologies may be used. The second stage of the model suggests IS planning methodologies like Business System Planning, Critical Success Factor and Ends-Means Analysis. Whereas in the resource allocation stage ROI, Charge Out, Portfolio Approach, or steering committees may be used. In the last stage, i.e. project planning stage, methodologies like Milestones, CPM and Gantt Charts are useful.

REVIEW QUESTIONS

1. Briefly discuss the concept of mission, objectives, goals, strategy and policy.
2. Define and discuss the four-stage model of IS planning.
3. 'Nolan's stage model is a diagnostic and monitoring tool.' Do you agree with the statement? Justify.
4. Briefly discuss Nolan's stage model. Give its applications.
5. Identify the methods used for strategic IS planning and resource allocation stage.
6. Identify and discuss information requirement analysis methods. Under what situations might you select one over the other?

7. Write a brief note on:
   (i) Project planning
   (ii) Strategic fit
   (iii) Strategic information system grid
   (iv) Maturity stage of Nolan's revised model.

ASSIGNMENTS

1. (a) Visit an organisation located in your city. Identify the IS planning stage of the organisation and planning methodologies being used.
   (b) Do you think the organisation is using the right methodologies? Justify, and give your suggestions with reasons.
2. Do you think, for determining the value of various applications, ROI is desireable? What are the issues in setting a Rupee Value to each IS Application ? Discuss.

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CASE STUDY 1

PLANNING OF IS AT ANOOP & COMPANY

Anoop & Company is a garment exporter, operating in several world markets. Their biggest market has been the USA, followed by Western Europe. The company sells garments under its own brand name.

In the past, both revenue and profit growth have been excellent, and the company had established a niche for itself. However, in the past year, the appreciation of the Rupee has hit the company because their earnings are in dollars, whereas expenses are largely in Rupees. Plus, the slowdown in the USA has cut down demand and therefore top-line growth has suffered. Consequently, the company is facing pressures on both the top-line as well as the bottom-line.

One approach identified for maintaining growth rates in both profit and revenue is to tap new geographies such as Korea. The problem is that the company does not have any data on what is happening in this market – who their competitors are, what products they sell, what products the local people prefer to buy, etc.

The company has tied up with partners in each country that it operates in. Typically, these partners are Retail Chains or Large Departmental Stores. Some of these partners have done well, but others have not brought in the level of business that Anoop & Company would have liked. Further more, Anoop & Company has very little idea about the level of potential business in these countries, and therefore must blindly accept what the partners do and the reasons they give for lack of performance. Among other things, Anoop & Company has very little idea about the potential business that the partners are likely to get in the next few months, the competition they are up against, activity levels in the market, sudden ups and downs in local conditions, fashion trends, etc.

In fact, the company has very little idea about Consumer Preferences. If a customer walks into a partner's retail outlet, but does not buy their product, Anoop & Company is never able to get information on why he or she did not buy it.

Another key reason for lower profitability has been found to be Cash Flow Management, for the following reason:

In this business there isn't too much brand loyalty, and therefore it is important to ensure that there are no stock-outs with the partners. The arrangement with the partners is that the partner pays only 10% of the cost of stocks up front, and the rest is paid only when the stocks are sold. Without this arrangement, no partner is willing to do business with Anoop & Company. This arrangement does not block the partner's capital significantly, but clearly blocks the capital of Anoop & Company. To ensure that there are no stock-outs, Anoop & Company maintains large buffer stocks with their partners, which leads to even more capital being blocked, and therefore significant interest costs.

QUESTIONS FOR DISCUSSION

1. identify the goals, strategies, and critical success factors for Anoop & Company.
2. Suggest possible IS Solutions for Anoop & Company.
3. How would you prioritise the two IS solutions?

CASE STUDY 2

APOLLO HOSPITALS

Apollo Hospitals Enterprise Limited has over 8065 beds across 46 hospitals in India as well as in the rest of Asia and Africa. The hospitals are multi specialty tertiary care facilities with centers-of-excellence in medical disciplines including cardiology, cardio-thoracic surgery, gastroenterology, orthopedics & joint replacement surgery, neurology, critical care medicine, nephrology, oncology, hand & micro surgery and reproductive medicine. Apollo Hospitals has diversified in the following areas:

Apollo Health and Lifestyle Limited

Apollo Health and Lifestyle Limited and has established over 100 Apollo Clinics across the country, and is an integrated model and offers facilities for specialist consultations, diagnostics, preventive health checks and 24-hour Pharmacy, all under one roof.

Apollo Pharmacy

Apollo Pharmacy is India's first and largest branded pharmacy network, with over 750 retail outlets in key locations across the country. The group adds one pharmacy every 23 hours.

Apollo Hospitals Education and Research Foundation

AHERF was set up to establish, maintain and support educational institutions in promoting medical, paramedical and hospital management courses. The institute offers over 18 post graduate teaching programmes, including the ones certified by the Royal College of Edinburgh. MedVarsity Online Limited is backed by two giants–Apollo in medicine and NIIT Limited in the field of electronic-education. MedVarsity has developed in-house, over 1500 hours of medical content that is accessible to the medical community, anytime and anywhere. The research division currently undertakes diverse projects from clinical trials in multiple locations to molecular biology, stem cell transplants, epidemiological studies, and in the future identification of genetic Biomarkers.

Apollo Telemedicine Networking Foundation

In 1999, Apollo launched its first model Telemedicine Unit at Aragonda village in the Chittoor district. Since then, Apollo has witnessed a steady growth in terms of delivering quality healthcare and reaching out to the masses. Telemedicine is a potent means of harnessing telecommunication technology to deliver healthcare and education to patients in regions that are geographically less accessible. It also saves time and cost of travel to access quality care. Apollo has pioneered the concept of telemedicine in India and Asia, and has over 100 telemedicine centres in India and overseas.

Apollo Insurance Company Limited

Apollo DKV is a joint venture of the Apollo Hospitals Group and DKV AG, Europe's largest private health insurer and a Munich Re Group company. The company offers innovative health insurance, wellness solutions and disease management to meet customer needs.

Apollo Wellness Plus

Apollo Hospitals launched the first Wellness Centre at Apollo Hospitals Chennai in Feb 2005. Wellness Plus is the perfect blend of modern and complementary medicine like aromatherapy, pranic healing, yoga, and meditation that fits the modern lifestyle.

Apollo Reach Hospitals

As an endeavour to bring world class healthcare to semiurban and rural India, every Apollo Reach Hospitals will be a specialty hospital, designed to complement existing private and public healthcare facilities in the proposed towns and villages. Construction of hospitals, procurement of land and identification of cities are underway to set up the first phase of 25 Apollo Reach Hospitals over the next two years across India. With an initial bed strength of 100 - 150 beds, each Apollo Reach Hospital can be ramped up to a 200 bedded specialty hospital.

Health Care Portal – Proposed Business

Keeping in mind the success of internet technology, Apollo plans to offer a Hospital Search Service, where a patient can specify his disease (or even his symptoms), as well as the city where he is located. The Portal will then help him:

- to find an appropriate hospital nearby, where this disease can be treated, it may include Apollo hospitals or any other hospital like Escorts, Fortis or any government/private Hospital.
- It will also rate the hospitals listed on the ability to handle the disease.

This service is offered by several portals, and therefore the company plans to offer it as an independent business opportunity,

You have been invited as a consultant. Give Your recommendations on the following:

(a) Whether the company should go ahead with starting a Health portal as an independent portal or only a web site support?

(b) Is there any conflict in the business strategy and IT strategy (starting of Health care portal as an independent business?) If yes, how would you resolve the conflict?

Chapter 13

System Acquisition

Learning Objectives

After reading this chapter, you should be able to:

- Understand the different alternatives to in-house system development available to an organization
- Evaluate the pros and cons of in-house system development alternatives
- Describe which systems acquisition approach is appropriate for a particular set of circumstances; and
- Understand the acquisition process of computer hardware and computer software

As discussed in IS Planning, once the requirements of IS applications and the sequence in which these applications are to be implemented in the organization is decided, management needs to take a decision whether to

(a) develop these applications in-house; or

(b) acquire these systems by outsourcing this wok to a vendor/service agent

The decision whether to develop IS in house or to hire the services of vendor depends on various factors like competence of the organization, specific information requirements, reliability of the vendors, criticality of the IS, time available to develop an IS, quality, and the cost etc. While a few organizations have their own in-house IT departments, which may have the required resources and the competence and thus would like to develop their own IS applications in-house. The software development has been covered in Chapters 17 and 18. It is important to understand that the knowledge of the system development process is important not only to the system analyst or system managers; rather it is also important for all the managers working in an organization. Many a times, the information systems fail because of the mismatch between the thinking of the managers and that of the technical persons on the development issue. Business managers avoid discussions with the technical people as they are not conversant with the technical jargons. Business managers also have the perception that IT would solve all their problems and thus have high expectations from the technical team. On the other side, technical people may not understand the business and the business processes and thus would not completely understand the requirements of their managers. As a result, the technical team would end up developing information systems, which may not cater to the needs of the managers, and thus leading to the failure of the developed information systems.

13.1 ACQUISITION OF INFORMATION SYSTEMS

Developing information systems in-house or engaging a software development company may be the most expensive way to acquire ISs. There are some other alternatives which might be less expensive and give other benefits. There are generally four alternatives to in-house development, which are mentioned as below:

(a) outsourcing;

(b) Software licensing;

(c) using the service of an application service provider (ASP); and

(d) end users development.

As discussed earlier, there are many factors that drive organizations to decide how they acquire ISs and the service that supports the maintenance and use of the systems. Let us discuss the various strategies for acquisition of ISs in an organization.

(A) Outsourcing

Generally, outsourcing refers to hiring the services of another organization or individual to perform some of the work that otherwise would be performed by the organization, itself. **Outsourcing**, with regards to IT, refers to hiring some organization for the development of information system or to hire the services of another company to manage all or parts of the services that otherwise would be rendered by an IT unit of the organization. The latter concept might not include development of new applications.

FOCUS

outsourcing refers to hiring the services of another organization or individual to perform some of the work

Outsourcing IS Applications

An organization may outsource the development of an IS application to another organization when the organization finds that existing commercial ISs can not satisfy their requirements and they have to develop custom designed or tailored IS. In such a case, an organization outsources the development of custom-designed applications to companies that specialize in providing consulting and software development services. Outsourcing custom-designed applications have several advantages and disadvantages, which are discussed as below:

Advantages

Fit to business needs: Since the application is custom made, it will meet the exact needs of the business.

Fit to organizational culture: The developer would develop the applications which fit the work of the employees.

Availability of trained manpower for maintenance: The programmers are easily available to the company and thus can provide maintenance of the customized application.

Interfaces with other information systems: As the systems are custom built, these are made compatible with the existing applications.

Availability of desired security measures: The desired security measures can be incorporated into the custom built applications.

Strategic advantage: A unique IS application may give a strategic advantage to the organization.

Disadvantages

High cost: The biggest disadvantage of tailor made application is its high cost. The high cost of such applications is because of the fact that the organization has to meet all the development costs, whereas this cost is shared among many users when the application is designed for general purpose.

Long wait for development: The development of IS may be delayed, as the people may be busy in other projects.

IS may be too organization-specific to interface with systems of other organizations: The custom designed IS is less likely to be compatible with the systems of other organizations.

Request for Changes: Many a times the developing organization may not entertain the request for change requirements as the development goes on, the developers might either refuse to deviate from the original requirements or might agree to make the changes for hefty additional charges.

Incompatibility with development methods: The development of the outsourced systems may be incompatible with the development methods such as iterative approaches discussed in Chapter 17. The essence of such methods is the clients' ability to make requests for changes as the development goes on.

Communication gap: Many a times, the communication gap comes in the way of delivering a quality software. The communication gap between system analysts and the users has also been highlighted in Figure 13.1.

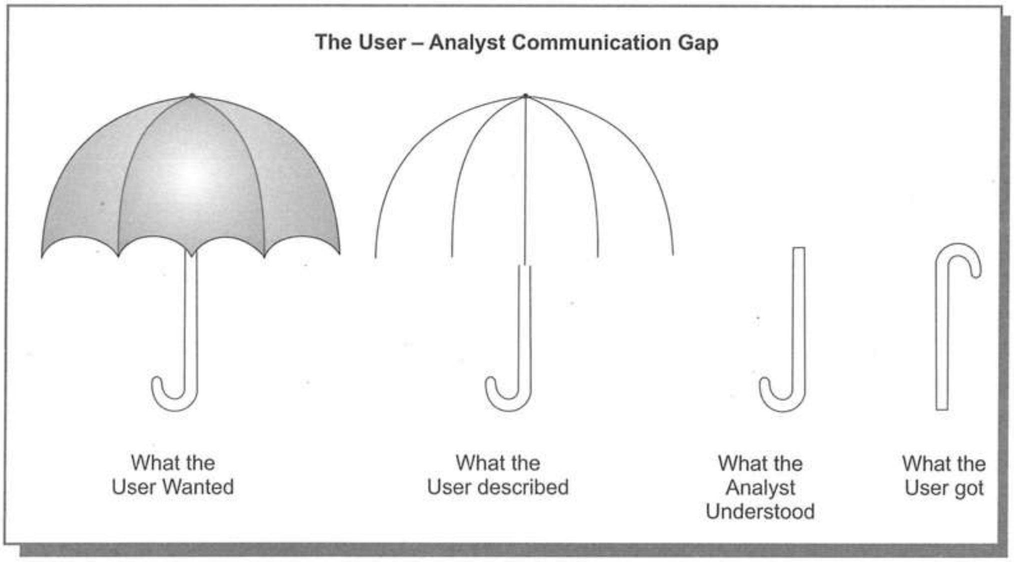

Fig. 13.1 Communication Gap between the User and the Systems Analyst

Outsourcing IT Services

Many business organizations may like to engage IT companies for long-term services: like purchasing and maintaining hardware; developing, licensing, and maintaining software; installing and maintaining communications networks; developing, maintaining, and operating Web sites; running IT daily operations, managing customer and supplier relations, and so on. An organization might use a combination of in-house and outsourced services. It might outsource the development of an IS, but then manage its operations of its own, or it might outsource both the development and operation of the system. When a business outsources only routine business processes, such as data entry or sales transactions, the practice is called *business process outsourcing.*

The decision whether to go in for outsourcing IT services or not depends upon many factors like core competency of the organization; specialization of other organizations in providing IT services; alliance with other IT organizations and the possible improvements in activities; criticality of the service required and reliability of the vendors etc. Many companies have come to realize that IT is not their core competency and should not be a focus of their efforts. In addition, the development of IT applications might require more expertise than is available within the organization. A large number of organizations, which provide IT services include IBM, Perot Systems, Hewlett-Packard, Accenture, Computer Sciences Corp. (CSC), Capgemini etc.

Advantages of Outsourcing IT Services

Organizations outsource their IT services to reduce in-house responsibility and to better manage risks. The various advantages of outsourcing IT services are given as below:

- *Increased attention to core business:* when IT services are outsourced, it will save some of their time. This saved time can be used to concentrate on the core businesses of the organization.
- *Improved financial planning:* Outsourcing allows the organisation to know exactly what the cost of its IS functions will be over the period of the contract, which is usually 1-3 years. This allows for better financial planning, as they would know the exact financial liability for IT services.
- *Reduced license and maintenance fee:* Professional IS firms often get the advantage of discounted prices for IT resources, based on volume purchases, which is normally passed on to their client organizations.
- *Shorter implementation cycles:* IT vendors can usually complete a new application project in less time than an in-house development team can, because of their experience with development projects of similar systems for other clients.
- *Reduction of personnel and fixed costs:* By outsourcing IT services, organizations can save on their fixed and variable costs in terms of manpower and other equipments/infrastructure etc.
- *Increased access to highly qualified know-how:* Outsourcing allows clients to tap into one of the greatest assets of an IT vendor: experience gained through work with many clients in different environments.
- *Availability of ongoing consulting as part of standard support:* Most outsourcing contracts allow client companies to consult the vendor for all types of IT advice, which otherwise would not be available.

Risks of Outsourcing IT Services

No doubt, IT services are gaining popularity these days because of its advantages. But outsourcing is not a panacea and should be considered carefully before IT services are outsourced. The major risks of outsourcing IT services are as follows:

- *Loss of control:* With outsourcing, the organization may loose control to outsiders. The organization must evaluate the nature of the industry in which it operates. While outsourcing can be a good option in a relatively stable industry, it is highly risky in one that is quickly changing. In the changing industry, the IS service provider may not able to adapt to the changes in the business of the client organization, and thus when the ISs would not be able to meet the changes, the client organization stands to suffer.
- *Loss of experienced employees:* Outsourcing often involves transferring employees of the outsourcing organisation to the IS vendor. Thus in the process, the organization may loose its well trained people to the vendor organization.
- *Risks of losing a competitive advantage:* Innovative ISs should not be outsourced, as outsourcing the development or maintenance of strategic systems means disclosing trade secrets. Secondly, a competitor may hire the same vendor to build his IS for the same purpose, which would eliminate the competitive advantage of the organization.

• *High price:* Despite careful pre contract calculations, some companies may find outsourcing as a costly proposition. Organisations must see the feasibility before opting this kind of alternative.

(B) Software Licensing

These days, a large number of high quality packaged software are available in the market for purchase. These packages are usually available for a large number of users. Therefore, purchasing prepackaged software should be the first alternative considered when a company needs to acquire a new system. Typically "purchased" software refers to licensed *software*. The purchaser actually purchases a license to use the software, not the software itself. Thus, the term "licensing" means purchasing a license to use.

FOCUS

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Ready-made software may be used as routine applications or as enterprise wide applications and accordingly, these packages may be classified into two groups:

(a) Small applications which are relatively inexpensive software, such as Microsoft Office, Accounting application and similar suites etc.

(b) Large software applications that support whole organizational functions, such as marketing management and financial management, or enterprise applications that span the entire organization. Such packages include ERP, SCM, and CRM applications. These are expensive packages, which may cost from lacs to crores of rupees.

Software Licensing Benefits

An organization gets many benefits from software licensing alternative. These benefits are discussed as follow:

(a) immediate system availability;

(b) high quality;

(c) low price (license fee); and

(d) after-sale support.

(a) Immediate system availability: The system is made available to the client organization almost immediately.

(b) High quality: High-quality software is ensured because the software company specializes in developing its products. Large developers often distribute prerelease versions, called beta versions of software to be tested by companies and is improved on the basis of the feedback received from the client organization. By the time the software is released to the general market, it has been well tested.

(c) Low price: Because software companies spread product development costs over many units, the price to a single customer is a fraction of what it would cost to develop a similar application in-house or to hire an outside company to develop it.

(d) After-sale support: The software development companies provide after sale support, which may vary between three months to two years.

Organisations may purchase small packaged software applications, also known as "off-the-shelf" (OTS) software without much effort as the stakes in acquiring these softwares is not high. However for purchasing large applications such as enterprise applications, organizations must follow the proper process and employ professionals who specialize in the installation of the software, which might take months. Within limits, the providers of these large applications agree to customize part of the applications to the specific needs of a client. However, such customization is very expensive and is often risky; in some cases, customization may take significantly longer than planned and may not be completed to the full satisfaction of the client.

Software Licensing Risks

Licensing a ready-made application has the following broad risks:

• *Inadequate fit between needs and features:* Ready-made software is developed for a large number of common users. It might be useful to many, but it may not be the best solution for some users. Since the general applications are developed keeping in mind the requirements of a large number of users, the packaged software may not adequately meet the requirements of a specific organization. Such packages may even not match the organizational culture.

- *Difficulties in modifications:* Because of the general nature of the packaged software, the organizations are supposed to change their processes as per the demands of this software *Bankruptcy of the vendor.* If the vendor goes out of business, the purchaser is left without support, maintenance service, and the opportunity to purchase upgrades to an application to which it is committed. Except for checking the financial strength of potential vendors, there is not much die purchaser can do to reduce this risk.
- *High turnover of vendor personnel:* Turnover among IS professionals is significantly higher than in other occupations. If a substantial number of employees involved in application development and upgrading leave a vendor, support is likely to deteriorate, and upgrades will be of poor quality. Purchasers can do little to reduce this risk.

When selecting a particular software package, companies invest a lot of money and make a long-term commitment to conducting their business in a particular manner. Factors such as the complexity of installation, cost of training, and quality and cost of after-sale service must be considered in addition to the demonstrable quality of the software. Once a company decides that it will purchase a ready-made application, a project management team should be formed to oversee smooth implementation of the system. The project management team should follow acquisition process as mentioned under acquisition of hardware and software.

(C) Software as a Service (SaaS)

Software as a service (SaaS) has started recently, which means renting out the applications through the Web. An organization that offers the use of software through communication lines is called an *application service provider (ASP).* The concept is called *software as a service (SaaS)* or *software by subscription.* Many companies including IBM Global Services, US internetworking (USi), and Oracle Corporation offer such services.

An ASP does not install any software on a client's computers. Rather, the application is installed at the ASP's location, along with the databases and other files that the application processes for the client. However, clients can choose to save all the files produced by the application on their own local storage devices. The clients' employees access the application through the Web. They call up the application, enter data, process the data, produce reports online and on paper, and in general use the application the same way as they would install the IS at their own computers. ASPs may not rent their own software packages. They often rent software developed by other companies.

FOCUS

An organization that offers the use of software through communication lines is called an application service provider (ASP). The concept is called software as a service (SaaS) or software by subscription.

The organization, which opts for this alternative, gets the following benefits:

Benefits

- The organization is not required to commit large sums of upfront money.
- The application is immediately available.
- There is no need to hire experts for installation and maintenance.
- No need to acquire hardware for the installation.
- There is no need to learn how to maintain the application, as it is the responsibility of the ASP.
- No storage hardware is required for the application and the associated data, as the vendor uses its own hardware.

However, SaaS has the following risks:

Risks

- There may be long transaction response time on the Internet.
- There is a high security risk, as the application is controlled by vendor.

While selecting ASP, the organizations must take care of the followings:

(a) *History of ASP:* The organization must ask the provider for a list of references, and contact these customers to ask about their experience.

(b) *Financial strength of ASP:* Make sure of the good financial strength of the ASP. The organization may ask copies of the ASP's financial reports and ensure that it has enough funds to stay in business for the duration of your planned contract.

(c) *Understand the price scheme:* The organization must understand the pricing schemes of the ASP.

(d) *Get a list of the provider's infrastructure:* A list of the ASP's hardware, software, and telecommunication facilities should also be assessed. The organization should also ask who the ASP's businesses partners are that provide hardware, software, and telecommunication services. Ask how data, including sensitive data such as credit-card account numbers, are stored and protected. Ask about security measures.

(e) *Service contract:* Ensure that the contract includes penalties the ASP will pay if services are not rendered fully. Ensure that your organization will not have to pay penalties for early termination.

(D) End user Development

When the application is simple and it is not available as a ready made package in the market or the organization does not want to take any risk in purchasing or renting it, the organization has got another alternative, known as *end user application development*. In this approach, the user managers, even without any background of programming, write their own business applications. As discussed, user-developed software is fairly simple and limited in scope. The organizations should encourage the managers to develop their own applications that may be used for a brief time and then discarded. However, end users should not develop large or complex applications; applications that interface with other systems; or applications that are vital for the survival of the organization. As a simple rule, organizations should encourage end users to develop their own applications when end users have the necessary skills; the application is small; the application is needed immediately; the application can be maintained by the users; and the application is to be used briefly and discarded. Similarly, the organization should discourage end user development when the application is large or complex; the application interfaces with other systems; and the application is vital for the organization's survival.

A wide spread of user-developed applications poses challenges to the organisations, both in IT units and other business units. In addition to the simple rules mentioned, management has to manage the reaction of IT professionals, as they may react to this approach negatively because IT professionals may perceive it as undermining their own expertise and threat to their established authority. The organization must arrange training sessions for both the business managers and IT professionals. Where business managers are provided training on some technical aspects, the IT professionals need to be sensitized to this kind of requirement in the organization.

FOCUS

When the application is simple and it is not available as a ready made package in the market, the organization has got another alternative, known as end user application development.

13.2 ACQUISITION OF HARDWARE AND SOFTWARE

Acquiring hardware and software for implementing information systems in an organisation is a serious and time-consuming process that passes through several phases. The main steps of the acquisition process are listed below.

(i) Requirement analysis
(ii) Preparation of tender specifications
(iii) Inviting tenders
(iv) Technical scrutiny and shortlisting
(v) Detailed evaluation of shortlisted vendors
(vi) Negotiations and procurement decision
(vii) Delivery and installation
(viii) Post-installation review

13.2.1 Requirements Analysis

System configuration requirements are clearly identified and a decision to acquire the system is taken in this step.

13.2.2 Preparation of Tender Specifications

After studying the feasibility and deciding upon the configuration, tender documents are prepared for the benefit of vendors to clarify the details of various specifications, as listed below.

(i) Purchase procedure and schedule: It includes
  (a) Date of tender submission,
  (b) Evaluation criteria,
  (c) Scope for negotiations, if any and
  (d) Expected usage environment and load pattern.

(ii) Equipment specification:
  (a) Detailed technical specifications of each item required for both mandatory and optional items. Some examples are given below.
    1. A dual bus system using a 32-bit CPU with in-built or add-on floating point processor. I/O bus bandwidth minimum 33MB/s. 32 MB RAM expandable to 256 MB, etc. (Future upgrade requirements should be clearly mentioned).
    2. Operating system required (open standards like UNIX or not).
    3. Other software (systems and application).

(iii) Quotation Format
  (a) Format for stating technical details and quoting prices
  (b) Whether deviations from specifications should be specifically listed
  (c) Prices and levies (duties, taxes, etc.) could be quoted as lumpsum or required separately
  (d) Required validity of the quotation
  (e) Earnest money deposit required, if any.

(iv) Proposed terms of contract
  (a) Expected delivery schedule
  (b) Uptime warranties required
  (c) Penalty clauses, if any
  (d) Payment terms
  (whether advance payment acceptable)
  (e) Arbitration clauses
  (f) Training needs
  (g) Post-warranty maintenance terms expected.

(v) Any additional information required.

13.2.3 Inviting Tenders

After the preparation of tender specifications, tenders are invited. Invitation of tenders may depend upon the magnitude of purchase (estimated equipment cost). It may be through

(i) Open tender
(through newspaper advertisement)

(ii) Limited tender
(queries sent to a few selected vendors)

(iii) Propriety purchase
(applies mostly to upgrade requirements)

(iv) Direct purchase from market
(applies mostly to consumables).

Different organisations may follow different procedures for purchase of computer systems/software, etc. In a typical organisation, the following norms are adopted.

(i) Value ceiling application
(e.g. open tender for value of equipment exceeding Rs 1,00,000, etc.)

(ii) Purchase committees

(iii) Appropriate sanctions at each stage.

13.2.4 Technical Scrutiny and Shortlisting

This step involves the following activities.

(i) All tendered bids are opened on a pre-defined date and time.

(ii) Deviations from the specifications, if any, in each bid are noted.

(iii) A comparative summary is prepared against the list of tendered technical features.

In large tender evaluations, marks or points are assigned, based on severity of differences from specifications, for example

(a) I/O bus bandwidth is 12 MB/s instead of 33 MB/s.

(b) Maximum memory expansion is 64 MB instead of the required 256 MB.

(c) Line printer has a speed of 800 LPM instead of the desired 1200 LPM.

Additional factors to be considered are:

(i) Financial health of the vendor
(from the balance sheets)

(ii) Nature and extent of support
(from information provided on number of support staff per installed site and cross-check with selected customers)

(iii) Engineering quality of products
(factory inspection of production facilities, QA procedures and R&D).

Either quantitative marks, or Okay/not Okay decisions are given by the committee on each of the issues. The fact that these factors will be considered should be stated in the tender documents.

The shortlisting decision also includes technical presentations by vendors to provide clarifications.

Based on the technical comparison, a shortlist of offers is prepared. Ideally speaking, there should be three or four vendors in the list. Care must be taken that each of the shortlisted offers must be technically acceptable for final procurement.

13.2.5 Detailed Evaluation

This step primarily involves getting any finer technical clarifications. Visits to customer sites and factory inspections may be planned.

If any specific performance requirement is stipulated, the offered product is to be examined at this stage through suitable benchmark tests. For benchmark tests, standard benchmarks may be used as adequate performance indicators.

13.2.6 Negotiations and Procurement Decision

Because of the extensive competition, computer system vendors may offer significant concessions. Negotiations are held to maximise these concessions.

However, price negotiations are often not permitted by some organisations.

For such organisations, the following procedure is suggested.

(i) The vendor is to quote for all tendered items individually, including optional items (e.g. additional disk, RAM, etc.).
(ii) The shortlisted vendors will attend a meeting in which the purchase committee will give the Final Configuration chosen (including optional items).
(iii) Each vendor will offer his Final and Best price for this configuration in a sealed envelope.
(iv) All final prices are opened and compared to select the lowest (shortlisted) bid.

When price negotiations are permitted, the committee members should have a good knowledge of the prevailing market prices, current trends, and also the duty/tax structure.

Sources of information can be:

(i) Computer magazines
(ii) Vendor directories
(iii) Contact with other users
(iv) Past personal experiences.

A 'Letter of Intent' is usually given immediately upon this decision being approved by the sanctioning authority. Finally, the negotiated contract has to be signed by both parties and then the formal purchase order is released.

13.2.7 Delivery and Installation

In this step, the vendor delivers the hardware/software to the buyer's organisation, where it is matched with the specifications mentioned in the purchase order. If it conforms to these specifications, the vendor installs the system in the premises of the organisation.

13.2.8 Post-Installation Review

After the system is installed, a system evaluation is made to determine how closely the new system conforms to the plan. A post-installation review, in which system specifications and user requirements are audited, is made. The feedback obtained in this step helps in taking corrective action.

When choosing a vendor, organizations look for the quality and reliability of the product, but there are additional factors, such as quality of service and support, vendor's support for industry standards, and vendor financial soundness, that are extremely important.

SUMMARY

Once the requirements of IS applications and the sequence in which these applications are to be implemented in the organization is decided, management needs to take a decision whether to

(a) develop these applications in-house; or
(b) acquire these systems by outsourcing this wok to a vendor/service agent

The decision whether to develop IS in house or to hire the services of vendor depends on various factors like competence of the organization, specific information requirements, reliability of the vendors, criticality of the IS, time available to develop an IS, quality, and the cost etc. While a few organizations have their own in-house IT departments, which may have the required resources and the competence and thus would like to develop their own IS applications in-house. Developing information systems in-house or engaging a software development house may be the most expensive way to acquire ISs. There are some other alternatives which might be less expensive and give other benefits. There are generally four alternatives to in-house development, which are mentioned as below:

(c) outsourcing;
(d) software licensing;
(e) using the service of an application service provider (ASP); and
(f) end users development.

Generally, outsourcing refers to hiring the services of another organization or individual to perform some of the work that otherwise would be performed by your organisation. With regard to IT, outsourcing refers to hiring some organization

for the development of information system or to hire the services of another company to manage all or parts of the services that otherwise would be rendered by an IT unit of the organization.

The decision whether to go in for outsourcing IT services or not depends upon many factors like core competency of the organization; specialization of other organizations in providing IT services; alliance with other IT organizations and the possible improvements in activities; criticality of the service required and reliability of the vendors etc. Many companies have come to realize that IT is not their core competency and should not be a focus of their efforts. In addition, the pace of developments in IT might require more expertise than is available within the organization. Businesses can select from a growing list of high-quality packaged software, from office applications that fit on a CD to large enterprise applications. Therefore, purchasing prepackaged software should be the first alternative considered when a company needs to acquire a new system. An organization that offers the use of software through communication lines is called an application service provider (ASP). The concept is called software as a service (SaaS) or software by subscription. Many companies including IBM Global Services, US internetworking (USi) and Oracle Corporation offer such services. If an adequate application is not available in the market, or if an organization does not wish to take the risks with purchasing or renting, and if the application is not too complex, there is another alternative to software development known as end user application development. In this approach, users can write their own business applications. Typically, user-developed software is fairly simple and limited in scope. It is important to note that users should not develop any major or complex applications.

Acquiring hardware and software for implementing information systems in an organisation is a serious and time-consuming process that passes through several phases. The main steps of the acquisition process are listed below.

(i) Requirement analysis
(ii) Preparation of tender specifications
(iii) Inviting tenders
(iv) Technical scrutiny and shortlisting
(v) Detailed evaluation of shortlisted vendors
(vi) Negotiations and procurement decision
(vii) Delivery and installation
(viii) Post-installation review

REVIEW QUESTIONS

1. Discuss the different alternatives to in-house system development available to an organization. Which is the best alternative and why?
2. Why do organizations prefer to get their IS developed from the organizations specializing in IS development? Justify your answer.
3. Discuss various alternative strategies for system acquisition. Describe which systems acquisition approach is appropriate for a particular set of circumstances.
4. Elaborate the acquisition process of computer hardware and computer software.
5. Why do companies opt for ASP? List and explain the benefits and risks of using the services of an ASP?
6. Discuss the pros and cons of user application development. Take a suitable example.

ASSIGNMENTS

1. Visit a large organization in your area. Analyse its various systems and services. If you were the CEO of that company, how you would have differently gone for acquiring the ISs and services.
2. You are CIO of a small organization. A software vendor has approached you for providing all IS related services. How you would proceed in accepting or rejecting his offer?

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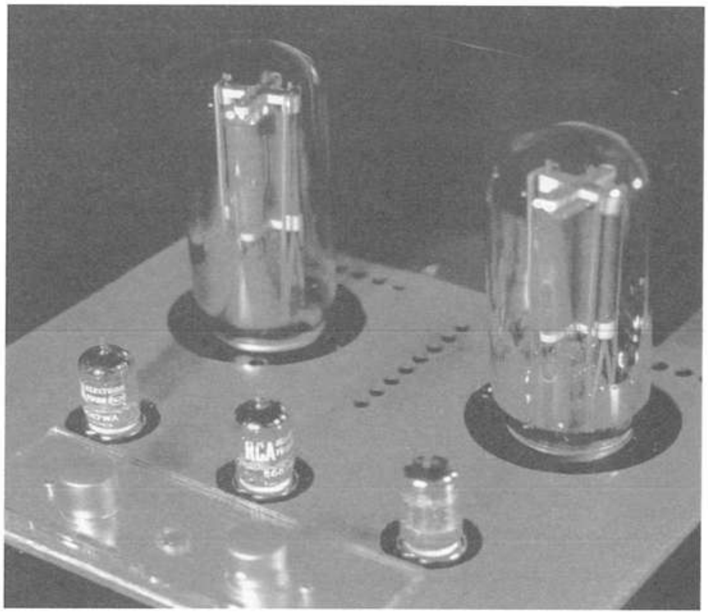
Chapter 14

System Implementation



Learning Objectives

After reading this chapter, you should be able to:

- Learn implementation process to be followed for implementing IS in your organisation
- Describe the installation approaches for a newly-developed IS in a new organisation and in an existing organisation; and
- Understand how to manage the resistance of change

Once the design of MIS is complete, it is ready for implementation. Implementation is a process of coding, testing, installation, documentation, training and support. In other words, during implementation phase, physical system specifications are converted into working and reliable software and hardware and the system is installed at the user's premises so as to continuously getting the output it was designed to generate. The thus implemented system may be a replacement of a manual system or a major modification to an already existing computer-based information system. Thus, in brief, implementation means constructing and putting the new system into operation.

14.1 IMPLEMENTATION PROCESS

Implementation of MIS is a process in itself and involves various steps. It is understood here that the major steps are based on the design specifications. All requirements of the system, such as input, processing, output, equipment, personnel, etc., are provided by the design specifications. However, the steps are not sequentially exclusive, some of the steps overlap. The various steps are as follows.

14.1.1 Planning the Implementation

It is obvious that the first step in the implementation of an MIS is to plan it. For proper implementation, the plan is a pre-requisite and is known as pre-implementation activity. It is in this step that various activities, which are required for implementing a system, are identified and their sequence and relation to each other is decided. In this step, various other estimates like time required for each activity and cost estimates are also obtained. To better describe the plan and implementation schedule, a system analyst should make use of various tools like Gantt Charts, Network Diagrams, etc. Especially in large projects, where many concurrent and sequential activities are interrelated, such diagrams are valuable in providing a clear picture of the total plan. An example of a Gantt Chart and a Network Diagram is given below in Figs. 14.1 and 14.2, respectively.

FOCUS

First step in the Implementation of an MIS is to plan and is known as the pre-implementation activity.

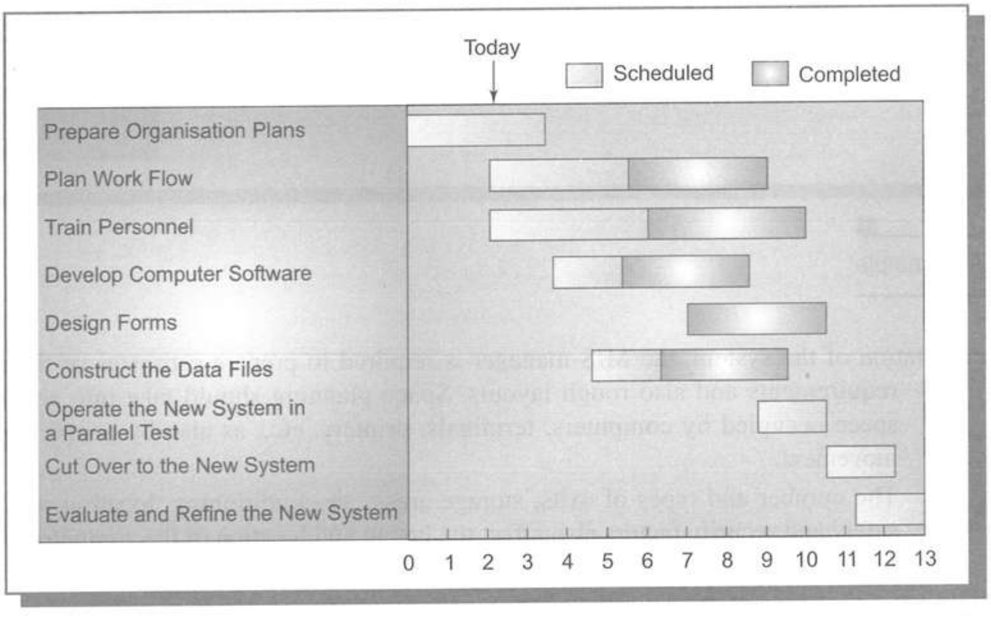


Fig. 14.1 Gantt Chart – An Example

14.1.2 Acquisition of Facilities and Space Planning

The information system to be implemented may be for a new organisation, where no old system is in existence or for an existing organisation, where the information system has been modified to a great extent or altogether a new one has been developed. This requires acquisition of facilities like office, computer room, computer library, etc.

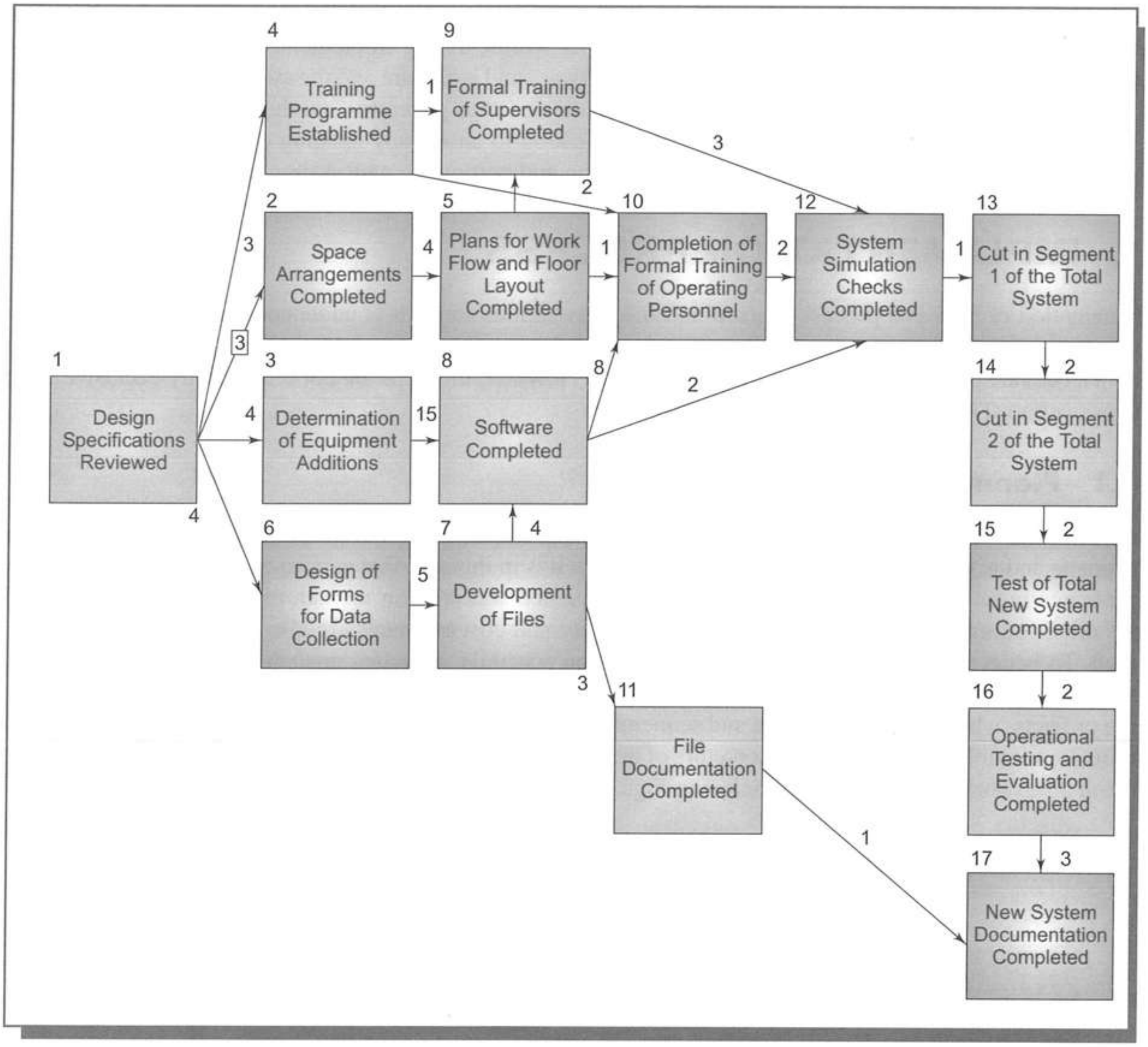


Fig. 14.2 Network Diagram – An Example

For proper implementation of the system, the MIS manager is required to prepare estimates of floor space requirements and also rough layouts. Space planning should take into account the space occupied by computers, terminals, printers, etc., as also by people and their movement.

FOCUS

For implementing MIS properly it requires acquisition of facilities like office, computer room, computer library, etc.

The number and types of exits, storage areas, air-conditioning, location of utilities, safety and security factors also affect the layout and location of the computer room.

14.1.3 MIS Organisation and Procedure Development

It is also important that a manager (may be from the finance/accounts/computer centre) be given the responsibility of guiding the task of implementation. The so-appointed MIS manager must make the role of line managers/users clear and ensure their involvement in the system to the maximum extent possible. In other words, the users should develop a feeling as if the system is their own system. It will help manage users' resistance to change and increase their acceptance. It is the right time here that the MIS manager starts recruiting/hiring other required personnel. Various types of organisations for MIS have been discussed in Chapter 12.

Just like proper organisation of MIS, development of procedures for various activities is also an important step. The various activities may include evaluating and selecting hardware, buying or developing software, implementation strategies, testing of the system, etc.

14.1.4 Acquisition of Hardware and Software

The process of acquiring the necessary hardware and software should, in fact, start immediately after the design specifications of the system are over, as selecting hardware and software may be quite complex and time-consuming (refer to hardware and software selection discussed in the later part of this chapter).

> **FOCUS** The process of acquiring the necessary hardware and software should, in fact, start immediately after the design specifications of the system are over.

It should be ensured that the facilities which are required for installing the hardware, such as, site preparation work, computer room layout, air-conditioning, electric connections, communication lines, etc., should be complete to avoid loss of time in making the system operational.

At this stage, consumables, like ribbons, paper, floppies, tapes, compact disks, etc., should also be acquired or orders placed as required.

14.1.5 Coding

During coding stage, the physical design specifications created by the system designer team are turned into working computer code by the programming team. Depending on the size and complexity of the system, coding can be an involved, intensive activity. Immediately after the coding has started, the testing process can begin and proceed in parallel. As each programme module is produced, it needs to be tested individually, then as part of a larger programme and then again as part of a larger system.

14.1.6 Testing

Tests should be performed in accordance with the test specifications at each and every phase. However, it is more important at implementation because, testing at this stage is done under real operating conditions with factual data. Testing can be done with only a small representative data but it should be done at various levels, starting from elements to sub-systems and finally to the system as a whole. The elements may include equipment, forms, programs, work procedures and formats, etc., and may be tested relatively independently of the system to which they belong. These tests are performed mainly for accuracy, range of inputs, frequency of inputs, operating conditions and reliability, etc.

Testing of information systems, nowadays, can be undertaken with the help of *Computer Aided Software Engineering* (CASE) tools. These tools provide for online debugging for correcting program and data errors.

> **FOCUS** Tests should be performed in accordance with the test specifications at each and every phase.

On the basis of the tests performed, a number of difficulties may arise. These may lead to changes in the design of the elements/subsystems or even in the system.

14.1.7 Creation of Forms and Database

Forms are very important for transmitting data. They are also required for input to the system and output from the system. For implementation of MIS, the required forms should be generated, but care must be taken that these are generated in the context of the entire MIS. Moreover, forms being the key user interfaces, become all the more important in the general acceptance of the system. Similarly, in the implementation stage, the actual data should be obtained and the database created, which is used, in the first instance, for the initial testing and then for the actual operation of the information system

14.1.8 Documentation

Broadly speaking, documentation can be understood as of two types, namely, system documentation and user documentation. *System documentation*, which is intended primarily for maintenance programmers or technical persons, records detailed information about a system's design specifications, its internal working, and its functionality. For example, System requirements specification, resource requirement specification, management plan, engineering change proposal, architecture design document, prototype design document, detailed design document, test specifications, and test reports, etc. *User documentation*, as the name implies, is intended primarily for users, and consists of written or other visual information about an application system, how it works and how to use it.

14.1.8 User Training

Adequate user training is very important for successfully implementing an information system. The users may be identified and classified differently on the basis of the operations/functions performed by them. For example, clerical or managerial, frequent users versus occasional users. These classes are not necessarily exclusive, as they quite often overlap. The MIS manager must design training programmes as per the needs of these users. Clerical users must be trained in the processing of transactions and managers must be informed as to the format and content of reports and terminal displays, as well as how to make online inquiries. Proper user training is an important factor in promoting the required culture and thus ensuring the acceptance of the new system, which is necessary for successful implementation.

14.1.9 Installation

Installation or changeover is the event of switch-over from the old system to the new system, which takes place after the system is tested and found reliable. The existing system is replaced by the new system in this phase. Conversion from the old system to the new system may be accomplished by selecting one or a combination of various conversion approaches. A brief description of conversion approaches is given below.

For New Organisation/Operation

If the organisation is a new one or when the old system does not exist, there is only one method for implementing the newly developed system, i.e. *install the system.*

The newly developed system is implemented as there is no old system in operation and thus no question of replacement of the old or existing system arises.

For Existing Organisation/Operation

When the old system is in existence, there may be four different strategies, namely:

(i) Direct Approach
(ii) Parallel Approach
(iii) Modular Approach
(iv) Phase-in Implementation

Direct Approach

A direct implementation is the installation of the new system and the immediate discontinuation of the old system, sometimes called cut-off. This is the 'Cold Turnkey' approach. This approach produces a time gap when no system is working. Thus, this approach is meaningful when:

(a) the system is not replacing any other system,
(b) the old system is judged absolutely worthless,
(c) the new system is either very small or simple, and
(d) the design of the new system is drastically different from that of the old system and comparisons between systems would be meaningless.

However, this approach may be used in organisations having seasonal operations like sugarcane processing or during the shut-down of a plant. The main advantage of this approach is that it is relatively inexpensive. On the other hand, the disadvantage of this approach is that it involves a high risk of failure. Figure 14.3 is a graphic representation of this approach.

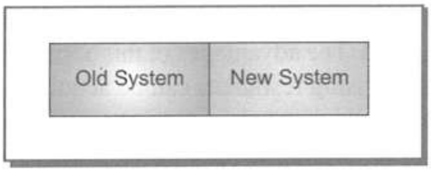


Fig. 14.3 Direct Approach to Implementation

Parallel Approach

In this approach, the new system is installed and operated in parallel with the current system until it has been tested thoroughly; then the current system is cut-out. This is the opposite of the direct implementation approach. In a parallel implementation approach, the outputs from each system are compared and differences reconciled. This method is expensive because of duplicating facilities and personnel to maintain the dual systems. However, it is required in certain essential systems, such as payroll, examination and defence systems. Its main advantage is that the accuracy of the system is properly checked before it is accepted as an information system of the organisation. In this approach, a target date should be set to indicate when parallel operation will cease and the new system will operate on its own. If possible, the target date should be set at the end of the longest processing cycle (e.g. at the end of the fiscal period and after year-end closings). A graphic representation of this approach has been depicted in Fig. 14.4.

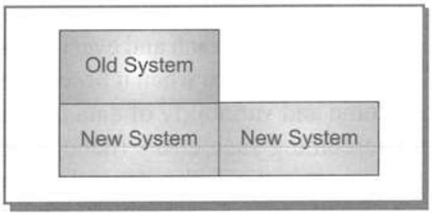


Fig. 14.4 Parallel Approach to Implementation

Modular Approach

Modular approach, sometimes termed the 'pilot approach', refers to the implementation of a system in the organisation on a module (piecemeal) basis. For example, an inventory system might be implemented with only a selected product grouping or with all products in one location of a multiple-location organisation. This approach has the following advantages.

(a) The risk of a system's failure is localised.
(b) The problems identified in the system can be corrected before further implementation.
(c) Other operating personnel can be trained in a 'live' environment before the system is implemented at their location. This approach has been illustrated in Fig. 14.5.

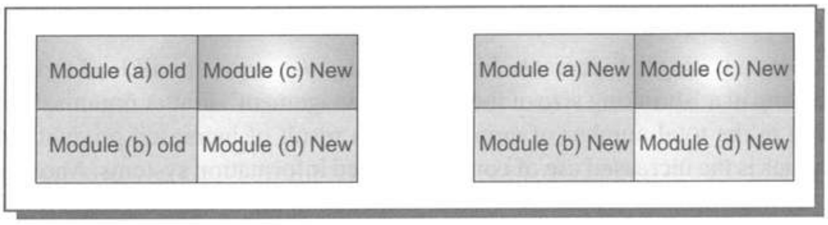


Fig. 14.5 Modular Approach to Implementation

Phase-in Implementation

This method is also referred to as 'cut over by segments' approach, which is similar to the modular approach. However, it differs in that the system itself is segmented and not the organisation. For example, the new data collection activities are implemented and an interface mechanism with the old system is developed. This interface allows the old system to operate with the new input data. Later, the new database access, storage, and retrieval activities are implemented.

Once again, an interface mechanism with the old system is developed. Another segment of the new system is installed until the entire system is implemented. The advantages of this approach are that the rate of change in a given organisation can be minimised and data processing resources can be acquired gradually over an extended period of time. This method is most-suited for systems which require only upgradation of the old systems. The disadvantages to this approach include the costs incurred to develop temporary interfaces with old systems, limited applicability and a feeling of 'pendency' in the organisation. This approach suggests that sub-systems are substituted for the old system. However, new systems, most of the times, are not substitutable piece by piece for the old systems. This approach is represented in Fig. 14.6.

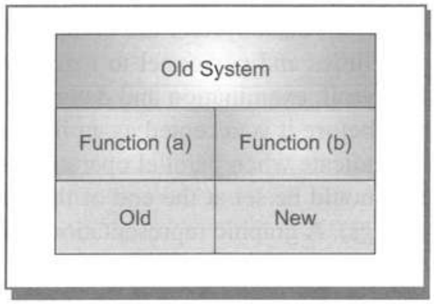


Fig. 14.6 Phase-in Implementation

No doubt, before changeover is affected, careful testing at each and every phase as well as at the implementation stage is undertaken; still there are chances of errors in the system when it becomes fully operational. Such errors may occur because of the failure to anticipate the volume and variability of data and unforeseen conditions under which the system actually operates. The process of overcoming such errors (debugging) associated with the changeover to the new system may continue for several days to several months, depending upon the size and complexity of the system.

After the system becomes operational, the system analyst should not feel that his/her job is over; rather the system has to be maintained within cost constraints at an efficient and effective level. Proper feedback is required to be received continuously for doing corrective adaptive and perfective, maintenance. Evaluation of the newly-developed and implemented system is required to be made to know the quality of the system developed and to get a continuous feedback on the performance of the information system.

14.2 ORGANISATIONAL CHANGE

The implementation of information systems may result in many changes in the organisations. It may affect the organisational structure, goals, work-design, values, competition between interest groups, decision-making and day-to-day behaviour. Some of the major potential areas of impact are discussed in the following paragraphs.

Organisational Structure

As an information system enables a manager to increase his or her *span of control*, it will lead to fewer managerial levels in the organisation, resulting in a 'shrinking size of the middle management'. Flatter organisational hierarchies may also result from reduction in the total number of employees as a result of increased productivity. Behind the downsizing of many organisations is the increased use of computer-based information systems. Another change is the creation of IS department in the organisation, which can lead to a change in the overall organisational structure.

Centralisation of Authority

The information systems affect the degree of centralisation of authority in the organisation.

Job Content

Many changes in job content take place when work is redesigned, especially in business process re-engineering (BPR). Job content is very important, not only because it is related to organisational structure but also because it is interrelated with employee satisfaction, status, productivity, etc. These changes sometimes create problems of *role conflict* and *role ambiguity*. Also, there may be resistance to change from the employees of an organisation.

Relationships

Because of information systems, relationships among employees also undergo a change. For example, with the introduction of computer-based information systems, face to face interaction between the supervisor and subordinate will be reduced. Similarly, information systems also change the relationship patterns among peers. With new information systems, some people in the organisation may start suffering a loss of identity and start feeling like 'just another number' because these systems dehumanise and depersonalise activities. Former informal work groups and working relationships may breakup. No doubt, an information system affects the organisational structure, goals, work design, values, competition, decision-making and day-to-day behaviour, yet it must be understood by the organisations that information technology exists for the sake of people and not vice versa. Moreover, information technology is just an organisational function and not the other way round. Therefore relationships among people or their behavioural aspects must be considered while designing information systems in the organisation. Basic premise of system development should be the recognition that all work processes be designed because of people and for people. It is also apparent that organisational change takes place because of the information system implementation.

Resistance to Change

There may be resistance to change because of new information systems in the organisation. Organisations, thus, must prepare themselves to manage this resistance to change for the successful implementation of information systems. It is said that people do not resist technological change of a new information system, but they resist the social change. This requires that organisations should avoid resistance to the new information system rather than defeating the resistance by shear power. Let us understand, how to manage this resistance to change.

14.2.1 Management of Change

The following three steps may be useful in managing the resistance to change.

(i) Create a climate for change
(ii) Develop effective agents of change
(iii) Modify the 'required' organisational system.

Create a climate for change

First of all, organisations should create a suitable climate for change. Such a culture may be created by getting the employees to feel dissatisfied with the present system. Employees may be exposed to a series of seminars and conferences with the main focus on the shortcomings of the present systems and ways to overcome those shortcomings. In this process, a thinking would be developed that some change is required in their organisation.

Develop effective agents of change

To win the support of the employees, organisations should identify their informal leaders and they should be sent to workshops or seminars. This will stimulate new ideas in the minds of the leaders. This in turn will help gain the support of other employees.

Modify the 'required' organisation

A technically ideal organisation is termed as the 'required' organisation. However, for achieving better working relationships of the users, rearrangements of the organisation should be made to fit the anticipated emergent organisation behaviour.

14.2.2 Organisational Learning

Organisational learning, which exhibits adaptive behaviour, is the process by which an organisation identifies action-outcome relationships, identifies and corrects errors, stores the experience in organisational personnel who teach the other employees of the organisation, and stores the experience in procedures, systems, rules, computer programs and other forms for transferring experience. For example, a user of an information system is imparted training on how to use the new system by information system specialists. Existing literature, manuals, etc., through previous organisational experience can educate users on how to use the system. The learning of the users is further enhanced when they informally exchange related stories on the system. These related stories may consist of unwritten rules, tips, and guidelines or learning experiences of other employees in the organisation.

Stimulus-Response Theory of Learning

Information and information systems can aid organisational learning. According to stimulus-response theory, the learning process consists of four main elements.

(i) Drive,
(ii) Cue,
(iii) Response, and
(iv) Reinforcement.

(i) *Drive* is defined as any strong stimulus that impels action. It arouses an individual and keeps him prepared to respond. The drive to learn beyond innate curiosity is acquired.

(ii) *Cue* or stimulus may be defined as any object in the environment perceived by the individual, which guides and determines response.

(iii) *Reinforcement* or reward means reduction in drive and stimulus that follows a response. The reinforcement causes responses to be 'learned'. These elements of the learning process are exhibited in Fig. 14.7.

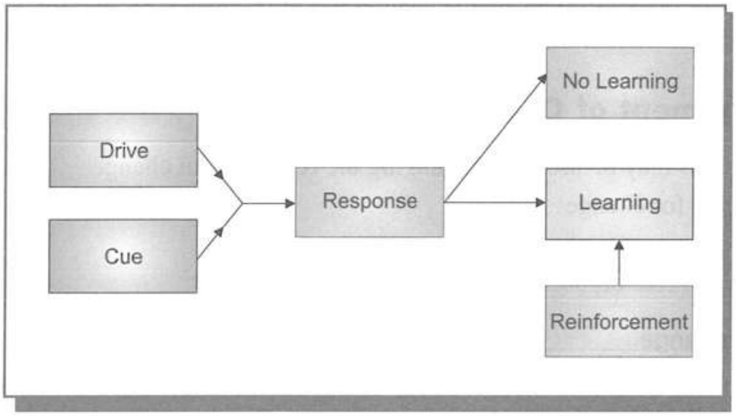


Fig. 14.7 A Learning Process

Some responses, at a higher level of mental processes are actions; others produce cues.

Information systems aid in the learning process by providing cues and responses in the following ways.

Interaction with Other Users

Information systems enable a user to interact with a wide variety of interorganisational and intra-organisational users and thus a user may share his or her experiences with others and vice versa. This sharing of experience promotes education of the organisational employees.

Interactive Systems and Databases

Nowadays, user-friendly interactive information systems also enable a user to learn about new products, advancements, etc., by providing a free access to the exhaustive databases.

Upgradation of Skills

As the new information systems are implemented in an organisation, the employees are trained in using them, which leads to the upgradation of their skills. This upgradation of employees' skills is a result of the learning activity.

SUMMARY

Implementation is a process of coding, testing, installation, documentation, training and support. In other words, during implementation phase, physical system specifications are converted into working and reliable software and hardware and the system is installed at the user's premises so as to continuously getting the output it was designed to generate. For the new organisation or operation, MIS is installed directly as there is no old/existing system to be replaced. However, for the organisations or operations which are already in existence, four different strategies could be adopted for implementing the developed MIS. These strategies may be direct, parallel, modular or phase-in strategy.

Implementation procedure is a step-by-step method which involves a number of steps, namely, Planning the implementation; Acquisition of facilities and space planning; MIS organisation and procedure development; Coding & testing; Acquisition of hardware and software; Creation of forms and database; Documentation; User training; and Changeover.

However, these steps are not necessarily sequential. Sometimes, some of the steps may overlap. Here, it may be noted that after the system becomes operational, the system analyst should not dissociate himself/herself from the system; rather the system has to be maintained, for which continuous feedback should be received by way of evaluating the system.

Information systems also enable an organisation to change. The organisational changes may be in the form of new organisation structure, new authority-responsibility patterns, changed job contents and new relationships among employees. Because of IS implementation, there may be resistance to change, which should be managed skilfully. Information systems also enable an organisation to learn new technology and its impacts. Information systems aid in the organisational learning by providing cues and responses.

REVIEW QUESTIONS

1. What is meant by system implementation? Discuss various strategies for installing a newly-developed MIS in your organisation.
2. Discuss the steps involved in the implementation process. Do you think, these steps are sequential in nature? Elaborate.
3. Do you think IS enables organisations to change? How? Discuss the organisational changes because of IS implementation.
4. How would you manage resistance to change? In your opinion, is resistance always negative? Discuss.
5. Define organisational learning. How does an information system aid in organisational learning?

ASSIGNMENTS

1. Identify various tasks for implementing an MIS in your organisation and draw a network diagram indicating all the identified tasks.
2. Assume you are to install a newly-developed MIS in your organisation, which method would you recommend for its implementation? Give reasons.
3. Study any organisation, in which information systems have recently been implemented. Find out if there was any resistance to change. If yes, study how the organisation managed that change. Identify the changes because of new information systems in the organisation.

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CASE STUDY 1

IMPLEMENTATION OF OLT AT DEEP COLLEGE OF MANAGEMENT & TECHNOLOGY

Deep College of Management & Technology (DCMT), which got started in 1987, is one of the top management colleges in India. More than eight thousand students from almost all states of India apply for 180 MBA seats. While in their last semester of two year MBA programme, almost all the students are placed in good companies with a good salary. In order to bring more rigour in academics and executive education and executive training, the management has brought in Professor T S Paliwal, who is in the early fifties with a lot of energy and mandate to transform the college. Among many other initiatives, automation of the institute activities was defined as a major agenda, covering academics, hostels, accounts, finance and administration. This includes student registration and profile management, scheduling and conduct of classes, examination and grading, students' feedback and fee deposit etc. The scope of work was no less than an ERP system, but the major ERP players seem to have ignored this market segment. Since the period of May and June is a lean period, in which most of the professors go on summer leaves, it was decided to take up the work of computerization during this period.

As the scale of application was large and time available was just two months, phase I targeted on the automation of academic programmes. The idea was to facilitate student attendance, registration for elective courses, online quizzes, marks, students' feedback and subject grading. There were limited readymade packages/applications available in the market to cater to the higher education model. There were high cost systems used world wide such as Blackboard and WebCT but they were not explored for purchase. A low cost software vendor was invited for product demo but the system offered by him was typical of a conventional university system. The company has large installation base in Gulf countries. Though, they have a development center in India and offer customization also, the proposal died out in the files.

In April 2005, Mr. A S Sikka, a software vendor was called for discussion and demonstration of his solution to Dr. P Singh – Dean, all academic heads and head of finance department. In a 2 hour session, all the departmental heads raised their queries. Some of them were answered there and then; many others were noted for action by Mr A S Sikka.

Prof. Paliwal had experienced this online system in the previous organization he came from. The system was web-based and managed students according to their course. It was running successfully at many other colleges. But at DCMT, the needs were quite different. It was much larger and dynamic set up as compared to most other educational institutes. Integration with other functions such as admissions, accounts etc. did also not exist in the system. After some deliberations, a contractual order was given to Mr Sikka according to which he had to customize the application to suit the needs of the college. The new system had to get ready and running before the June session. Thus time available was two months and expectation was a complete solution for students' record of identity, attendance, quizzes and marks.

For the smooth implementation of the system, many training sessions were organized for faculty, staff and students. The Phase I of system was up and running on the day the students joined the institute. This got popularized as OLT (Online learning and Teaching) system.

Then onwards, every other day, the users watched an un-installation and installation procedure executing while the desktops booted in the morning. This was to enable the upgraded version of OLT as and when Mr Sikka released it. Teaching staff had their own set of problems. They all were using laptops rather than desktops for now more than two years and were accustomed to hibernation rather than shut down feature of machine. So, as they would try to log on to OLT, it would generally fail forcing them to restart the machine. The first expectation of faster attendance and quick quizzes seemed shattered. 10 weeks later, as the term results were being generated; minor errors in calculation and data inconsistency were traced; which were rectified after a lot of struggle.

Every one seemed disturbed. Many students, professors and staff used to complain about the inefficiency and unfriendliness nature of the new system. But pressure from top management ensured that negative feedbacks get curtailed and the genuine people start registering constructive feedback to Dr Singh or Mr Verma – the Administrative officer. Disgruntled users kept cribbing; Mr Sikka was often seen in the campus busy with modules related to accounts and general administration. Many features of phase I were still not used. Some of the professors went to the extent of telling that some features were not usable at all.

Even after one year, new versions still keep coming though no significant change was visible in the academic module. Still students do not like the design of the dialogue box of the system. For the quizzes, the system takes a long time before it gets started and the system hangout problem is very common. Academic program staff has started finding solutions by export of data to Excel, update and import back. They find it less troublesome than asking for a change. Mr Sikka was given annual maintenance contract of the system and now he rectifies the problems from his office through remote login.

Questions

(a) Do you think the decision of the top management to implement such a system was right? Discuss.
(b) Identify the problems in the implementation of this system. Why do you think, such problems arose?
(c) If you were the person responsible for the implementation of such a system, how differently you must have done it?

Source: Adapted from 'Which Model Suits Me' from Software Quality, A Practitioner's Approach by Khanna Malik & Praveen Choudhary Published by Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008, pp. 39-40.

Chapter 15

Evaluation & Maintenance of IS

Learning Objectives

After reading this chapter, you should be able to:

- Understand the concept of evaluation
- Describe evaluation approaches and evaluation classes for assessing an MIS
- Discuss and implement product based and cost-benefit based evaluation of MIS
- Understand process based evaluation of MIS
- understand the concept and types of system maintenance

15.1 EVALUATION OF MIS

Evaluation of MIS is an integral part of the management control process, in which the organisations determine or appraise the quality or worth of their information systems. In other words, evaluation of MIS is a process of measuring performance of organisational information systems. The feedback so obtained helps determine the necessary adjustments to be made in their information systems.

15.1.1 Evaluation Approaches

There are different approaches to evaluate MIS in an organisation. The MIS evaluation approaches provide different means to measure accomplishments of system objectives. Hamiltons' survey (1980) indicates that the following approaches on MIS evaluation are frequently employed in organisations. The scope of each evaluation approach has been summarised as follows (Hamilton et al., 1981).

(i) *Quality Assurance Review*

Quality assurance reviews or technical reviews focus on assessing the information system's technical quality, e.g. comparison to standards and operations acceptance procedures. Technical evaluation includes variables like data transmission rate, main/secondary storage, CPU capacity, etc. Technical reviews are performed by MIS development/ operations personnel or a separate quality assurance group within the MIS function.

(ii) *Compliance Audits*

Compliance audits or application control reviews assess the adequacy and completeness of controls for the system inputs, outputs, processing, security and access. Compliance audits are typically performed by an autonomous internal audit function.

(iii) *Budget Performance Review*

Evaluation of MIS budget performance concentrates on compliance with a predetermined budget expenditure level for the MIS development or operations process. Evaluation of user budget performance has its focus on MIS resource consumption by the user. Both may be supported by a chargeback mechanism.

(iv) *MIS Personnel Productivity Measurement*

The capability of MIS personnel is typically determined in terms of productivity. Examples of productivity measures include lines of code per unit time for the programming (development) personnel and keystrokes per unit time for the data entry (operations) personnel.

(v) *Computer Performance Evaluation*

The production capability of the computer hardware is typically evaluated in terms of performance efficiencies and bottlenecks that limit production. For example, computer performance evaluation measurements are made on per cent uptime, actual throughput, and I/O channel utilisation.

(vi) *Service Level Monitoring*

Service level monitoring focusses on assessing the information and support provided to the user, based on the terms established between the MIS and the user personnel. Assessment of the information provided include turnaround time, response time and error rates. Assessment of the support provided include the time required to respond to the user's problems and requests for changes.

(vii) *User Attitude Survey*

User attitude survey method is used in operational evaluation. Operational considerations refer to whether the input data is adequately provided and the output is usable. This type of attitude surveys are conducted through questionnaires and/or interviews to appraise the user's perceptions of the information and support given by the MIS function. User attitude surveys typically assess such aspects as the quality and timeliness of reports, quality of service and MIS-user communication.

(viii) *Post-Installation Review*

The focus of a Post-Installation Review (PIR) is often on estimating whether the system meets the requirement definition, i.e. 'Does the system do what it is designed to do'? However, the scope of the PIR may include a post-hoc review of the development and operation processes, an examination of the information and support provided, an analysis of the actual use process, and cost/benefit analysis of the system and its effects on the user performance.

(ix) *Cost/Benefit Analysis*

Cost/Benefit analysis is also known as economic evaluation. The analysis quantifies the system's effect on organisational performance in terms of dollars, e.g. direct cost savings or tangible financial benefits. Cost/Benefit analysis is often used in capital budgeting to gauge the return on investment.

15.1.2 Evaluation Classes

Evaluation of performance measurement consists of two major classes (Davis and Olson, 1985), as given below.

Effectiveness

This refers to the quality of the outputs from the system. Effectiveness means doing the 'right' thing in the right manner so that desired result may be achieved. Information System is said to be effective if its product (i.e. output) is of quality, and the process of producing output is right (effective).

Efficiency

It is a measure of the amount of resources required to achieve the output, i.e. the use of system resources to get results. Being efficient implies the system is operating the 'right' way.

The relationship between effectiveness and efficiency is that effectiveness is a measure of the 'goodness' of output, while efficiency is a measure of the resources required to achieve the output. This relationship has also been shown in Fig. 15.1.

FOCUS

Evaluation of performance measurement consists of two major classes, which are Effectiveness and Efficiency.

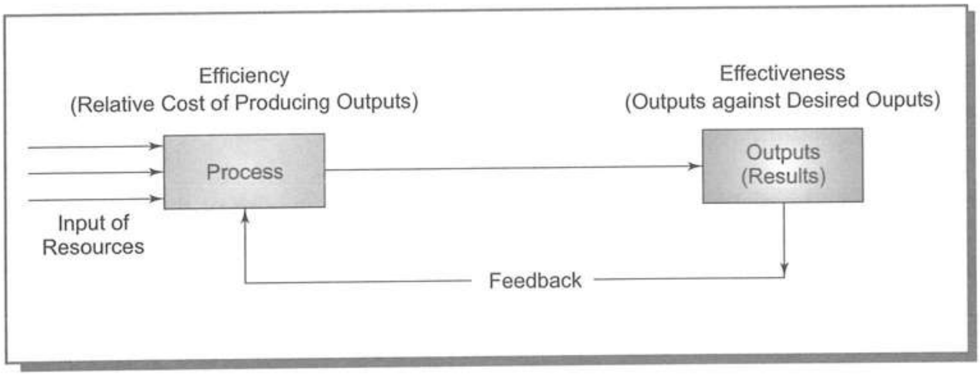

Fig. 15.1 Relationship between Efficiency and Effectiveness

There are various dimensions of information systems that should be evaluated. These may include the development process, which, concerns whether the system was developed following set standards; information being provided and the system's performance. Depending upon the dimensions of the information system to be evaluated, an appropriate evaluation approach may be adopted. To understand the concept of MIS evaluation, three approaches of evaluation have been discussed in this section. These are product-based evaluation, economic evaluation, and process based evaluation. Product based evaluation focuses on the product, i.e. information support from the MIS; economic evaluation focuses on the costs/benefits of MIS; and the process based evaluation focuses on the processes, which make it. Let us try to understand these approaches.

15.1.3 Product-Based MIS Evaluation

Since the focus of the product-based evaluation is on the product (information support) or the output from the system, the evaluation may be termed as effectiveness evaluation. For assessing the effectiveness of output from MIS, the following model may be used.

Model Structure

The information attributes may be identified as components of a general model for evaluation of MIS effectiveness in an organisation (see Chapter 3). Some of these attributes are listed below.

(i) Timeliness
(ii) Relevance
(iii) Accuracy
(iv) Completeness
(v) Adequacy
(vi) Explicitness
(vii) Exception-based.

Model Implementation

Various types of outputs/reports, being generated by MIS of the organisation can be evaluated for their effectiveness in terms of the attributes of the management information. The attributes of information have been listed in the structure of the model as mentioned above. To employ this model, managers at different levels of management of the organisation may be asked to rate the outputs/reports on each of the information attributes.

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Since the focus of the product-based evaluation is on the product (information support) or the output from the system, the evaluation may be termed as effectiveness evaluation.

To get responses, a five-point scale may be used on which the respondents (users of information systems) may be asked to rate the effectiveness of MIS in terms of these information attributes. The rating is based on the number of the reports/outputs which observe the information attributes. For example, a five-point scale may be prepared to get an evaluation of the number of reports received by the managers in terms of 'Timeliness', as given below.

All reports	Most reports	Many reports	Some reports	No report
*	*	*	*	*
4	3	2	1	0

The scale thus prepared is to be administered either through a mailed questionnaire or through a personal interview and the scoring may be done by assigning a numerical value of 0 to the least favourable location on the scale, 1 to the next favourable, and so on.

The following formula may be applied to compute effectiveness score for each of the attributes.

$$ES_k = \frac{\Sigma s \cdot f}{N}$$

where ES_k = Effectiveness Score for kth attribute

s = Score assigned to the response

f = Frequency of the score

N = Number of respondents

On the whole, the effectiveness score for all the n information characteristics of MIS can be computed as follows:

$$ES_{\text{MIS}} = \sum_{k=1}^{10} \frac{E \cdot S_k}{n}$$

Effectiveness Norm

Now, ideally speaking, ES_{MIS} should be equal to 4. However, owing to the high cost involved in such a system and uncertain environment, such a situation is not practical. Therefore, a tolerance limit is to be prescribed which serves as a standard or effectiveness norm, against which the organisation may compare the effectiveness of the existing MIS to determine deviations, if any. It is on the basis of this comparison that an MIS may be termed as either effective or otherwise. The tolerance limit for defective reports may be decided by the organisations concerned; it may vary from 5 to 20% and accordingly, the standards for an effective MIS may be computed in terms of its ES_{MIS} as follows.

On the five-point scale, the total scale is divided into four parts. Taking the total scale equal to 100, each part on the scale is equal to the value of 25. Thus on this scale, 100%, 75%, 50%, 25% and 0% of the reports are represented by a score of 4, 3, 2, 1 and 0, respectively. According to this conversion rule, 1% of the reports would be represented by l/25th (0.04) part on the scale. For 90% of the reports, the score may be calculated as below.

If 1% of the outputs are represented by a score of 0.04 part on the scale,

90% of the outputs are represented by a score of $0.04 \times 90 = 3.6$ on the scale.

Therefore, 90% of the outputs will be represented on the scale by an effectiveness score of 3.6. From the above, it may be said that ES_{MIS} for 5%, 10% and 15% defective reports should be equal to 3.8, 3.6 and 3.4, respectively.

15.1.4 Cost/Benefit-Based Evaluation

In cost/benefit evaluation, a thorough study of various expected costs, the benefits to be expected from the system and expected savings, if any, is done. It is an economic evaluation of the system, in which costs to be incurred for developing, implementing and operating a system are to be justified against the expected benefits from the system. In other words, cost/benefit analysis determines the cost-effectiveness of the system.

> **FOCUS**
> In cost/benefit evaluation, a thorough study of various expected costs, the benefits to be expected from the system and expected savings, if any, is done.

For undertaking cost/benefit evaluation, various estimates of costs as well as benefits expected from the system are to be made. In developing cost estimates for a system, several cost elements are considered. Among them are initial development costs, capital costs, operating costs, etc. Similarly expected benefits from the system are considered. The benefits may be in terms of reduced cost, better performance/decisions, etc. The various categories of costs and benefits are measured and included in cost/benefit analysis. A brief description of all these cost elements and benefits is given below.

Initial Development Cost

Initial development cost is the cost incurred in developing an information system. Various elements of development cost include project planning cost, feasibility study cost, design cost, conversion cost, implementation cost (including user training cost, testing costs, etc.). In other words, total development cost is considered one-time cost and is termed as initial development cost.

Capital Cost

Capital cost is also one-time cost. It is the cost incurred in facilities and in procuring various equipment, including hardware, etc., required for the operation of the system. Facility costs are expenses incurred in the preparation of the physical site where the system will be implemented. It includes wiring, flooring, lighting, acoustics, and air-conditioning cost. The cost on space required for office, storage and computer room, if not hired, is also included in the facility cost. Hardware and equipment cost relates to the actual purchase or lease of the computer and peripherals.

Annual Operating Cost

Annual operating cost is the cost incurred in operating the system. It includes computer and equipment maintenance cost, personnel cost, overheads and supplies cost. Computers and equipment are to be maintained and thus some cost is incurred, known as Annual Maintenance Cost (AMC). Similarly, personnel are required to operate the system. Personnel cost includes EDP staff salaries and other benefits (provident fund, health insurance, vacation time, pensionary benefits, etc.). Overhead costs include all costs associated with the day-to-day operation of the system; the amount depends on the number of shifts, the nature of the applications, and capabilities of the operating staff. Supply costs are variable costs that increase with increased use of paper, ribbons, disks, etc.

Just as the cost elements, in cost/benefit evaluation, various expected benefits from the system are also studied. The first task is to identify each benefit and then assign a monetary value to it. Benefits may be tangible or intangible, direct or indirect.

There are two major benefits, namely, improving performance and minimising the cost of processing. The performance part suggests improvement in the accuracy, timeliness, non-duplication, adequacy, usefulness in information and easier access to the system by authorised users; which in turn leads to better decisions and allows more time to managers for planning purposes, etc. Minimising costs through an efficient system, such as error control, reduced salary and labour cost and reduced inventory cost is a benefit that is to be measured for evaluating cost-effectiveness of a system.

For identification and categorisation of various costs and benefits, the following concepts are important.

Identification of Costs and Benefits

Certain costs and benefits are more easily identifiable than others. For example, direct costs, such as the price of a personal computer, ribbon, etc., are easily identified from invoices or from organisational records. Similarly, direct benefits like reduction in staff because of the new system or fast processing of transactions, may be identified. Other direct costs and benefits, however, may not be well-defined, since they represent estimated costs or benefits that are not very certain or well-defined. An example of such a cost is a reserve for bad debt.

Classification of Costs and Benefits

The various categories of costs and benefits are important to make a cost/benefit analysis. These categories may be tangible or intangible, direct or indirect, fixed or variable.

Tangibility

Tangibility refers to the ease with which costs and benefits can be identified and measured. Cost incurred or to be incurred on a specific item or activity is termed as a tangible cost. For example, computer cost, consultancy fee paid to a consultant, employee salary are tangible costs. Whereas intangible costs are those costs that are known to exist but whose monetary value cannot be accurately measured. For example, lowered employee morale because of a new system is an intangible cost.

Like costs, benefits may also be categorised as tangible or intangible.

Tangible benefits such as reduced salaries, producing reports with no errors are quantifiable. Intangible benefits, such as high morale among employees, improved organisational image are not easily quantified.

Costs are also categorised as *direct* or *indirect* costs. Direct costs are those with which an amount in rupees can be directly associated to any of the items or operations of the system. For example, the purchase of a computer ribbon for Rs 200 is a direct cost. Direct benefits also can be identified which could be attributed to the new system. For example, a 5 per cent reduction in salary expenditure because of the new system can be classified as a direct benefit. Indirect costs are the results of operations that are not directly associated with the system or activity. They are termed as *overheads*. For example, safety or security of computer room, electricity, air conditioning and maintenance, etc., are included in indirect costs.

Similarly, indirect benefits are realised as a by-product of some other activity or system. For example, newly computerised salary system provides information on the total amount required for disbursements and total deductions to be made under various heads like insurance, provident fund, recovery from loan advances, etc. Information about the amount recovered from loan advances becomes an indirect benefit of the salary system as the management would be able to properly utilise the amount and thus can earn maximum returns.

Fixed costs are constant costs and do not change, regardless of how well a system is used. They are only one-time costs like development cost, capital and insurance cost, etc., whereas *variable costs* are incurred on a regular basis. They are usually proportional to work volume and continue as long as the system is in operation. For example, the cost of supplies depends upon the size and volume of reports/processing work. Fixed benefits are also constant and do not change. For example, 10 per cent reduction in staff as a result of the new system is a fixed benefit.

Table 15.1 MIS Evaluation Form

Name of the organisation ____		Date ____	
Address ____		Ref. No ____	
(A) **Estimated Initial Development Cost**			
1. Project Planning		Rs ____	
2. Feasibility Study		Rs ____	
3. Design		Rs ____	
4. Conversion		Rs ____	
5. Implementation		Rs ____	
6. Miscellaneous		Rs ____	
	Total (A)		Rs ____
(B) **Estimated Capital Cost**			
1. Computer Room Equipment and H/W		Rs ____	
2. Facilities		Rs ____	
	Total (B)		Rs ____
(C) **Estimated Operating Cost**			
1. Personnel		Rs ____	
2. Computer/Equipment Rent		Rs ____	
3. Overhead and Supplies		Rs ____	
	Total (C)		Rs ____
(D) **Estimated Benefits**			
1. Reduced Salary and Labour Cost		Rs ____	
2. Reduced Inventory Cost		Rs ____	
3. Better Decisions		Rs ____	
4. Any Other Intangible Benefit		Rs ____	
	Total (D)		Rs ____
(E) Annual savings	D – C		
(F) Rate of Return (rate at which present value of savings equals present value of one-time costs) (*Pv* of *E* = *Pv* of *A* + *B*)		–%	

Variable benefits, on the other hand, are realised on a regular basis. For example, the amount of daily time saved of a manager varies with the number and types of decisions taken.

Once the variable of interest and their respective figures are identified, a table, known as MIS evaluation table may be prepared, as shown in Table 15.1.

The MIS evaluation table summarises the benefits to be expected from the system, the expected costs and expected savings, if any, for the MIS user. The annual savings and rate of return are computed by using any or a combination of evaluation methods which have been mentioned below. Equipment life has tended to be relatively short because of technological obsolescence. For medium-to-large scale equipment, it is estimated to be five years; for microcomputers, owing to faster obsolescence, it is considered to be three years.

Capital Budgeting Models used in Evaluation

Having identified and categorised various costs and benefits, monetary value of each and every cost as well as benefit is estimated. A business analyst/user manager may evaluate the costs and benefits so estimated. For evaluation, there are several capital budgeting models, which can be used, namely:

(i) Net benefit analysis,
(ii) Present value analysis,
(iii) Net present value,
(iv) Payback method,
(v) Cash-flow analysis,
(vi) Break-even analysis, etc.

Each method has got its own advantages and disadvantages. Any one or a combination of several methods may be used to evaluate the estimated figures of costs and benefits.

No doubt, cost/benefit analysis is a very important tool used in economic evaluation of the system, however, the difficulty in quantifying intangible and indirect costs and benefits becomes its major limitation.

15.1.5 Process Based Evaluation

Process based evaluation focuses at the effectiveness of the processes (sub processes) that make it. The IS sub processes are plan process, development process and use process. These sub processes, as the contributors to IS effectiveness, are shown in Fig. 15.2 and the detailed view is given in Figure 15.3.

FOCUS

Process based evaluation focuses at the effectiveness of the processes (sub processes) that make it.

As per this model, for effectiveness of IS, the efforts must begin at the planning stage. To achieve this effectiveness, all the contributors of IS must be well in place, i.e. their effectiveness should contribute to the overall IS effectiveness.

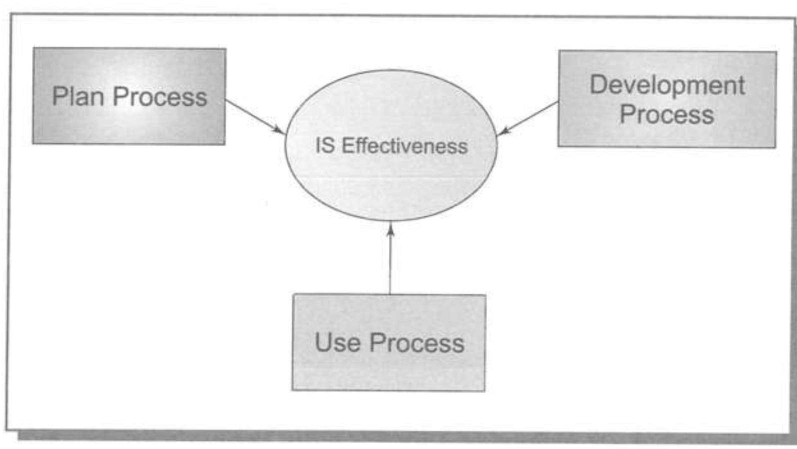

Fig. 15.2 Contributors to IS Process Effectiveness

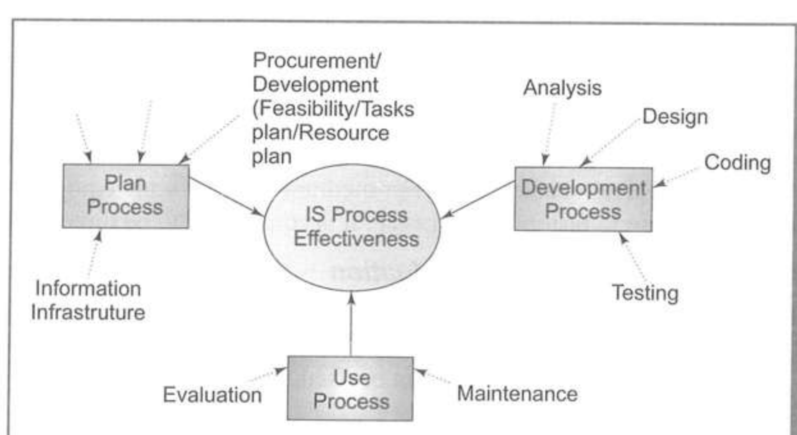

Fig. 15.3 Contributors to IS Process Effectiveness (Detailed View)

15.2 SYSTEM MAINTENANCE

The results obtained from the evaluation process help the organisation to determine whether its information systems are effective and efficient or otherwise. As the organisations are existing in dynamic and competitive environments, evaluation is a continuing activity. On the basis of the feedback provided by the evaluation process, the organisation, in order to keep its MIS at the highest levels of effectiveness and efficiency, of course, within cost constraints, must respond by taking corrective actions. Corrective action may include removing errors which may be due to design, due to environmental changes or due to organisational changes, or due to changes while enhancing the existing system. This process of monitoring, evaluating, and modifying of existing information systems to make required or desirable improvements may be termed as *System Maintenance.*

System maintenance is an ongoing activity, which covers a wide variety of activities, including removing program and design errors, updating documentation and test data and updating user support. For the purpose of convenience, maintenance may be categorised into three classes, namely;

(i) Corrective,
(ii) Adaptive, and
(iii) Perfective.

15.2.1 Corrective Maintenance

This type of maintenance implies removing errors in a program which might have crept in the system due to faulty design or wrong assumptions. Thus, in corrective maintenance, processing or performance failures are repaired.

15.2.2 Adaptive Maintenance

In adaptive maintenance, program functions are changed to enable the information system to satisfy the information needs of the users. This type of maintenance may become necessary because of organisational changes which may include:

(i) change in the organisational procedures,
(ii) change in organisational objectives, goals, policies, etc.,
(iii) change in forms,
(iv) change in information needs of managers,
(v) change in system controls and security needs, etc.

15.2.3 Perfective Maintenance

Perfective maintenance means adding new programs or modifying the existing programs to enhance the performance of the information system. This type of maintenance is undertaken to respond to the user's additional needs which may be due to the changes within or outside of the organisation. Outside changes are primarily environmental changes, which may in the absence of system maintenance, render the information system ineffective and inefficient. These environmental changes include:

(i) changes in governmental policies, laws, etc.,
(ii) economic and competitive conditions, and
(iii) new technology.

No doubt, maintenance is regarded as a necessary evil but it should not be delegated to junior programmers; nor should it be performed on a haphazard or informal basis; rather maintenance must be given its due status in the organisation and should be, as far as possible, properly planned and the maintenance responsibility should be entrusted to a qualified supervisor and team of MIS experts.

SUMMARY

After the system becomes operational, the system analyst should not dissociate himself/herself from the system; rather the system has to be maintained, for which continuous feedback should be received by way of evaluating the system. Evaluation of MIS also helps an organisation to know whether the system is performing as per the expectations of the user. There are various approaches for conducting evaluation of an MIS; like Quality assurance review; compliance audits; Budget performance review; MIS Personnel productivity measurement; Computer performance evaluation; Service level monitoring; User attitude survey; Post insallation review; and Cost-benefit analysis, etc. Depending upon the need and convenience, evaluation of MIS may be done by using any one or a combination of various approaches.

Performance evaluation may be categorised into two classes, namely effectiveness and efficiency.

Effectiveness is product-based evaluation, whereas efficiency focusses on the use of inputs to produce outputs, i.e. the use of system resources to achieve results. In other words, efficiency is a measure of the resources required to achieve the output. Operational evaluation done from the system's point is an example of evaluation, which measures efficiency or performance of the system.

The results obtained from the evaluation help determine the health of an information system in the organisation. As organisations are operating in a dynamic and competitive environment, they keep on changing. This change may be within or outside the organisation, which necessitates changes in the information system.

REVIEW QUESTIONS

1. Why is evaluation of MIS important? Describe, in detail, various approaches for evaluating an MIS.
2. How would you categorise performance evaluation? Discuss two major classes of performance measurement.
3. What is product-based evaluation? Discuss, in detail, the model which may be employed for product-based MIS evaluation.
4. Prepare a cost/benefit evaluation table. Elaborate its various components. How is cost/benefit evaluation carried over?
5. Why is system maintenance necessary? Discuss the types of system maintenance.

ASSIGNMENT

1. Suppose you want to evaluate an MIS of your department. Prepare a questionnaire to be administered to the users of MIS.

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CASE STUDY 1

EFFECTIVENESS OF MIS – A CASE STUDY

The chairman of a public utility organisation in India wanted to know the effectiveness of MIS in his organisation. He didn't know how to proceed. So, he invited Mr Ashok, a consultant from a reputed management institute in India, to evaluate the effectiveness of MIS of his organisation so as to determine whether the system needed any improvement, and if so, in which areas. Mr Ashok, who was an expert in MIS, keeping various constraints in mind, selected the product-based evaluation method for determining the effectiveness of MIS of the organisation. He used the model suggested by Goyal (1994) for the purpose (see product-based evaluation model). In order to elicit responses, a total of 99 managers who were selected on the basis of stratified random sampling, were administered the pre-tested and corrected questionnaire (see questionnaire in Exhibit 1). Out of 99 responses, 9 were from the middle-level and 90 from operational/control-level managers.

Using the information from the questionnaires, scoring for each and every characteristic in the model was done by assigning a numerical value of –2 to the least favourable position on the scale, –1 to the next least favourable position and so on. As further suggested in the model, the respective effectiveness score for each attribute and effectiveness score as a whole at the two levels were computed (shown in Exhibits 28.2 and 28.3).

The consultant fixed an effectiveness norm of 1.6, which was equivalent to 90 per cent of the effective reports/information provided by the MIS of the organisation. Thus, as per this standard, the consultant would term the system effective if it satisfied the information characteristics equal to or more than 90 per cent, otherwise the system would be termed as ineffective if the score fell below 1.6.

On the basis of the study, the consultant concluded that the MIS of the organisation was not effective. He suggested to the chairman of the organisation that improvement in respect of timeliness, accuracy, adequacy, no-duplication and exception-based reporting was needed; restructuring of the information system was also recommended.

QUESTIONS FOR DISCUSSION

1. Do you think the consultant rightly evaluated the MIS of the organisation? Comment on the model employed and the reliability of the questionnaire used for the study.
2. Comment on the overall methodology of the research carried out by the consultant in this case.

Exhibit 1

QUESTIONNAIRE

CONFIDENTIAL

1. (a) Name : ____________________
   (b) Designation : ____________________
   (c) No. of years of service : ____________________
   (d) No. of years of service in present position
2. (a) Please mention your normal duties : ____________________
   (b) Any additional duties : ____________________
3. Please evaluate the reports received by you in the following aspects.
   (Please note the following codes)

All reports	Most reports	Many reports	Some reports	No report
*	*	*	*	*
A	MO	MA	S	N

Please tick at the appropriate place:

TECHNICAL REPORTS

Attributes

	A	*MO*	*MA*	*S*	*N*
(a) Timeliness	*	*	*	*	*
(b) Relevance	*	*	*	*	*
(c) Accuracy	*	*	*	*	*
(d) Up-to-datedness	*	*	*	*	*
(e) Adequacy	*	*	*	*	*
(f) No-overloading	*	*	*	*	*
(g) Format clarity	*	*	*	*	*
(h) No-duplication	*	*	*	*	*
(i) Explicitness	*	*	*	*	*
(j) Exception-based reporting					
FINANCIAL REPORTS					
(a) Timeliness	*	*	*	*	*
(b) Relevance	*	*	*	*	*
(c) Accuracy	*	*	*	*	*
(d) Up-to-datedness	*	*	*	*	*
(e) Adequacy	*	*	*	*	*
(f) No-overloading	*	*	*	*	*
(g) Format clarity	*	*	*	*	*
(h) No-duplication	*	*	*	*	*
(i) Explicitness	*	*	*	*	*
(j) Exception-based reporting					
GENERAL REPORTS					
(a) Timeliness	*	*	*	*	*
(b) Relevance	*	*	*	*	*
(c) Accuracy	*	*	*	*	*
(d) Up-to-datedness	*	*	*	*	*
(e) Adequacy	*	*	*	*	*
(f) No-overloading	*	*	*	*	*
(g) Format clarity	*	*	*	*	*
(h) No-duplication	*	*	*	*	*
(i) Explicitness	*	*	*	*	*
(j) Exception-based reporting	*	*	*	*	*

Exhibit 2 MIS Effectiveness at Level-II Management

Attributes	*Sample size*	*Technical*		*Financial*		*General*	
		Mean (X)	*Range*	*Mean (X)*	*Range*	*Mean (X)*	*Range*
Timeliness	9	1.556	1–2	0.333	(–1)–2	1.556	1–2
Relevance	9	1.556	1–2	1.667	1–2	1.000	0–2
Accuracy	9	–0.111	(–1)–1	–0.222	(–1)–1	–0.556	(–1)–0
Up-to-datedness	9	1.555	1–2	0.333	(–1)–1	1.556	0–1
Adequacy	9	1.111	1–2	1.000	1	1.000	1
No-overloading	9	1.111	1–2	1.222	1–2	1.000	1
Format clarity	9	1.556	1–2	1.556	1–2	1.667	1
No-duplication	9	0.889	0–1	1.000	0–2	0.778	0–1
Explicitness	9	0.222	(–1)–1	0.667	0–1	0.111	0–1
Exception-based reporting	9	–1.889	(–2)–(–1)	–1.889	(–2)–(–1)	–1.889	(–2)–(–1)
ΣX =		7.557		5.667		6.223	
ΣX/10 =		0.755		0.566		0.622	
ΣX/9 =		1.050		0.840		0.900	

Source: Survey conducted by the consultant.

Exhibit 3 MIS Effectiveness at Level-III Management

Attributes	*Sample*	*Technical Size*		*Financial*		*General*	
		Mean (X)	*Range*	*Mean (X)*	*Range*	*Mean (X)*	*Range*
Timeliness	90	0.944	0.568	0.889	0.550	0.000	0.524
Relevance	90	1.011	0.437	1.222	0.576	0.900	0.451
Accuracy	90	0.444	0.736	0.822	0.646	0.278	0.735
Up-to-datedness	90	0.956	0.559	0.889	0.550	0.867	0.479
Adequacy	90	1.289	0.456	1.244	0.504	1.067	0.292
No-overloading	90	1.256	0.552	1.256	0.552	1.000	0.367
Format clarity	90	1.344	0.501	1.278	0.541	1.344	0.544
No-duplication	90	0.144	1.001	1.011	0.590	0.444	0.638
Explicitness	90	0.622	0.572	1.000	0.561	0.467	0.690
Exception-based reporting	90	–1.144	0.712	–1.222	0.845	–1.189	0.634
ΣX =		6.866		8.389		5.178	
ΣX/10 =		0.686		0.830		0.510	
ΣX/9 =		0.900		1.070		0.700	

Source: Survey conducted by the consultant.

REFERENCE

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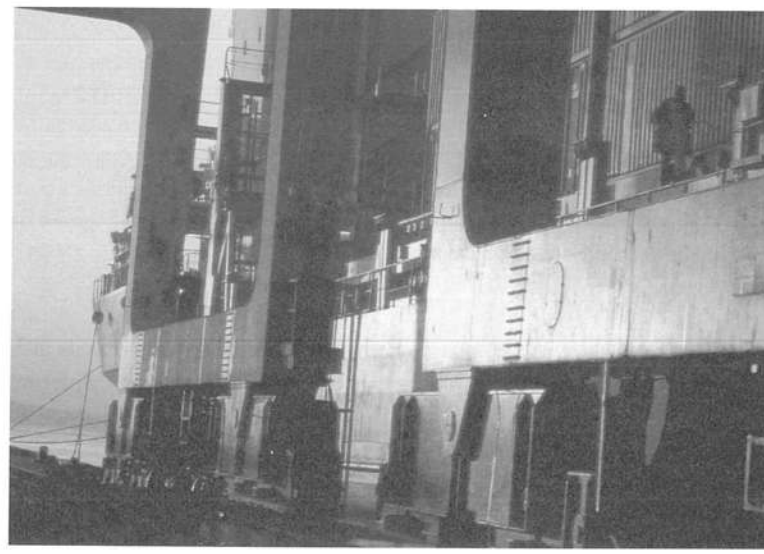
Chapter 16

IS Security and Control



Learning Objectives

After reading this chapter, you should be able to:

- Understand the various types of IS threats
- Describe the types of IS strategies and IS controls
- Describe the various kinds of security technology that can be implemented to protect IS resources; and
- Understand the need and process of business recovery plan

IS security is not a new concept. It started from the day the first mainframe computer was developed. Even when the ISs were not computer based, organisations, to keep the confidentiality of their data, used coded languages in transmitting messages. With the invent of computers and telecommunication systems, organisations have started using more and more computer based information systems, especially the networked systems. Because of the networked systems, ISs have become easy targets of threat as the internet has thousands of unsecured computer networks, which are in communication with each other. Thus, nowadays, IS security has assumed more significance than ever before. Today, organisations need to understand the potential threats/risks to their ISs and must have well defined strategies to manage those risks. IS security refers to the policies, procedures, and technical measures adopted to prevent potential threats to IS resources. Let us understand the various categories of threat to information systems, so as to understand the prevention and management of these threats.

16.1 IS SECURITY THREATS

Some of the major threats to the information systems are categorised as follows:

- Human errors or failures
- Manipulation of data/systems
- Theft of data/systems
- Destruction from virus
- Technical failure/errors of systems
- Natural disasters like flood, fire, earthquake, etc

To get a better picture of the above mentioned categories of threats, let us discuss these threats in some more detail.

16.1.1 Human Errors or Failures

This category includes unintentional errors made by an authorised user. The employees of the organisation may commit errors like entry of wrong data, accidental deletion or modification of data, storage of data in unprotected areas like a desktop, website or in the trash bin, disclosing of confidential data to person who would exploit the information etc without any wrong intention. These types of errors or failure of ISs may happen because of lack of experience, improper training or other circumstances. But these errors or failures may cause a great damage.

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Organisations are increasingly becoming dependent on information systems/technology, so control and security is an important issue of concern for the management.

16.1.2 Manipulation of Data/Systems

As the name implies, this category of threat happens because of the deliberate acts of some persons or organisations designed to harm the data or information systems of an organisation. In this type of threat, an unauthorised individual gains an access to the private/confidential or important data of an organisation and purposefully do some wrong acts like delete, corrupt or steal the data.

16.1.3 Theft of Data/Systems

It is a deliberate attempt of some person to steal the important data of an organisation. Though thieves may steal physical items like entire computer, circuit boards and memory chips, the theft of electronic data pose a greater challenge. Telecommunication networks are highly threat prone to misuse by users or by computer experts. People with computer knowledge can tap the communication lines and illegally intercept data. The person, who intercepts the communication lines to steal data without the knowledge of the owner of the data, is known as a hacker.

16.1.4 Destruction from Virus

This category of threat is the potential for deliberate software attack. This kind of attack happens when a person or a group write software to attack data or IS of an organisation with the purpose to damage, destroy, or deny service to the target systems. The programme, which is written with an intent to attack data or IS, is known as malicious code or malicious software, or malware. Some of the common examples of malware are viruses and worms, Trojan horses, logic-bombs, etc. The Computer *Viruses* are the secret instructions inserted into programs or data that are run during ordinary tasks. The secret instructions may destroy or alter data, as well as spread within or between computer systems. *Worm* refers to a program which replicates itself constantly and penetrates a valid computer system. Worms can continue replicating themselves until they completely fill available memory, hard drive space, and network bandwidth. It may spread within a network, penetrating all connected computers.

Trojan horses: This name has been taken from the Trojan horse from Greek mythology, which is very deceiving. Trojan horses refers to illegal programs, contained within another useful or beneficial program, that hide their true nature or 'sleeps' until some specific event occurs, then triggers the illegal program to be activated and cause damage. When a virus is attached to a legitimate software program, the program becomes infected, which is not known to the user. When the software is used, the virus spreads, causing damage to that program and possibly to others. Thus the legitimate software is acting as a *Trojan horse*. Many viruses can be hidden in Trojan horses, but Trojan horses do not have the ability to replicate themselves.

Logic bombs: A logic bomb, which is also known as *time bomb*, is a kind of programme that executes when certain conditions are met. It is similar to Trojan horse in its ability to damage data but it activates at a particular time.

It may be noted that the above mentioned list of viruses is not exhaustive; rather only a few examples of the viruses have been mentioned. In fact new viruses emerge daily, however, it emphasizes the fact that viruses are dangerous and deadly.

16.1.5 Technical Failure/Errors of Systems

This category of threat includes technical failures or errors, which may occur because of the manufacturing defects in the hardware or the hidden faults in the software. Sometimes unique combinations of certain software and hardware may give new errors. These failures may also be because of technological obsolescence.

16.1.6 Natural Disasters

Sometimes the threat may not be because of unintentional acts or the deliberate acts of an individual or a group of persons; rather it may be from the acts of God resulting from forces of nature that cannot be prevented or controlled. Such threats include fire, flood, earthquake, lightning, etc.

In view of the above mentioned threats, organisations need to implement controls so as to avoid, reduce or manage risk from these threats.

16.2 PROTECTING INFORMATION SYSTEM

Avoiding, reducing and/or managing IS threats is one of the challenging tasks for any IS manager. To do so, organisations need to formulate the right protection strategies, policies and implement appropriate controls. These strategies, policies and controls are intended to prevent accidental hazards; deter intentional acts; detect problems as early as possible; and improve damage recovery problems. Controls can be integrated into hardware and software during the system development phase, or in the implementation phase or during the maintenance phase of the software.

Let us discuss some of the main IS strategies and controls, which may be used to avoid, reduce or manage threats to information system resources.

FOCUS

1. Controls for Prevention and Deterrence
2. Detection
3. Recovery
4. Correction

IS Strategies

- *Preventive strategy:* This strategy refers to the controls that would help prevent errors from occurring, deter criminals from attacking the system, and deny access to unauthorised people.
- *Detection strategy:* It may not be feasible to prevent the IS systems from all hazards and therefore many IS resources may be unprotected from threats and the unprotected systems are vulnerable to attacks. Thus organisations should use special diagnostic software that may detect the potential threats.
- *Minimum losses strategy:* It refers to the minimising of losses once a threat has happened. Users should get their systems back in operation as early as possible. Thus, organisation should think of having a fault-tolerant system that permits operation in a degraded mode until full recovery is made, otherwise, a quick recovery must take place.
- *Recovery strategy:* A recovery plan, that explains how to fix a damaged information system as quickly as possible, must be in place. Replacing rather than repairing components is one way to fast recovery.
- *Corrective action strategy:* The damaged system must be corrected immediately so as to prevent the problem form occurring again.

IS Controls

Similarly, the organisation can plan and implement various kinds of IS controls so as to avoid, reduce and manage the risks of the potential threats to information systems. These controls can be understood under the following five categories, namely

(i) Physical Controls
(ii) Technical Controls
(iii) Administrative Controls
(iv) General Controls
(v) Application Controls

Let us try to understand these controls.

(i) Physical Controls

As the name implies, these controls refer to the protection of computer facilities and other IS resources. This includes protecting computer hardware, computer software, database, computer networks, etc. Physical security of the IS resources include various controls such as:

- The location and layout of the computer centre must be decided keeping in view the physical security of the IS resources. For example, organisations would like to decide that the site of computer centre should be water proof and fire proof.
- The site should have proper air-conditioning systems, extinguishing systems, adequate drainage facilities and emergency power shutoff and backup systems.

(ii) Technical Controls

The technical controls are the controls which are implemented in the application of IS itself. These types of controls include access controls, data security controls, communication controls, etc.

Access Controls: These controls refer to the restrictions imposed for the unauthorised access of any user to IS resource. In other word, a user, in order to gain access, must be authorised and before he/she is given an access, must be authenticated. The identification of the user can be obtained through a unique user identifier, such as the password, a smart card, digital signature, voice, fingerprint, or retinal (eye) scan. Unique user identifier is normally implemented through *bio-metric controls*. A biometric control is an automated method of verifying the identity of an individual, based on physiological or behavioural characteristics.

Data Security Controls: To protect data from accidental or intentional disclosure to unauthorised person, or from unauthorised changes or destruction, data security controls are very useful, which can be implemented through operating systems, database security, access control programmes, backup and recovery procedures, etc. Organisations should make sure that in the event of any security breach, there is no data loss. For this, organisations must have a clear cut policy in place and must implement data security controls like taking of backup of all data periodically, duplicate the data automatically on regular intervals, etc.

Communication Controls: With an increased use of the Internet, intranet and electronic commerce, communications controls have become all the more important. Various communication controls include access control, data encryption, firewalls, etc.

(iii) Administrative Controls

Administrative controls which include clear guidelines, policies of the organisations with regards to the use and deployment of IS resources are very important in protecting ISs. For example, email policy, internet use policy, access privileges of employees, programming and documentation standards, etc., fall under the category of administrative controls.

(iv) General Controls

There may be some controls, which are categorised as general controls. These controls are implemented so as to ensure that ISs are protected from various potential threats. For example, system development controls like budgeting, schedule, quality, etc., are meant to ensure that a quality system is developed within the budgeted cost and competed on time.

(v) Application Controls

The application controls, as the name implies, are embedded within the application itself. These controls are usually written as validation rules. These controls are popularly known as input controls, processing controls, and output controls.

16.3 IS SECURITY TECHNOLOGY

In order to protect the IS resources, organisations implement a number of technical solutions as security measures. The technical solutions to be implemented depend upon the criticality or the value of the IS resource. Some of the technical solutions may include firewalls and proxy servers; authentication and data encryption; digital signatures and digital certificates. Let us try to understand the basics of some of these technical solutions, which are implemented as IS security measures.

(a) Firewall

A firewall refers to a protection device that selectively discriminates against data flowing out or into the organisation based on the pre defined rules. A firewall protects unauthorised access to ISs over the Internet. It may be a hardware and software that stops access to ISs resources. Thus, a firewall, which acts like a watchman, will not allow any unauthorised user to access the server of an organisation. A firewall can also be used as a front line defense against attacks, as through a firewall, only a few types of protocols can be allowed to enter and thus the incoming data for any probable viruses or any attempt to attack on the IS resources can be screened. In other words, a firewall can restrict the sites from viewing which might have threat of attacks.

(b) Proxy Servers

A proxy server, as the name implies, acts as a representative of the true server of an organisation. It is another approach of IS security measures which performs actions on behalf of another system. A proxy server is configured to look like a web server with the domain name of the true server of the organisation. When any person from outside requests a particular web page, the proxy server receives the request, and in turn asks for the information from the true server, and then responds to the request of a person as a proxy for the true web server. Thus the person gets the information without getting in direct contact with the true web server.

(c) Authentication and Data Encryption

As already mentioned, these controls refer to the restrictions imposed for unauthorised access to IS resource. Before gaining an access to IS resource, it is important to prove the identity of the user as well as to authenticate the message sent by an individual or an organisation. *Authentication* is the validation of a user's identity. For the authorised access, a user is given *a password* or *personal identification number,* which is a private word or combination of characters. The password is known only to the authorised person. It is suggested that the password should not be simple to guess, meaning it should not be associated with the user, such as a spouse's, children's name, date of birth, car number, etc. Also the password must be changed at regular intervals. ID cards, ATM cards, smart cards are the other access control measures, through which the user's identity is proved. A smart card contains a chip that can verify and validate a number of pieces of information along with the PIN, whereas ID cards, or ATM cards, contain magnetic stripes, on which user personal identification number is stored, which is compared against the input of the user. Under bio-metric access control, the human characteristics, which are considered as unique and can be used to recognize a person, namely, fingerprints and retina of the eye are scanned and converted to images and are stored in digitised format. The subsequent scan, used to verify the authenticity, is also digitised and then compared with the stored digitised value.

To authenticate the users and maintain secrecy, another IS security measure, which is known as encryption, is used. In encryption, the message is coded into an unreadable form to an interceptor, as encryption uses mathematical algorithms to jumble information (coded) to be transmitted over the network. It ensures the authentication of the sender as the message is encrypted and sent by a certain person or the organisation.

(d) Digital Signatures

Digital signatures, which are analogous to physical signatures, are used to authenticate the identity of the sender of a message and also guarantee that the sent message has not been modified. Digital signatures are encrypted messages that are verified as authentic by an independent central facility. The digital signatures, which are implemented with public-key cryptography, are created in two phases. First, the encryption programme uses a mathematical algorithm/formula to create a message digest for the message is to be transmitted. A *message digest* is similar to the unique fingerprint of a message. Then, the software uses the private (secret) key to encrypt the message digest. This results into a digital signature for that specific message. On the receiver's side, the public key is used to decode (decrypt) the message. The sender cannot deny the fact that the message was sent by him or the organisation, as the owning of the private key cannot be refuted. In legal terms, this is known as nonrepudiation, which is, infact the basis of the digital signatures.

(e) Digital Certificates

A digital certificate is an electronic document, which is attached to the message certifying that the message is from the sender it claims to be from and has not been modified from the original format. Thus, a digital certificate is like a digital signature, which is used to authenticate the sender as well as the content. A digital certificate associates one's identity with one's public key. Digital certificates are issued by organisation which is then called a certificate authority. The information like sender's name, serial number, expiration date, and a copy of the certificate holder's public key along with the digital signature of the certificate authority are stored on the digital certificate. This information is used to verify the authenticity of the certificate.

16.4 THE DISASTER RECOVERY PLAN

As it has already been emphasized, that the organisations must understand the importance and need of IS security and must have strategies, plans and policies to avoid, reduce, and manage potential risks from IS security threats. As it is difficult or may be very expensive to avoid or control all disasters, organisations must be ready to reduce the risk from the potential threats and manage on its own if some disaster occurs. In order

FOCUS

In view of the unauthorized and destructive activities on the internet, organizations need to protect themselves against such attacks.

FOCUS

A Number of Security Measures an organization can take are:Firewalls, proxy Servers, Authentication and Encryption, Transport Layer Security, Digital Signatures, Digital Certificates

to minimise the business loss, it is important that IS services must be brought back to order or resumed as early as possible. Thus, it becomes important for all organisations that they must have IS recovery plan in place.

The disaster recovery plan is a well documented programme that provides detailed guidance and procedures to execute during and after a disaster. It also lists the roles and responsibilities of the person(s) involved in recovery, if IS resources go down.

A disaster recovery programme involves the following steps:

- *Commitment of the top management:* For the success of any disaster recovery plan, it is important that there is a strong commitment from the top management. The plan requires a substantial amount of resources, which must be properly budgeted and provided by the top management.
- *Sensitisation of all the employees:* IS security, is not the sole responsibility of any one person; rather it is the responsibility of the whole organisation. This concept of shared responsibility of all the employees is very important, and thus all the employees of an organisation must be sensitised regarding the concept of IS security and their overall responsibility.
- *Appointment of business recovery coordinator:* There should be a team of persons drawn from all the departments of the organisation, along with a coordinator, who should be responsible for the disaster recovery. The roles and responsibilities of the members and the coordinator should be clearly established.
- *Establishment of priorities:* In the event of any disaster, the committee should know what actions are required to be taken and in which order. It is not possible to restore everything at once so the most important and critical function is to be dealt with first. For this the committee should identify all the risks and then prioritise these risks so as to handle them as per their impact on the business. For example, the applications, without which the business cannot conduct its operations, should be given the highest priority and so on.

FOCUS

Business recovery plan, which is also called *disaster recovery plan,* is a well planned programme that lists the actions to be taken and the person(s) responsible for such actions, if critical systems go down.

- *Selection of a recovery plan:* The committee should find out various recovery plan alternatives, which are evaluated by considering advantages and disadvantages in terms of risk reduction, cost, and the time required for an organisation to adjust to the alternative system. On the basis of evaluation, the recovery plan is finalised and selected.
- *Execution of the selected plan:* Immediately after the recovery plan is selected, it must be executed as the top most priority.
- *Review and Updation of the disaster recovery plan:* The plan must be reviewed after a regular interval to consider the changing requirements so as to update the plan.

SUMMARY

With the invent of computers and telecommunication systems, organisations have started using more and more computer based information systems, especially the networked systems. Because of the networked systems, ISs have become easy targets of threat as the internet has thousands of unsecured computer networks, which are in communication with each other. Thus, now-a-days, IS security has assumed all the more significance than ever before. Today, organisations need to understand the potential threats/risks to their ISs and must have well defined strategies to manage those risks. IS security refers to the policies, procedures, and technical measures adopted to prevent potential threats to IS resources. IS security refers to the policies, procedures, and technical measures used to prevent potential threats to IS resources.

Some of the major threats to the information systems are categorised as follows:

- Human errors or failures
- Manipulation of data/systems
- Theft of data/systems
- Destruction from virus
- Technical failure/errors of systems
- Natural disasters like flood, fire, earthquake, etc.

Avoiding, reducing and/or managing IS threats is one of the challenging tasks for any IS manager. To do so, organisations

need to formulate the right protection strategies, policies and implement appropriate controls. These strategies, policies and controls are intended to prevent accidental hazards, deter intentional acts, detect problems as early as possible, and improve damage recovery problems. Controls can be integrated into hardware and software during the system development phase, or in implementation phase or during the maintenance phase of the software.

The organisation can formulate various IS strategies and also plan and implement various kinds of IS controls so as to avoid, reduce and manage the risks to the potential threats to information systems. These controls can be understood under the following five categories, namely:

- Physical Controls
- Technical Controls
- Administrative Controls
- General Controls
- Application Controls

In order to protect the IS resources, organisations implement a number of technical solutions as security measures. The technical solutions to be implemented depend upon the criticality or the value of the IS resource. Some of the technical solutions may include firewalls and proxy servers; authentication and data encryption; digital signatures and digital certificates. It must be kept in mind that it is difficult to avoid or control all disasters, therefore organisations must be ready to reduce the risk from the potential threats and manage if some disaster happens. In order to minimise the business loss, it is important that IS services must be brought back to order or resumed as early as possible. Thus, it becomes important for all organisations that they must have IS recovery plan in place.

The disaster recovery plan is a well documented programme that provides detailed guidance and procedures to be executed during and after a disaster. It also lists the roles and responsibilities of the person(s) involved in recovery, if IS resources go down. The plan must be reviewed after a regular interval to consider the changing requirements so as to update the plan.

REVIEW QUESTIONS

1. Discuss various types of attacks on networked systems. How can you protect your systems from such attacks?
2. What is the purpose of IS controls? Discuss various types of ISs controls.
3. Describe the various kinds of security measures that can be taken to protect data and ISs.
4. Differentiate between digital signatures and digital certificate.
5. What is the purpose of business recovery plan? How can you create a business recovery plan? Illustrate.
6. Write Short notes on:
   (a) Firewalls
   (b) Proxy servers
   (c) Security threats
   (d) Authentication
   (e) Trojan horses
   (f) Bio-metric controls

ASSIGNMENTS

1. Identify an organisation that has recently been in the news for some kind of IS security breach. Analyse its security plan and suggest the security measures.
2. You have joined as a chief security officer for a major IT service company. Formulate a strategy for the company to ensure a good security culture is developed, implemented and maintained.
3. Study at least four companies to find how a good security culture is developed and maintained in non-IT based environments. How can lessons from these implementations be used for developing and sustaining IS security culture?
4. Evaluate the business recovery plan of an organisation in your area and suggest improvements, if any.

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Part

5 Building of Information Systems

Chapter Outline

System Development Approaches

Systems Analysis and Design

Chapter 17

System Development Approaches

Learning Objectives

After reading this chapter, you should be able to:

- Understand system development as a life cycle approach, and describe system development stages
- Discuss the methods for conducting preliminary investigations
- Describe various system development approaches

System development is regarded as another form of problem-solving in software which consists of activities like:

(i) understanding the problem,
(ii) deciding a plan for a solution,
(iii) coding the planned solution, and
(iv) testing the coded program.

17.1 SYSTEM DEVELOPMENT STAGES

In order to develop a system successfully, it is managed by breaking the total development process into smaller basic activities or phases. Any system development process, in general, is understood to have the following phases:

(i) Investigation,
(ii) Analysis,
(iii) Design,
(iv) Construction,
(v) Implementation, and
(vi) Maintenance.

A brief description of the above-mentioned stages is discussed as follows.

17.1.1 System Investigation

Some problem may be bothering a business organisation. The managers in the organisation (user) may or may not be very clear about the problem. The user may invite a system analyst or information analyst (consultant) to assist him/her in defining and resolving the problem in a clear way.

Preliminary investigation is the first step in system development project. The preliminary investigation is a way of handling the user's request to change, improve or enhance an existing system. The objective is to determine whether the request is valid and feasible before any recommendation is made to do nothing, improve or modify the existing system, or build altogether a new one. It is not a design study, nor does it include the collection of details to completely describe the business system. These objectives should be accomplished, while working on the preliminary investigation. System investigation includes the following two sub-stages:

FOCUS

System Investigation is the first step in the system development project and it is used to define and resolve the problem in a clear way.

(i) Problem definition, and
(ii) Feasibility study.

Problem Definition

Although the need for problem definition may seem obvious, this is perhaps the most frequently bypassed step in the entire system development process. So the first responsibility of a system analyst is to prepare a written statement of the objectives and scope of the problem. Based on interviews with the user, the analyst writes a brief description of his/her understanding of the problem, and reviews it with both groups, ideally in a joint user/information analyst meeting. People respond to written statements. They ask for clarifications and they correct obvious errors or misunderstandings. This is why a clear statement of objectives is so important.

In other words, proper understanding and definition of the problem is essential to discover the cause of the problem and to plan a directed investigation by asking questions like what is being done? Why? Is there an underlying reason different from the one the user identifies?

Here are some possible definitions of problems:

(i) The existing system has a poor response time, i.e. it is slow.
(ii) It is unable to handle the workload.
(iii) The problem of cost, i.e. the existing system is not economical.
(iv) The problem of accuracy and reliability.

(v) The requisite information is not produced by the existing system.

(vi) The problem of security.

Similarly, a system analyst should provide a rough estimate of the cost involved for the system development. This is again a very important question, which also is not asked until it is quite late in the system development process.

Feasibility Study

The literal meaning of feasibility is viaility. This study is undertaken to know the likelihood of the system being useful to the organisation. Feasibility study, is basically, a high-level capsule version of the entire process, intended to answer a number of questions like what is the problem? Is the problem even worth solving? However, as the name indicates in preliminary investigation, feasibility study should be relatively brief, as the objective at this stage is only to get an idea of the scope. The finding of this study should be formally presented to the user management. This presentation marks a crucial decision point in the life of the project. If the management approves the project, the feasibility study report represents an excellent model of the system analyst's understanding of the problem and provides a clear sense of direction for the subsequent development of the system.

The aim of a feasibility study is to assess alternative systems and to propose the most feasible and desirable system for development. Thus, feasibility study provides an overview of the problem and acts as an important checkpoint that should be completed before committing more resources.

The feasibility of a proposed system can be assessed in terms of four major categories. These are summarised below.

(i) Organisational Feasibility

The extent to which a proposed information system supports the objective of the organisation's strategic plan for information systems determines the organisational feasibility of the system project. The information system must be taken as a sub-set of the whole organisation.

(ii) Economic Feasibility

In this study, costs and returns are evaluated to know whether returns justify the investment in the system project. The economic questions raised by analysts during the preliminary investigation are for the purpose of estimating the following:

(a) the cost of conducting a full system investigation.

(b) the cost of hardware and software for the class of application being considered.

(c) the benefits in the form of reduced costs, improved customer service, improved resource utilisation or fewer costly errors.

(iii) Technical Feasibility

Whether reliable hardware and software capable of meeting the needs of the proposed system can be acquired or developed by the organisaton in the required time is a major concern of the technical feasibility. In other words, technical feasibility includes questions like:

(a) Does the necessary technology exist to do what is suggested, if it does then can it be acquired?

(b) Does the proposed equipment have the technical capacity to hold the data required to use the new system?

(c) Will the proposed system provide adequate responses to inquiries, regardless of the number of locations and users?

(d) Can the system be expanded?

(e) Is there any technical surety of accuracy, reliability, ease of access and data security?

(iv) Operational Feasibility

The willingness and ability of the management, employees, customers, suppliers, etc., to operate, use and support a proposed system come under operational feasibility. In other words, the test of operational feasibility asks if the system will work when it is developed and installed. Are there major barriers to implementation? The following questions are asked in operational feasibility:

(a) Is there sufficient support from the management? From employees? From customers? From suppliers?
(b) Are current business methods acceptable to the users?
(c) Have the users been involved in the planning and development of the system project?

Operational feasibility would pass the test if the system is developed as per rules, regulations, laws, organisational culture, union agreements, etc., and above all with the active involvement of the users.

Besides these four main categories, the system should also be assessed in terms of legal feasibility and schedule feasibility. Whereas legal feasibility refers to the viability of the system from the legal point of view, i.e. it checks whether the system abides by all laws and regulations of the land, the schedule feasibility evaluates the probability of completing the system in the time allowed for its development, since for the system to be useful, it must be finished well before the actual requirement of its usage.

For determining feasibility, a project proposal must pass all these tests. Otherwise, it is not a feasible project. For example, a personnel record system, that is economically feasible and operationally attractive, is not feasible if the necessary technology does not exist. Infeasible projects are abandoned at this stage, unless they are reworked and resubmitted as new proposals.

Following are the methods for conducting a preliminary investigation:

Methods of Preliminary Investigation

During a preliminary investigation, the following two main methods are used:

(i) Reviewing documents, and
(ii) Interviewing selected persons.

(i) Reviewing Organisation Documents

The analysts conducting the investigation first learn about the organisation involved in, or affected by, the system project. For example, to review an inventory systems proposal means knowing first how the inventory department operates and who the managers and supervisors are? This can be learnt by examining the organisation charts and studying written operating procedures. The procedures describe how the inventory process should operate and identify the most important steps involved in receiving, managing and dispensing stock.

(ii) Conducting Interviews

Written documents do not give user-views about current operations. To learn these details, analysts conduct interviews. Interviews allow analysts to learn more about the nature of the system project request and the reason for submitting it. To accomplish the purpose of the interview, analysts must be sure to emphasise the request and the problem it addresses. In other words, interviews should provide details that further explain the project and show whether assistance is merited economically, operationally and technically. It must be kept in mind that working out a solution to the situation comes later, during detailed investigation.

The following format is suggestive of the preliminary investigation scope:

1. Project Title
2. Problem Statement : Concise, possibly in a few lines, stating the problem.
3. Project Objectives : State objectives of the project defined by the problem.
4. Preliminary Ideas : Possible solutions, if any, occurring to user and/or analyst could be stated here.
5. Project Scope : Give overall cost estimate.
6. Feasibility Study : Indicate here time and cost for the next step.

17.1.2 System Analysis

Analysis is a detailed study of the various operations of a business activity (system), along with its boundaries. The objective of this phase is to determine exactly what must be done to solve the problem. Many system analysts have a technical background. The temptation of many technically trained people is to move too quickly to program design, to become pre-maturely physical. Such a temptation must be avoided. Rather a logical model of the system should be developed using various modern tools such as data flow diagrams, an elementary data dictionary and rough descriptions of the relevant algorithms. System analysis involves a detailed study of:

FOCUS

Analysis is a detailed study of the various operations of a business activity (system), along with its boundaries and it is used to determine exactly what must be done.

(i) The information needs of the organisation and its end users.
(ii) Existing information systems (their activities, resources and products).
(iii) The expected information system (in terms of capabilities of IS required to meet the information needs of users).

The final product of system analysis is a set of system requirements of a proposed information system. Keeping in view the importance of system analysis, this has been discussed in detail. The analysis phase provides the analyst with a clear understanding of what is to be done. The next step is to decide as to how the problem might be solved.

17.1.3 System Design

System analysis describes WHAT a system should do to meet the information needs of users. System design specifies HOW the system will accomplish this objective. The term design refers to the technical specification (analogous to the architect's blue prints) that will be implied in constructing the system. System design should stress on the following three activities:

FOCUS

System design specifies HOW the system will accomplish the goal of meeting the information need of users.

(i) User interface,
(ii) Data design, and
(iii) Process design.

Where an interface design activity focuses on designing the interactions between end users and computer systems, the data design activity focuses on the design of the logical structure of database and files to be used by the proposed information system. Process design activity focuses on the design of the software resources, that is, the programs and procedures needed by the proposed information system. In this phase, system designers should use their knowledge of business operations, information processing and hardware and software to specify the physical design of an information system. The design must specify what type of hardware resources, software resources (programs and procedures), and people resources (end users and system staff) would be needed. These specifications are also known as system specifications. A detailed system design is given in the later part of this chapter.

17.1.4 Construction and Testing

Once the system specifications are understood, the system is physically created. The required programs are coded, debugged, and documented. The system should be tested with some test data to ensure its accuracy and reliability. In fact, construction of the system takes place on the basis of the system design specifications. So in this phase, the various directions as per system specifications are followed. In addition to the activities performed during system development, some activities are performed after the basic development is complete. Such activities are covered under the implementation phase and maintenance phase. These phases are described below.

FOCUS

Construction of the system takes place on the basis of the system design specifications.

17.1.5 Implementation

The system implementation stage involves hardware and software acquisition, site preparation, user training and installation of the system. Here again, testing of the system, involving all components and procedures should be done. It must be realised that implementation may be the most crucial phase of System Development Life Cycle, because this step is vital in assuring the success of any newly developed system. Even a well-designed system will fail if it is not properly implemented. Chapter 12 discusses in detail the processes and strategies for the implementation of a newly developed information system.

FOCUS

The system implementation stage involves hardware and software acquisition, site preparation, user training and installation of the system.

17.1.6 Maintenance

System maintenance involves the monitoring, evaluating and modifying of a system to make desirable or necessary improvements. In other words, maintenance includes enhancements, modifications or any change from the original specifications. Therefore, the information analyst should take change as his/her responsibility so as to keep the system functioning at an acceptable level. This aspect has also been touched upon in Chapter 12.

FOCUS

System maintenance involves the monitoring, evaluating and modifying of a system to make desirable or necessary improvements.

Software needs to be maintained not because some of its modules or programs 'wear out' and need to be replaced, but because there are often some residual errors remaining in the system that have to be removed as soon as they are discovered. This is an on-going process, until the system stabilises.

17.2 SYSTEM DEVELOPMENT APPROACHES

As discussed in the preceding paragraphs, system development in general, is considered as a process consisting of various phases.

In order to make sure that the systems are analysed and designed efficiently and effectively, it is essential to adopt a suitable model, for which a basic understanding of various system development approaches/models currently in use, is a must. In a system development effort, the goal is to produce high quality software. As has already been discussed, the development process consists of various activities, namely,

(i) Investigation,
(ii) Analysis,
(iii) Design,
(iv) Construction,
(v) Implementation, and
(vi) Maintenance.

A system development model specifies how these activities are organised in the total system development effort. Various models for system development are discussed below.

17.2.1 Waterfall Model

Waterfall model, which follows the SDLC (System Development Life Cycle) approach, became popular in 1970s. The model states that the phases are organised in a Linear Order. In other words, the output of one phase becomes the input for the next phase. Various phases have already been explained under a general model of system development. The waterfall model is shown in Fig. 17.1.

In SDLC approach, the system is visualised as a living organism. The system takes birth, reaches the maturity stage through adolescence and ultimately dies its natural death.

Limitations of Waterfall Model

(i) In the waterfall model, every phase is considered as a distinct phase, which can be isolated from the rest or the next phase. To elaborate, the model assumes that the requirements of a system can be frozen before the design begins. But for a new system, determining requirements is a difficult process as the user himself does not know his/her information requirements and thus to freeze them before design is not practical.
(ii) Freezing the requirements usually requires the choice of hardware to be made. However, in the case of large projects, which might take a few years to be completed, the earmarked hardware technology may become obsolete even before the system becomes physical.
(iii) The model stresses that the requirements should be completely specified before the beginning of the next phase. But in some of the situations, it might be desirable to first develop a part of the system completely and later enhance the system in phases. For example, systems developed for general marketing.

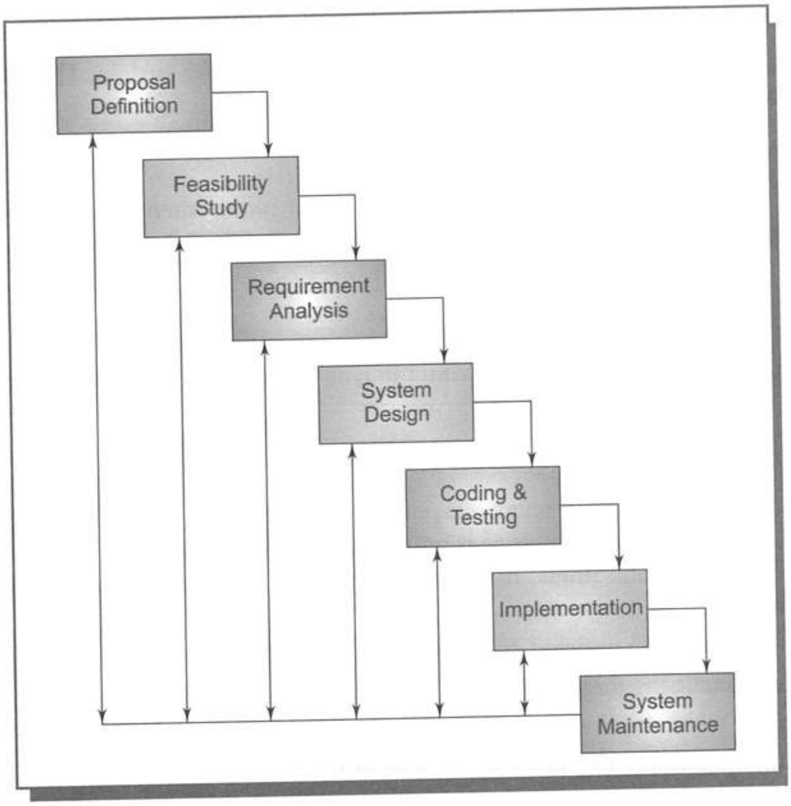

Fig. 17.1 The Waterfall Model

17.2.2 Prototyping

In the prototyping approach, a prototype of the system is developed, instead of the complete system. A prototype is a comprehensive system and does not include all the requirements of the user. This model is based on the evolutionary method of system development (see Fig. 17.2). Prototyping is used in those systems, in which identification of requirements is difficult and requirements may change during the development process. This model advocates the development of a throw-away prototype to be given to the user to help understand his/her requirements. On the basis of feedback, the actual system is developed. The model, in general, has the following four steps.

FOCUS

A prototype is a comprehensive system and does not include all the requirements of the user.

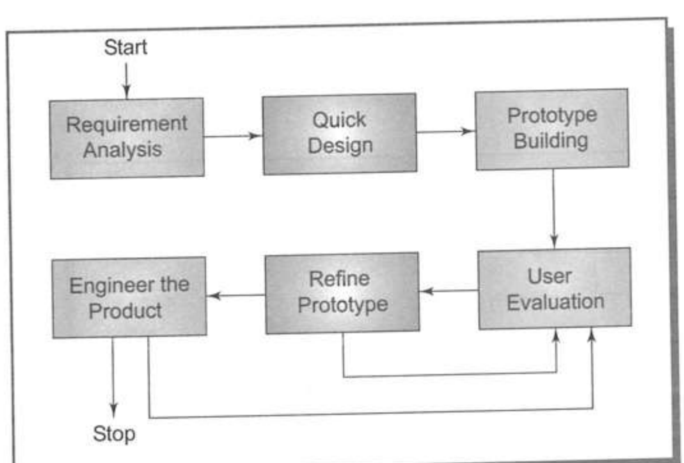

Fig. 17.2 Prototype Model

(i) Identify the user's basic information requirements

In this step, the user identifies his requirements in the form of outputs required from the system. The information analyst, on the basis of user expectations, estimates the cost of a workable prototype.

(ii) Develop the initial prototype system

Here, the initial prototype system, which meets the user's basic information requirements, is developed. It is developed in the minimum possible time. The speed of building rather than efficiency of the prototype is the main consideration.

(iii) Use of the prototype system to refine the user's requirements

The initially-developed prototype is delivered to the user to allow him to gain hands-on experience with the system to identify further refinements/changes required in the prototype.

(iv) Revise and enhance the prototype system

In this stage, the designer makes the necessary changes/refinements pointed out by the user after using the prototype. Steps (iii) and (iv) are repeated again and again till the prototype is refined to the satisfaction of the user. Prototyping approach may not be cost-effective in small organisations. It is more suitable for larger organizations, where it is difficult to identify user requirements.

The prototyping approach has the following significant advantages in the development of a system:

(i) Ability to 'try out' ideas without incurring large costs.

(ii) Lower overall development costs when requirements change frequently.

(iii) The ability to get a functioning system into the hands of the user quickly.

However, a major criticism of this approach is because of its iterative nature. This approach requires at least two iterations. Moreover, it may become an unending process of refinement, which may take too much time, effort and money.

Second, it is also criticised because prototypes are usually not complete systems and many of the details are not built in the prototype. Third, due to frequent changes, management of the development process also becomes difficult.

17.2.3 Iterative Enhancement Model

In an iterative enhancement model, the system is developed in increments and each increment adds some functional capabilities to the system, until the full system is developed. Additions and modifications can be done at each step. To begin with, only a subset of the overall problem is considered in developing the system. The selected subset may be one of the important subsets, which may contain some of the key aspects of the problem. The iterative enhancement process model is understood to have only three phases, namely, analysis, implementation and design, as shown in Fig. 17.3.

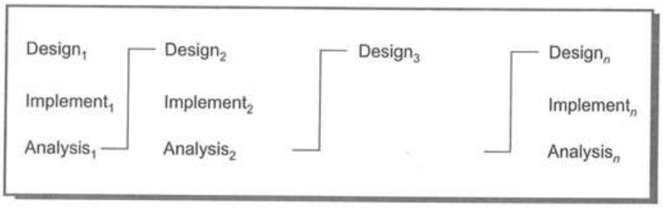

Fig. 17.3 The iterative enhancement model

This model has an obvious advantage – it can result in better testing, as testing each increment is relatively easier than testing the entire system, (as in the waterfall model). Also, as in prototyping, the increments provide feedback to the user which is useful for determining the final requirements of the system. Thus, iterative enhancement model combines the benefits of both prototyping and the waterfall model.

However, iterative enhancement model also suffers from the following limitations:

(i) The model does not give a complete system and thus many of the details may not be incorporated in the developed system.

(ii) As the model is based on a 'modify-it-again' approach, it may be time-consuming and is not cost-effective.

17.2.4 Spiral Model

The spiral model is the most recent system development model, which has been proposed by Boehm. This model suggests that the various activities involved in system development should be organised like a spiral. This model provides a framework for developing a process, which is guided by the risk level of the project. This model, as the name indicates, is cyclic in nature and is shown in Fig. 17.4. Each cycle of the spiral consists of four stages represented by one quadrant each. The angular dimension represents the progress in the development process, whereas the radius of the spiral represents the cost involved.

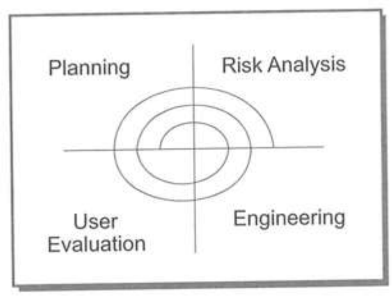

Fig. 17.4 Spiral Model

The first stage is concerned with the identification of the objectives, various developmental alternatives and constraints to develop an information system. Evalutation of various alternatives and identification of the risk is undertaken in the second stage. In the third stage, next level prototype is developed and verified and the results of the previous stages are reviewed. Planning for next iteration is done in the fourth stage.

The spiral model is more suitable for high-risk projects. For small projects, this model may not be time- and cost-effective.

Nowadays, another technique, known as the Fourth Generation Technique (4GT), is also being used to develop information systems quickly. This technique makes use of a number of software development tools. The developer has only to specify a few characteristics of the software at a high level. The tools then automatically develop the code for the given specifications. This model, no doubt is quick but its success is restricted by the capacity of the available 4GLs. However, the model may be useful for smaller projects.

It may be noted that the different approaches discussed above are used as supplementary rather than complementary approaches to software development. Depending upon the nature and size of the project and the risk involved therein, a combination of more than one model (Hybrid Approach) may be an appropriate strategy.

SUMMARY

System development is regarded as a complete process consisting of various phases, namely, investigation, analysis, design, construction, implementation, and maintenance. System investigation, which is the first step in the system development, is a way of handling users' request to change, improve or enhance an existing system. The objective of this phase is to determine whether the request is valid and feasible before any recommendation is made regarding the system. Basically this phase involves two sub-stages, namely, problem definition and feasibility study. Preliminary investigation may be conducted by reviewing organisation documents and/or interviewing selected persons.

System analysis is a detailed study of the various operations of a business activity along with its boundaries. The main objective of this phase is to find out the requirements of the users, known as requirement specifications. In other words,

system analysis describes WHAT a system should do to meet the information needs of users. System design specifies HOW the system would accomplish this objective. System design stresses on user interface, data design, and process design. Having prepared the design specifications, which is an output of the design phase, the system is physically created, i.e. the required programming is done. The constructed system is tested, debugged and documented. System implementation is a phase which takes place after the system is physically created and is ready for installation. The system is put to operation by installing it in the users' premises. This process is known as system implementation. Maintenance of an implemented system is an ongoing activity, which involves monitoring, evaluating and modifying the system to keep it updated and working at the highest level of efficiency.

There are several development approaches which could be adopted in developing an information system. These approaches include waterfall model, prototyping, iterative enhancement model, spiral model, etc. No approach could be termed as the best approach. It is the developer of the system, who decides a particular approach or a combination of more than one approach for developing a system, depending on the situation.

REVIEW QUESTIONS

1. Briefly explain the phases involved in system development.
2. What alternative development strategies exist? Why are there different strategies?
3. How do the SDLC and Prototyping methods differ? How might they be interrelated?
4. Why is a system prototype? Will you recommend the use of the prototype method for system development? When and Why?
5. Discuss the iterative enhancement method. How does this method differ from other development methods?

ASSIGNMENT

1. Assume you have been asked to develop an information system for processing the result of your class. Which method would you prefer for developing such a system? Also conduct a feasibility study and prepare a feasibility report.

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CASE STUDY 1

MIS AT MANIK MANUFACTURING

Manufacturing is a medium-sized manufacturer with annual sales of Rs 50 million per year. It is primarily a job-shop manufacturer, known for its ability in custom-manufacturing which mainly involves metal fabrication.

Over the past 20 years, Manik has been able to automate most of the major transaction-oriented computer-based information systems with marginal success. The major complaint about the systems is that they mainly assist in the transaction/ clerical area. They provided little support for middle- and upper-level management decision-making.

In an effort to improve Manik's information systems, D.S. Vasu, vice president of information systems, recently brought in a new systems development manager, K.K. Raina, previously working for a competitor. Mr Raina has a reputation for doing innovative things in the area of information system development. The general and top-management of his previous employer was extremely pleased with the types of information system support that they had received.

Mr Raina had been particularly successful in implementing a heuristic development in the system analysis and design process as a way to define more accurately end-user requirements and to cut-short the system development process. He was also greatly skilled in selecting the best information system development tools available and thereby ensuring that his staff was as the productive as technology would allow.

When Mr Raina arrived at Manik Manufacturing, he was prepared to implement the technologies and techniques that he had been so successful with prior to joining Manik Manufacturing. Unfortunately, he ran into a serious problem. The system analysis and design staff had recently gone through a revamping of their system development methodologies. They had a rather substantial system development methodology that had evolved over the years and in their most recent revision, they had incorporated the latest structured techniques into their old methodology. Having been involved in its development, the staff had a strong commitment to the methodology.

In assessing the methodology, Raina quickly decided that it was too procedure and rule-oriented and was exceptionally time-consuming to use as a system development guide. The staff also had made no provision for incorporating heuristic or prototyping techniques into their system development methodology.

In a staff meeting, Mr Raina raised heuristic and prototyping concepts with the staff, but their response was defensive. Most of them had not heard of a heuristic or prototyping technique, but felt it was a way to develop systems for sloppy designers who did not have enough discipline to do it right. They urged that there was no way one could have their cake and eat it too. They stated that if a sloppy approach to system development, such as heuristic or prototyping was to be used, you would have to be willing to give up the rigor and discipline of good formal procedures and good structured techniques. Overall, their general response was quite negative.

After the meeting, a couple of the younger system analysts stuck around and indicated some interest in the concepts Mr Raina was proposing. They had friends working at other organisations who had been using heuristic or prototyping concepts and were quite positive about them. The younger analysts did stress the importance of having the right tools available to use such a process, but indicated that if Mr Raina was interested in pursuing the concept at Manik Manufacturing, they would be interested in giving it a try. However, they expressed concern that the 'old guard' might create some problems. The 'old guard' might view their work as a breaking of the rules that had very carefully been developed by the leaders in the system analysis and design group.

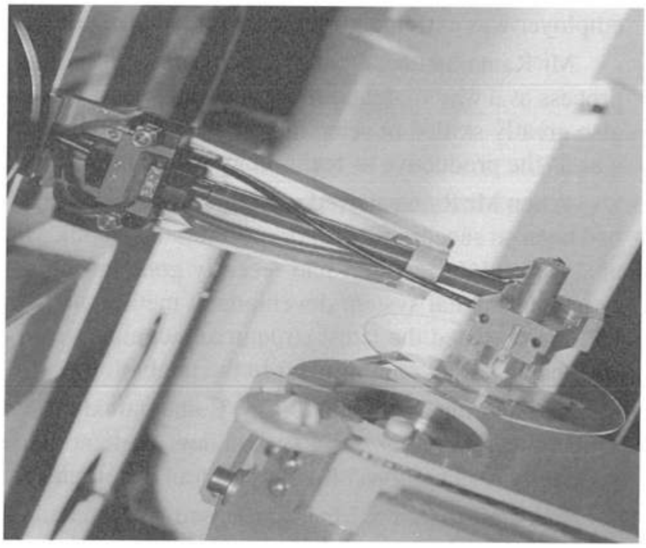
Mr Raina feels he has a tricky situation on his hands. He knows a better way to approach system development, but he does not want to cross swords with the system analysts and design staff, many of whom have more experience than him in system development. He knows that if he tries the heuristic approach and it fails, there's going to be a lot of 'I told you so' kind of talk. He's also concerned that if he pulls the young designers off to the side and works with the methodology, it might cause a division among the staff and some serious hard feelings that could be detrimental to the two young analysts.

QUESTIONS FOR DISCUSSION

1. Identify the problem in this case study.
2. Comment on the proposal of Mr Raina for developing MIS using heuristic or prototyping methodologies.
3. How would you manage the situation at Manik Manufacturing?

Chapter 18

Systems Analysis and Design



Chapter Outline

After studying the chapter, you will be able to:

- Define system analysis and system design
- Understand the aim and process of system analysis and system design
- Describe the strategies to determine information requirements
- Understand structured system analysis tools
- Describe the process of conceptual and detailed system design

SYSTEMS ANALYSIS

18.1 INTRODUCTION

System analysis may be understood as a process of collecting and interpreting facts, identifying problems and using the information to recommend improvements in the system. In other words, system analysis means identification, understanding and examining the system for achieving pre-determined goals/objectives of the system. System analysis is carried out with the following two objectives.

(i) to know how a system currently operates, and

(ii) to identify the users' requirements in the proposed system.

Basically, system analysis is a detailed study of all important business aspects under consideration and the existing system, and thus, the study becomes a basis for the proposed system (may be a modified or an altogether new system). System analysis is regarded as a logical process. The emphasis in this phase, is on investigation to know how the system is currently operating and to determine what must be done to solve the problem.

> **FOCUS** System analysis may be understood as a process of collecting and interpreting facts, identifying problems and using the information to recommend improvements in the system.

The system analysis phase is very important in the total development efforts of a system. The user may be aware of the problem but may not know how to solve it. During system analysis, the developer (system designer) works with the user to develop a logical model of the system. A system analyst, because of his technical background, may move too quickly to program design to make the system prematurely physical, which is not desirable and may affect the ultimate success of the system. In order to avoid this, the system analyst must involve the user at this stage to get complete information about the system. This can be achieved if a logical model of the system is developed on the basis of a detailed study. Such a study (analysis) should be done by using various modern tools and techniques, such as data flow diagrams, data dictionary and rough descriptions of the relevant algorithms. The final product of the system analysis is a set of system requirements of a proposed information system. In subsequent sections we will discuss determination of system requirements and system analysis tools.

18.2 REQUIREMENT DETERMINATION

Requirement determination, which is also termed as a part of software requirement specification (SRS) is the starting point of the system development activity. This activity is considered as the most difficult and also the most error-prone activity because of the communication gap between the user and the developer. This may be because the user usually does not understand software and the developer often does not understand the user's problem and application area. The requirement determination is a means of translating the ideas given by the user, into a formal document, and thus to bridge the communication gap. A good SRS provides the following benefits:

> **FOCUS** Requirement determination, which is also termed as a part of software requirement specification (SRS) is the starting point of the system development activity.

(i) It bridges the communication gap between the user and the developer by acting as a basis of agreement between the two parties.

(ii) It reduces the development cost by overcoming errors and misunderstandings early in the development.

(iii) It becomes a basis of reference for validation of the final product and thus acts as a benchmark.

Requirement determination consists of three activities, namely, requirement anticipation, requirement investigation and requirement specification. Requirement anticipation activities include the past experience of the analysis, which influence the study. They may foresee the likelihood of certain problems or features and requirements for a new system. Thus, the background of the analysts to know what to ask or which aspects to investigate can be useful in the system investigation. Requirement investigation is at the centre of system analysis. In this, the existing system is studied and documented for further analysis. Various methods like fact-finding techniques are used for the purpose. In the requirement specification activities, the data produced during the fact-finding investigation is analysed to determine requirement specification, which is the description of the features for a proposed system.

Requirement determination, infact, is to learn and collect the information about

(a) the basic process,

(b) the data which is used or produced during that process,

(c) the various constraints in terms of time and the volume of work, and

(d) the performance controls used in the system.

Let us discuss these activities in more detail.

18.2.1 Understand the Process

Process understanding can be acquired, if the information is collected regarding

(a) the purpose of the business activity,

(b) the steps, which and where they are performed,

(c) the persons performing them, and

(d) the frequency, time and user of the resulting information.

18.2.2 Identify Data Used and Information Generated

Next to process understanding, an information analyst should find out what data is used to perform each activity. For example, in an inventory system, the buyer may require data describing the quantity of an item, supplier name, item cost and demand for the item. To know when to place an order, the buyer would also like to get the information regarding lead time. The information generated in business transactions is also required to be gathered, as such information may be used by managers in many decision-making activities. For example, data about inventory system also provides information about warehousing, sales and cash flow decisions.

18.2.3 Determine Frequency, Timing and Volume

Information should also be collected to know how often the activity is repeated and the volume of items to be handled. Similarly, timing does affect the way analysts evaluate certain steps in carrying out an activity. In other words, timing, frequency and volume of activities are important facts to collect.

18.2.4 Know the Performance Controls

System controls enable analysts to understand how business functions can be maintained in an acceptable manner.

During system investigation, information is gathered mainly from personnel and written documents from within the organisation's environment, which includes financial reports, personnel documents and various other types of documents like transaction documents, manuals, etc. To get information about the external environment, the sources include vendors, various government and private agencies, newspapers and journals, etc.

It must be understood that the personal managerial attributes of the individual manager and the organisational environment in which decisions are made affect the information requirements for the proposed system. The personal attributes may be a manager's knowledge of information systems, managerial style, his perception of information needs, whereas organisational environment factors may include nature of the company, level of management and structure of the organisation.

As already mentioned, system analysis consists of two main activities:

(i) Studying the business operations to understand the existing system.

(ii) To make an analysis of the information gathered to determine information requirements of the manager in the proposed system.

In order to study the business operations of the organisation and thus to know the existing system and information requirements for the new system, an information analyst collects the information and then makes an analysis of the collected information by using certain analysis tools.

18.3 STRATEGIES FOR REQUIREMENT DETERMINATION

In order to collect information so as to study the existing system and to determine information requirement, there are different strategies, which could be used for the purpose. These strategies are discussed below.

18.3.1 Interview

The interview is a face-to-face method used for collecting the required data. In this method, a person (the interviewer) asks questions from the other person being interviewed. The interview may be formal or informal and the questions asked may be structured or unstructured. The interview is the oldest and the most often used device for gathering information about an existing system. The respondents are generally current users of the existing system or potential users of the proposed system. Although it is one of the preferred techniques, interviewing is not always the best source of application data. Because of the time required for interviewing and the inability of the users to explain the system in detail, other methods are also used to gather information.

However, this method is helpful for gathering information from individuals who do not communicate effectively in writing or who may not have the time to answer questionnaires. Interviews allow analysts to discover areas of misunderstanding, unrealistic expectations and even indications of resistance to the proposed system.

FOCUS

The interview is a face-to-face method used for collecting the required data.

The analyst must plan the interviews and must know clearly in advance regarding the following issues:

(i) Whom to interview?
(ii) When to interview?
(iii) What to ask?
(iv) Where to hold the interview?
(v) How to begin the interview?
(vi) How to conclude the interview?

Interviewing is regarded as an art and it is important that analysts must be trained in the art of successful interviewing. This is also important because of the fact that the success of an interview depends on the skill of the interviewer and on his or her preparation for the interview.

18.3.2 Questionnaire

A questionnaire is a term used for almost any tool that has questions to which individuals respond. The use of questionnaires allows analysts to collect information about various aspects of a system from a large number of persons. The questionnaire may contain structured or unstructured questions. The use of a standardised questionnaire may give more reliable data than other fact-finding techniques. Also the wide distribution ensures greater anonymity for respondents, which can lead to more honest responses. The questionnaire survey also facilitates time-saving as compared to interviews. However, this method does not allow analysts to observe the expressions or reactions of respondents as is possible during interviewing and also, it is difficult to design exhaustive questionnaires. The analyst should know the advantages and disadvantages of structured as well as unstructured questionnaires. Questionnaires must be tested and modified as per the background and experience of the respondents.

FOCUS

A questionnaire is a term used for almost any tool that has questions to which individuals respond.

18.3.3 Record Review

Record review is also known as review of documentation. Its main purpose is to establish quantitative information regarding volumes, frequencies, trends, ratios, etc. In record review, analysts examine information that has been recorded about the system and its users. Records/documents may include written policy manuals, regulations and standard operating procedures used by the organisation as a guide for managers and other employees. Procedures, manuals and forms are useful sources for the analyst to study the existing system. The main limitation of this approach is that the documentation on the existing system may not be complete and up-to-date. There are two different views regarding the study of the existing system. One view, which favours the study of the existing system, is that through study of the existing system, one learns about its shortcomings and may use this knowledge to avoid repeating the mistakes. Whereas the view which is against such a study, argues that it inhibits the generation of new ideas and may bias the developer towards the same logic which is contained in the old system. It is difficult to comment upon the two views. However, both the views seem valid. It can only be suggested here that an information analyst should study the existing system, if any, to know more about the whole of the system.

FOCUS

Record review is also known as review of documentation and Its main purpose is to establish quantitative information regarding volumes, frequencies, trends, ratios, etc.

18.3.4 Observation

Another information-gathering tool used in system studies is observation. It is the process of recognising and noticing people, objects and occurrences to obtain information. Observation allows analysts to get information, which is difficult to obtain by any other fact-finding method. This approach is most useful when analysts need to actually observe the way documents are handled, processes are carried out and whether specified steps are actually followed. As an observer, the analyst follows a set of rules. While making observations, he/she is more likely to listen than talk. The exercise is time-consuming and costly. Also the observer may not be able to get all the required information, especially about some intricacies of the system. Nowadays, electronic observation and monitoring methods are being used widely as information-gathering tools because of their speed and efficiency.

FOCUS

Observation is the process of recognising and noticing people, objects and occurrences to obtain information.

The analysts usually use a combination of all these approaches to study an existing system, as any one approach may not be sufficient for eliciting information requirement of the system.

The fact-finding techniques which have been discussed above represent only one aspect of system analysis. Various tools for organising the details collected are discussed as follows.

18.4 STRUCTURED ANALYSIS TOOLS

Structured analysis tools help the system analyst to document the system specification of a system to be built. The main tools which are used for the purpose are given as follows:

(i) Data Flow Diagram (DFD)
(ii) Data Dictionary
(iii) Structured English
(iv) Decision Trees
(v) Decision Tables

18.4.1 Data Flow Diagram (DFD)

Data Flow Diagram (DFD) is a graphical representation of the logical flow of data. It helps in expressing the system's requirements in a simple and understandable form.

It is also known as a bubble chart. Its aim is to clarify the system requirements and identify major transformations that will become programs in system design. It decomposes the requirement specifications down to the lowest level of details.

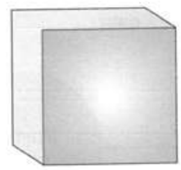
A DFD consists of a series of bubbles joined by lines representing data flow in the system.

FOCUS

Data Flow Diagram (DFD) is a graphical representation of the logical flow of data.

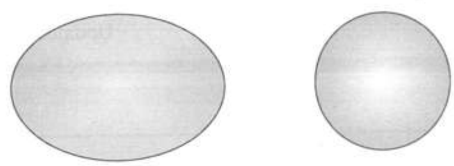
There are four main symbols used in a DFD, which are depicted here.

(i) *Square*: It represents source/destination of system data.

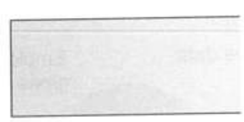


(ii) *Arrow*: It identifies data flow; it is a pipeline through which the data flows.

(iii) *Circle/Bubble*: It represents a process that transforms incoming data flow into outgoing data flow. A process can be represented by a circle or an oval bubble.



(iv) *Open Rectangle*: It represents a data store.



A number of rules are to be followed in drawing a DFD:

(i) Processes should be named and numbered. Name should represent the process.

(ii) The direction of flow is from top to bottom and from left to right.

(iii) When a process is exploded into lower levels, they are numbered properly, e.g. the process obtained from the explosion of process number 5, should be numbered as 5.1, 5.2, etc.

(iv) The name of data stores, sources and destinations are written in capital letters. Process and data flow names have the first letter capitalised.

A DFD should have no more than 10–12 processes, as having even 12 will make a DFD complex and difficult to understand.

A DFD shows the minimum contents of a data store. Each data store should contain all the elements that flow in and out of it.

DFD is very effective, when the required design is not clear and the user and the analyst require some symbolic representation for communication.

The main disadvantage of a DFD is that a large number of iterations are often required to arrive at an accurate and complete solution.

For example, consider the case of a payroll system to prepare salary statements for each employee of an organisation. Data flow for such a system can be represented, as shown in Fig. 18.1.

Employees data originate from accounts departments (source), gets processed, salary statements are received by employees (sink) and updated data on employees (e.g. total tax deducted, provident fund contribution, etc.) is stored in an intermediate file (data store), which is required for processing in the subsequent months.

A DFD displays data flow in a top-down approach. To draw a DFD, start with a macro DFD (overview) and then explode it into micro DFDs. Figure 18.2 illustrates the method.

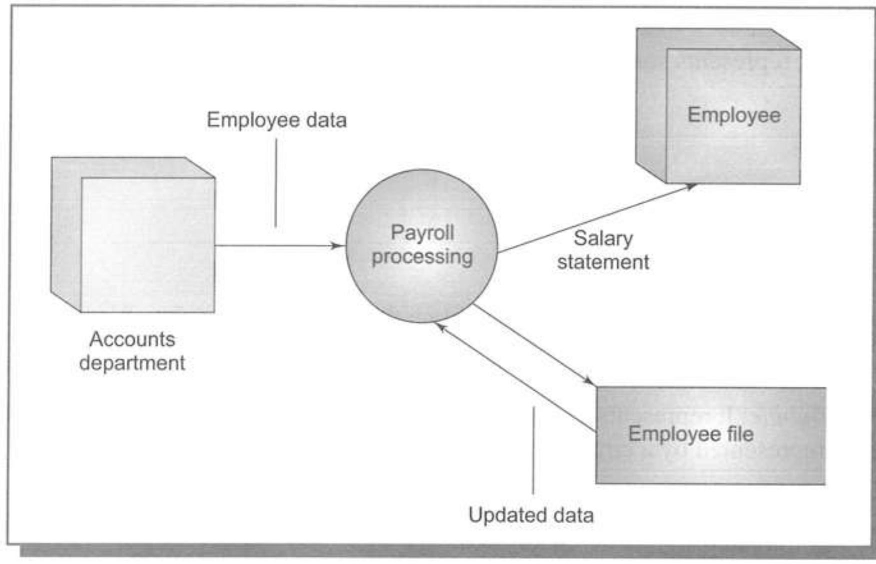


Fig. 18.1 A DFD for Payroll Processing: Macro View

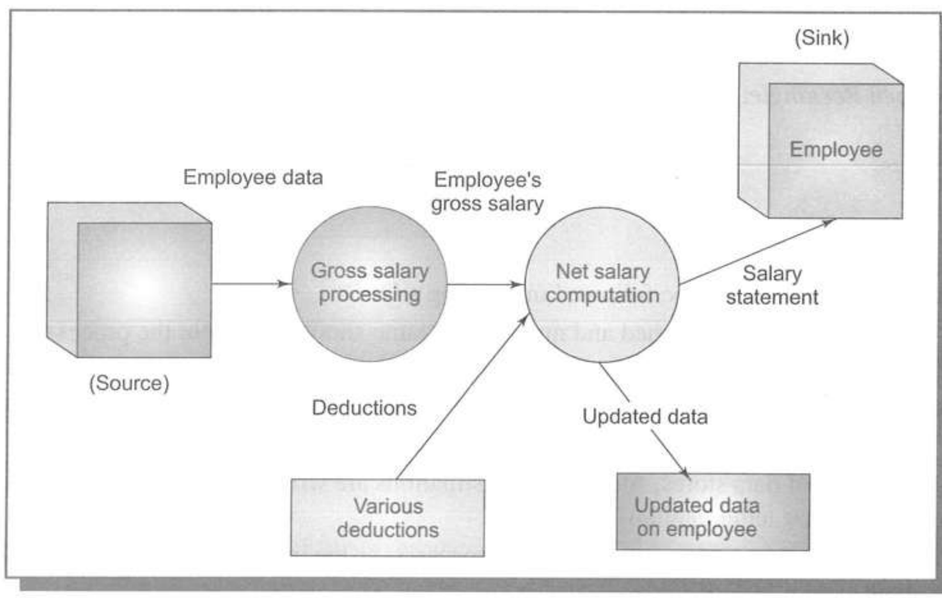


Fig. 18.2 A DFD for Payroll Processing: Exploded View

While exploding a DFD into lower levels, continuity and linkage is maintained between a DFD and its member DFDs. This is achieved by numbering each circle (processing step) by adopting the numbering system, e.g. 1, 2, 3,. . ., each further numbered as 1.1, 1.2, 1.3, . . ., and still further numbered as 1.1.1, 1.1.2, . . . Figure 18.3 illustrates the point.

18.4.2 Data Dictionary

A data dictionary is a structured repository of data, about data. In other words, it is a set of precise and accurate definitions of all DFDs, data elements and data structures.

FOCUS

A data dictionary is a structured repository of data, about data.

It supports documentation in a better way. It also improves communication between the user and analyst as it provides precise and consistent definitions for various data elements, terms and procedures. It can also serve as a common database for programmers and can also be used for control purposes. Most databases have data dictionary as a desirable feature.

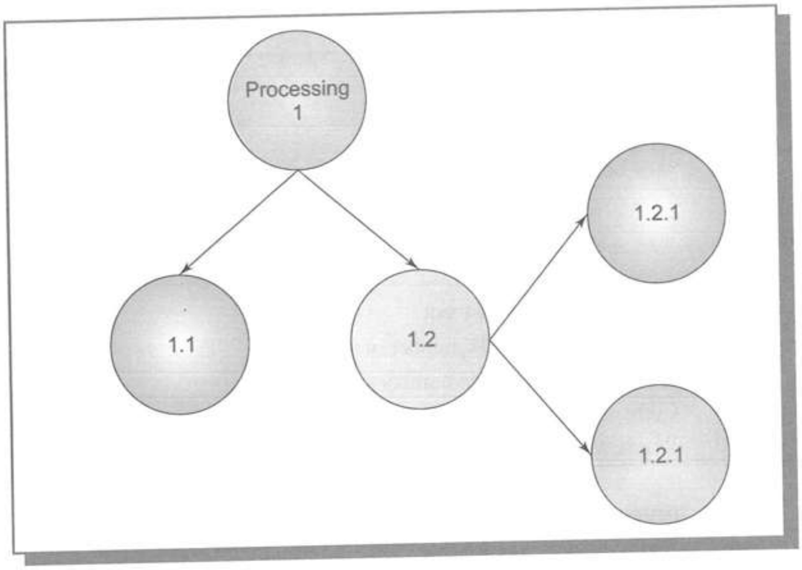


Fig. 18.3 Explosion of a DFD

There are mainly three items of data present in a data dictionary.

(i) *Data Element:* It is the smallest unit of data and cannot be decomposed further.

(ii) *Data Structures:* It is a group of data elements handled as a unit. A data structure contains a number of data elements as its fields.

(iii) *Data Flows and Data Stores:* Data flows are nothing but data structures in motion, whereas data stores are data structures at rest. In other words, data stores are locations where data structures are temporarily stored. Data dictionary is an integral part of the structured specifications.

The following rules are followed in constructing a data dictionary.

(i) The terms used to describe data structures are always in capital letters.

(ii) Multiple word names are hyphenated.

(iii) Assigned names should be straight-forward and user-oriented.

(iv) There should be names for every data flow, data store, data structure and data element.

(v) Consistency checks should be performed.

(vi) Identification numbers of the processes and their names should be mentioned in the data dictionary.

(vii) Aliases must be discouraged.

Various symbols, which are used in the data dictionary are explained in Table 18.1.

Data dictionary and DFD are correlated and data should be present in a specification. However, a DD does not provide functional details and thus is not very acceptable among non-technical users.

18.4.3 Decision Tree and Structured English

The logic of the process, which may not be very clear through DD, can easily be represented using a graphic representation, which looks like the branches of a tree, called decision tree. A decision tree has as many branches as there are logical alternatives. It is easy to construct, read and update. For example, a policy can be shown through a decision tree (see Fig. 18.4)

FOCUS

A decision tree has as many branches as there are logical alternatives. It is easy to construct, read and update.

The example illustrates the following discount policy.

Computer dealers get a trade discount of 35 per cent if the order size is 6 or more PCs, whereas for orders from educational institutions and individuals, 15 per cent discount is allowed on orders of 6–19 PCs, per PC type; 20 per cent on orders for 20–49 PCs; 30 per cent on orders for 50 PCs or more, per PC type.

Alternatively, the logic can be represented by using Structured English. It uses logical construction and imperative sentences designed to carry out instructions for actions. Decisions are made through IF-THEN-ELSE statements.

Table 14.1 Symbols Used in Data Dictionary

Symbol	*Meaning*
=	is equivalent to
+	add
[Option 1 Option 2 : :]	only one of the options is used at a given time.
max {Component} min	Iteration of the component min = lowest possible number of iterations. max = highest possible number of iterations.
(COMPONENT)	Component is an optional one.
Comment	Words within asterisks are comments.

An Example:

VENDOR – INVOICE

= INVOICE-NUMBER + VENDOR-NAME + TOTAL-INVOICE-AMOUNT +
INVOICE-DUE-DATE+(SHIPPING-DATA)

30
{ ITEM-DETAIL-LINE }
1

One extra copy may be kept

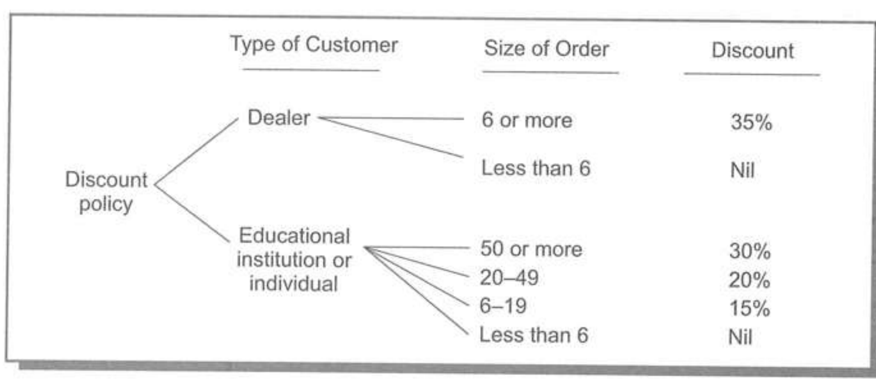


Fig. 18.4 A Decision Tree – An Example

Structured English can be made compact by using terms defined in the data dictionary. However, its sentences should be clear, concise and precise in wording and meaning. For example, the process ORDER may have the data element ORDER-SIZE, which defines the following values.

Using these values, structured English would read as shown in Fig 18.5.

Decision trees can be used to verify logic in problems that involve few complex decisions, resulting in a limited number of actions. However, its biggest limitation is the lack of information due to its structure.

18.4.4 Decision Table

Decision table is a matrix of rows and columns that shows conditions and actions. Decision rules state the procedure to be followed when certain conditions exist.

Decision tables are best-suited for dealing with complex branching routines, e.g. inventory control, etc.

FOCUS

Decision table is a matrix of rows and columns that shows conditions and actions.

A decision table consists of four sections.

A condition stub at the upper left, a condition entry at the upper right, an action stub at the lower left, and an action entry at the lower right (see Fig. 18.6).

MINIMUM	: 5 or less Personal Computers, per PC type
SMALL	: 6 to 19 PCs
MEDIUM	: 20 to 49 PCs
LARGE	: 50 or more PCs

Discount-Policy
Add up the number of PCs per PC type
If order is from a dealer
and—If ORDER-SIZE IS SMALL OR MEDIUM OR LARGE
THEN: Discount is 35%
ELSE (ORDER-SIZE IS MINIMUM)
So: no discount is allowed
ELSE (ORDER is from educational institution or individual customers)
SO—IF ORDER-SIZE IS LARGE
Discount is 30%
ELSE IF ORDER-SIZE IS MEDIUM
Discount is 20%
ELSE IF ORDER-SIZE IS SMALL
Discount is 15%
ELSE (ORDER-SIZE IS MINIMUM)
So: no discount is allowed.

Fig. 18.5 Structured English – An Example

Questions are listed in the condition stub and the action stub outlines the action to be taken to meet each condition.

The condition entry part contains the answers to questions asked in the condition stub and the action entry part indicates the appropriate action resulting from the answers to the conditions in the condition entry quadrant.

Condition Stub	Condition Entry
Action Stub	Action Entry
Stub	Entry

Fig. 18.6 A Decision Table

In constructing a decison table, the following rules are observed.

(i) A decision should be given a name to be written at the top left of the table.
(ii) The logic should be independent of the sequence in which the condition rules were written, but the actions take place in the order in which the events occur.
(iii) Consistent and standardised language should be used.
(iv) Duplication of terms should be avoided to the maximum extent.

A decision table of the earlier problem is constructed in Fig. 18.7.

SYSTEMS DESIGN

System design is another important step in the system development process. This phase starts after the system analysis phase is over. In other words, the output of the system analysis phase, i.e. requirement specifications become an input in the design phase. Data requirements are worked out on the basis of user requirement estimates.

Condition Stub	*Condition Entry*					
	1	2	3	4	5	6
Is the customer a dealer?	Y	Y	N	N	N	N
Is the order size 6 PCs or more?	Y	N	N	N	N	N
Is the customer educational institution or inidividual?	Y	Y	Y	Y		
Is the order size 50 or more PCs?			Y	N	N	N
Is the order size 20 to 49 PCs?				Y	N	N
Is the order size 6 to 19 PCs?					Y	N
Action Stub	*Action Entry*					
Allow 35% discount	X					
Allow 30% discount			X			
Allow 20% discount				X		
Allow 15% discount					X	

Fig. 18.7 Decision Table – An Example

The identification of data requirements includes identifying data sources, the nature and type of data that is available and data gaps. For example, for designing a salary system, a system designer would consult the input documents (data sources) such as attendance, leave account, deductions to be made, etc. so that he may understand what kind of data is available, in what form, when it is supplied and by whom.

18.5 DESIGN OBJECTIVES

A system is designed with the following main objectives.

Practicality

The system should be designed in such a way that it may be learnt and operated with ease by the users. Thus, the design should be user-oriented.

FOCUS

A system is designed with the following main objectives: Practicality, Flexibility, Efficiency, Security

Flexibility

The business organisations are dynamic in nature. Therefore, a system must be responsive to the change inevitably requested by its users.

Efficiency

A system must be efficient, i.e. it should perform jobs within their specified time. The efficiency of a system may be measured in terms of the following parameters.

(i) *Throughput*: It is the ability to handle a specified number of jobs per unit of time.

(ii) *Response time*: The ability to respond to a request made by the user within a given time limit.

(iii) *Run time*: It is the ability to undertake the complete job within a given time limit.

Security

This aspect relates to hardware reliability, physical security of data and the detection and prevention of fraud and abuse of data.

System design is carried out at two levels, namely conceptual level and physical level, known as conceptual design and physical design, respectively. These two phases are also called external design or general design and internal design or detailed design.

18.6 CONCEPTUAL DESIGN

It is in the conceptual design stage that alternative overall MIS designs are conceived and the best one is selected by the system analyst in consultation with the top management. In the conceptual design, the feasibility of meeting the management objectives for the MIS is assessed and a broad-brush picture of the system is painted. That is why, conceptual design is also known as gross design, high-level design or an overall MIS design, which becomes a basis for the detailed MIS design. In other words, a conceptual design is a prerequisite for the detailed design. Conceptual design involves the following steps:

(i) Define problem
(ii) Set system objectives
(iii) Identify constraints
(iv) Determine information needs
(v) Determine information sources
(vi) Develop various designs
(vii) Document the conceptual design
(viii) Prepare report

A brief discussion of these steps will make the concept clearer.

18.6.1 Define Problem

The first step in conceptual MIS design is to clearly understand and define the problem to be solved. It should be noted here that these are not only the current problems, which are of concern; rather MIS design should be related to long-range planning for the organisation so as to solve future problems. Further, MIS function is supposed to solve the problems relating to information needs for the business organisation. Thus information needs of the organisation are to be identified and understood in this step, which can be determined by understanding the mission, objectives, and strategic and operating plans for the business.

18.6.2 Set System Objectives

Having defined and understood the problem to be solved, the system analyst, in consultation with the user, must set the system objectives. While setting system objectives, it must be kept in mind that the value of an information system lies in the benefits to its users. Thus, mere efficiency of the system would not serve the purpose. However, it is very difficult to set the real objectives of an information system. Quite often the objectives of an information system are set in vague terms, for example, 'keep accurate records', 'have maximum efficiency', 'reduce costs', 'provide quality information', 'pay salary to employees by due date'. No doubt, setting of specific objectives is difficult, but it is very important, so that system objectives may provide a measure of performance of the system or to design an information system to help achieve its objectives. Therefore, system objectives should be stated, as far as possible, in quantitative rather than qualitative terms. For example, some of the already given objectives may be re-stated as 'pay salary to 100 per cent employees by the last day of the month', 'pay 100 per cent of invoices before due date', etc.

18.6.3 Identify Constraints

System constraints are also known as problem boundaries or restrictions. Knowledge of the constraints is essential, as it helps the designer to consider the limitations that restrict the design of the system. In other words, constraints limit freedom of action in designing a system to achieve the objective. In the light of the constraints, a constant review of objectives is necessary. Thus, establishing constraints will help ensure that the design is realistic.

System constraints may be classified under two categories, namely:

(i) External constraints, and

(ii) Internal constraints.

External constraints, as the name indicates, are external to the organisation. For example, constraints posed by customers, the government and suppliers. Whereas internal constraints are posed from within the organisation, for example, non co-operation and lack of support from top management; organisational policy; resource constraints like manpower, time and money, etc.

18.6.4 Determine Information Needs

For a good design of information system, it is very important to know the real information needs of management (users) in a clear statement. Thus, information needs which can really help the management in discharging their functions are identified. For etermination of information needs, users should specify the following:

(i) What they want out of an information system; and

(ii) Items of information that are needed to achieve the pre-determined objectives.

But, user-managers are rarely specific on these points, since getting them to be specific about their information needs is a challenging job for the system analyst. A system analyst, thus depending on the situation, has to adopt either a direct or an indirect approach for eliciting information needs. In the direct approach, the system analyst would ask four or five major responsibilities of the user-manager, followed by one or two specific items of information that are required to carry out each of the responsibilities. Indirect approach stresses on the avoidance of direct questions. Instead, the system analyst asks the user to describe his/her decision-making process. This is found an easy way as the user-manager is well-familiar with the operation/job and thus can describe clearly his/her decision-making process.

As already discussed in system analysis, there are several approaches like interviewing the user managers, using questionnaires, record review and observation, etc., but the system analyst has to take a judicious decision regarding an approach or a combination of approaches to understand clearly the information needs of user-managers in an organisation.

18.6.5 Determine Information Sources

Just as a clear understanding and wholistic view of the users' information needs is the basis for the design of MIS, the source of this information requires to be determined in order to identify input data, along with identification of its source, timing and format, etc.

Though some information systems may require considerable external information, the main information in a majority of the information systems is found from within the organisation: the internal records, files, books, statistical and accounting documents, etc. Thus, for determining sources of information, studying the existing system is quite helpful. A system analyst should clearly understand that in this step, the structure of the new system starts to take shape and thus he should not only determine information sources for the particular sub-system under consideration, but also must take into account how they fit into the overall sources of information and techniques of analysis. Sources of information may be classified as given below.

(i) *Internal and External Records:* The internal records may be in written form like files, inputs and outputs, correspondence, reports, documentation of the present or planned systems, etc., whereas external sources may include trade publications, government statistics, etc.

(ii) *Managers and Operating Personnel:* User-managers and operating personnel may be an important source for understanding input, output and data processing requirements of an information system. However, gathering data from this source involves interviewing the managers and operating personnel, which requires proper planning and skill.

Once the information sources and information needs are determined, the next activity is to match the information needs and sources. This can be done by using a matrix diagram, which is a valuable device for integration of sub-systems and in the rest of the system design process. Figure 18.8 illustrates the use of a matrix diagram in one of the sub-systems of the materials management system.

18.6.6 Develop Various Designs

By now, a system analyst should be able to conceptualise the overall structure of the information system, he or she is going to design. As already mentioned, conceptual design gives us an overview or a sketch of the structure of the MIS. Thus, conceptual design is like a skeleton of the MIS, which guides and restricts the form of the detailed design. To be more concise, it may be said that if conceptual design is the skeleton, then detailed design is the flesh. At this stage, the conceptual design would define the main decision points, information flows, channels of information and roles of user-managers. Here the system analyst works out broad feasible alternative combinations of input, storage, processing, communication and output to generate various conceptual MIS designs. More than one alternative conceptual designs are to be developed which are compared to select the optimum one, which

Information needs ↓ / Sources →	Production	Accounting	Purchasing	
Annual requirements	X			
Unit price		X		
Ordering cost		X		
Carrying cost		X		
Lead time			X	
Consumption rate	X			

Fig. 18.8 Information Needs/ Information Sources Matrix

(i) meets the requirements of the users/organisation, and

(ii) is cost effective.

The following examples of alternative conceptual designs will further clear this point.

Suppose a person who wants to build his house, approaches an architect for the plan of his 'would be' house. The architect in turn, on the basis of the requirements of the person, prepares three or four plans for his house. These three or four plans, in fact are alternative conceptual designs of the house. Each design may differ in terms of dimensions, locations or any other specifications of the rooms, etc. For example, one design may propose two bedrooms on the ground floor and one room on the first floor for a three-bedroom house. Whereas other designs may propose all the three bedrooms at the ground floor but having different specifications and locations of each room. The person, on the basis of already specified criteria, selects the optimum design for his 'would be' house from these alternative designs.

Similarly consider an organisation having 15 finished inventory stores, which are spread all over India. Head office of the company and the manufacturing plant are located at Delhi. The organisation is facing a crisis in carrying out deliveries to its customers. To provide better service to its customers, it requires an MIS to be developed, which may regulate its manufacturing and inventories. The systems analyst may develop more than one alternative conceptual designs of MIS. One design may suggest all orders from customers be sent directly to marketing department at the organisational head-office. Marketing department will then provide demand forecasts to the production department and shipping order to the stores of the organisation. A computer-based information system will maintain a perpetual inventory of all products in all the stores. The second design may propose orders to be sent by the customers directly to the nearest store. Each store keeps its own inventory records; each forecasts its demand for the month ahead and sends it to the production department. A third design may propose region-wise control of the orders, which are sent by the customers to the stores at the regional level, which in turn process the orders of customers from their respective regions and transmit the orders to the marketing department at the head office of the organisation. Marketing department sends the demand order to the production department and shipping orders to the concerned stores. Before recommending the optimal conceptual design, the system analyst evaluates each of the alternative designs. The following criterion may be adopted as a basis for evaluating the designs:

Economic Basis

A preliminary cost-benefit analysis of each of the designs is made.

Performance Basis

Each alternative is objectively evaluated for the anticipated performance with the objectives of the systems as previously developed.

Operational Basis

For each alternative, analysis is made to determine the strong and weak points in respect of quality of the database, information, potential breakdown points, etc.

18.6.7 Documentation of the Conceptual Design

The final selected conceptual alternative is documented in specific terms. The documentation of the conceptual design involves:

(i) Overall system flow,
(ii) System inputs,
(iii) System outputs, and
(iv) Other documentations like activity sheet and system description, etc.

18.6.8 Report Preparation

Having documented the conceptual design, the next step is to get an approval of the management (user) so as to start the detailed design activity. Thus, a proposal giving the cost to be incurred and possible organisational changes is prepared for the management. The report thus prepared should briefly mention the problem, the objectives, an overall view of the system, justifications for selecting one alternative over others, time and other resources required for developing and implementing the system. Documentation of the system should also be appended in the annexure or be given in a different volume of the report. The report thus submitted, is reviewed by the top management of the organisation. If approved, the detailed system design activity is undertaken.

18.7 DESIGN METHODS

There are a number of methods for designing information systems. Following is a brief description of some of the popular methods.

Problem Partitioning

The method is based on the principle of 'divide and conquer'. In this method, instead of solving the entire problem at once, the problem is divided into small manageable parts (modules) that can be solved separately. This problem partitioning method aims at reducing complexity because each module can be developed, coded and tested relatively independently of the others. Also, maintenance is minimised if each module can be modified separately.

Structured Design

In this method, a structured chart is created, which can be used to implement the system. The chart depicts modules defining each module by the specific function. The aim is to produce a structure where the modules have minimum dependence on each other (decoupling); and have a high level of cohesion, meaning all the statements within a module are functionally related. Various tools like flow-charting, data flow diagrams, structure charts, structured English, etc., are used in a structured design.

FOCUS

The number of methods for designing information systems are: Problem Partitioning, Structured Design, Top-Down Design

Top-Down Design

The top-down design is based on the concept of a system which suggests that a system consists of sub-systems (components), which have sub-systems of their own. In other words, a system may be termed as a hierarchy of sub-systems, the highest level sub-system corresponding to the total system. Accordingly, this method involves the identification of the main components of the system, decomposing them into their lower-level components and iterating until the desired level of detail is reached.

It attempts to smoothen the path of system design by starting at the top and designing the broad modules first. At each stage, adequate attention is paid to subsequent interfacing so that as the system expands further, modules can be added without trouble.

18.8 DETAILED SYSTEM DESIGN

Conceptual design in itself is not the end of the design process; rather it serves as a basis for the detailed MIS design. The performance requirements specified by the conceptual design become inputs to the detailed design phase, in which these are further refined, detailed and finalised to be called the system specifications. Thus, the main objective of the detailed system design is to prepare a blue print of a system that meets the goals of the conceptual system design requirements. Detailed system design involves the following phases.

(i) Project Planning and Control
(ii) Involve the User
(iii) Define the Detailed Sub-Systems
(iv) Input/Output Design
(v) Feedback from the User
(vi) Database Design
(vii) Procedure Design
(viii) Design Documentation

A brief discussion on each of these phases is given as follows:

18.8.1 Project Planning and Control

In order to ensure an effective and efficient design of an MIS, it is very important that a detailed design process should in itself be considered a complete project. Therefore, the first step in the detailed design is planning and controlling, so that standards may be established and a proper follow-up is made. Some of the main points, which are important in planning and control of a detailed design are given here.

Project Planning

(i) Formulate the project objectives.
(ii) Define the project tasks.
(iii) Prepare a network diagram of all events and activities so as to specify sequential and parallel events.
(iv) Schedule the work as per the requirements of the user.
(v) Prepare a budget for the project.

Project Control

(i) Get a feedback of the actual performance of the project with respect to time, cost and work of the project and compare it with schedules, budgets and technical plans.
(ii) Take corrective action where required so as to maintain control.

18.8.2 Involve the User

System designers must inform the users regarding the new information system being developed and gain their support and acceptance. In this phase, users are assured that changes will benefit them or that they will not be at disadvantage because of the new system. It is also important to take users in confidence so as to obtain information for the design of the system. This will also help managing resistance to change and would ensure successful implementation of the system.

18.8.3 Detailed Sub-System Definition

In detailed system design, every system needs to be broken down to ascertain all activities required and their respective inputs and outputs. In some of the cases, sub-systems are broadly defined in the conceptual design phase, but at this stage they are specifically defined to work out every detail concerning the sub-system. Decomposition of the system to operational activities in general is carried out as follows.

- System
  - Sub-system
    - Functional Component
      - Task
        - Sub-task
          - Operation element

Wherever needed, integration of activities into a sub-system may be done on the basis of any one or more of the following common features.

(i) Common functions
(ii) Common techniques or procedures
(iii) Logical flow relationships
(iv) Common outputs or inputs

18.8.4 Output/Input Design

Having defined the sub-systems well, by way of flow diagrams and a thorough discussion with the users of the MIS, the system designers now define the specifications of outputs and inputs for each sub-system, in more detail. These specifications will later be used by programmers to develop programs to actually produce the output/input. As the main purpose of an MIS is to provide information to aid decision-making, to the user, output/input is one of the most important characteristics of the information system. As decisions are based on the output from the system and input to the system, system designers must give this phase the attention it deserves. The following paragraphs will highlight the key points to be considered while preparing output and input design.

Output Design

The term output implies any information printed or displayed, produced by an MIS. At this stage, the following activities take place.

(i) Specific outputs which are required to meet the information needs are identified.
(ii) Methods for presenting information are selected.
(iii) Reports, formats or other documents that act as carrier of information, produced by an MIS, are designed.

Objectives of Output Design

An output from an MIS should meet one or more of the following objectives:

(i) It should provide information about the past, present or future events. Outputs at the operational control level provide information of the past and the present events, whereas outputs which are required at the strategic planning level include information on future projections.
(ii) It should signal important events, opportunities and problems. For example, exceptional reports indicate such happenings.
(iii) It should trigger an action in response to some event. A set of rules is pre-defined for such a trigger. For example, an order is prepared when inventory reaches a certain level.

(iv) It should confirm an action as a result of some transaction. For example, printing a receipt upon receiving the telephone bill.

Main Points for Output Design

The following questions need to be answered for designing good output.

(i) *Who will receive the output?* The answer to this question will help determine the level of the user and also the use of the information, i.e. internal or external to the organisation. The content, format and media needs of the output may be designed accordingly. For example, vice president of an organisation may require reports only of exceptions and in summary form, supplemented by graphic displays, whereas customers may like on-line query facilities.

(ii) *When and how often is the output needed?* This determines the timing and frequency of output generation. Some outputs are generated regularly, whereas some are generated only when certain conditions arise, e.g. inventory orders are generated when inventory falls to a certain level.

(iii) *What is its planned use?* The usage of the output determines its content, form and media. For example, the content, layout and media will be different for the output if it is used to convey information (sales report), to ask a question (queries by the customer) or to trigger an action (generation of an order).

(iv) *How much details are needed?* This question specifically answers about the details required from an output, which will affect the output design.

Presentation of Output

Even a high quality content may go unnoticed, if presented poorly. Therefore, presentation of output is regarded an important feature of output design. The presentation may be either tabular or graphical, or both. The tabular format, in general, should be preferred when

(i) details dominate the contents,

(ii) contents are classified in groups,

(iii) total are to be drawn and comparisons are to be made.

In the detailed reports, a tabular format is preferred. However, graphics are used to improve the effectiveness of output, especially in detecting patterns in data and trends or changes in trends. Some users like to see information in graphic form rather than in rows and columns. Figure 18.9 exhibits tabular and graphic forms of output. Tabular and graphical formats may be combined together to enhance the presentation of output.

Output Design Specifications

The main points which should be considered in the output design specifications are given as follows:

(i) *Paper Size:* The designer must specify the size of the paper to be used for the output, e.g. A4 size, A3 size, etc., or 9.5 × 11 inch, 11 × 14.7/8 inch or 8 × 14.7/8 inch, etc.

(ii) *Special Forms:* Outputs can be designed on the pre-printed form where standard print headings/titles, etc., are required. For example, the pre-printed form may have the name and logo of the organisation printed at the top. This enhances presentation and gives a professional look to the output document. Some of the universities use this type of form for the certificates/degrees to be awarded to the students. Railways are also using similar forms for reservation tickets.

(iii) *Multiple Copies of Output:* When more than one copy is required from the system, multiple copies are to be produced. This can be achieved by using multipart forms. Multiple paper is available in carbon and carbonless forms.

(iv) *Turnaround Documents:* The output may be designed as a turnaround document, if the organisation uses optical scanners for reading data from the forms. Thus, in a turnaround document, the output later comes back as an input document.

(v) *Output Layout:* The arrangement of items on the output medium is known as an output layout. The layout design acts as a blueprint that guides the programmer in the development of codes. The output layout should have the following.

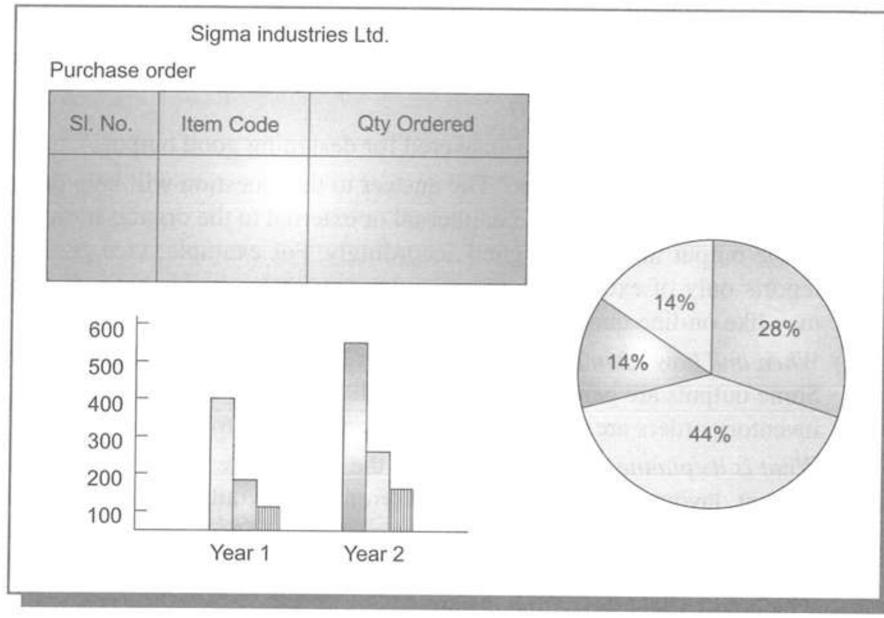


Fig. 18.9 (a) Tabular Format of Output; (b) Graphical Format of Output

(a) Headings and date
(b) Data and details
(c) Summaries and totals
(d) Page title, number and date
(e) Notes and comments
(f) Column headings and data type. Designers usually use *N*(*n*) for numeric data type and *X*(*n*) for alpha data type,–specifies the width of the column.

Figure 18.10 depicts output layout.

For designing screens, system designer may design multiple screens or special windowing capabilities such as pop-up windows. Such designs will enhance readability for the visual displays.

Input Design

Generally, output from a system is regarded as the main determinant of the system's performance, yet as already mentioned, outputs from the system are affected by the inputs to the system. Therefore, input design is equally important for the system designer.

		ABC Pvt. Ltd. Salary Statement for the Month N(2)		
Total Pages N(2)				Print Date:
Emp. Code	*Name*	*Amount*	*Account No.*	*Remark*
X(4)	X(20)	N(8)	X(4)	X(25)

Fig. 18.10 Output Layout

Objectives of Input Design

The main objectives which guide the input design are briefly discussed as follows:

(i) *Control the volume of input data.* Try to reduce data requirements and avoid capturing unnecessary data. Constant and system-computable data should not be captured.

(ii) *Avoid processing delays during data entry.* Automating data capturing may reduce this delay.

(iii) *Avoid data entry errors.* Checks in the data entry programs, which are called input validation techniques may help.

(iv) *Keep the process simple.* The system should be kept as simple and easy to use as possible.

Input Layout

The input layout should contain the following:

(i) Heading and date of data entry.

(ii) Data heading and value.

(iii) Data type and width of the column.

(iv) Initials of data entry operator.

Figure 18.11 illustrates an input layout design.

18.8.5 Feedback from the User

Having specifically defined sub-systems, output and inputs, the designers once again involve the user to get feedback. This step will increase the acceptance of the MIS being designed. The system analyst should demonstrate the proposed MIS to the users of the system sub-system. This step will also reassure the top management of the user organisation that the detailed design project is progressing as per plans.

	ABC Pvt. Ltd. Customer Order Form	
Customer Code: X(4)		Date:
Sr. No.	Item Code	Qty. Ordered
1	X(4)	N(4)
2		

Fig. 18.11 Input Layout Design

18.8.6 Database Design

A database is an orderly arrangement of all the records related to each other. It serves as a data resource for the MIS of an organisation. To have optimum performance, storage and fast retrieval of data, database design is an important phase in the detailed design of a system. For designing a database, the designer should keep the following points in mind:

(i) Identify all data tables and record types.

(ii) Identify fields for each table, the key fields for each table and relations between various tables.

(iii) Determine the data type and width for each field of the tables.

(iv) Normalise the data tables.

(v) Properly document data dictionary.

18.8.7 Procedure Design

Procedures are the rules, standards or methods designed to increase the effectiveness of the information system. The procedures detail about the tasks to be performed in using the system. They serve as ready reckoners for the designers as well as for the users. Sometimes they perform the task of a supervisor over operators. There is a wide variety of procedures, which include the following:

(i) *Data Entry Procedures:* These are the methods designed for data entry, e.g. data entry sequence.

(ii) *Run-time Procedures:* The actions to be taken by the users to achieve the intended results, e.g. a procedure may instruct the user to load printer with a specific size of paper.

(iii) *Error-handling Procedures:* These procedures help the user in detecting and correcting errors.

(iv) *Security and Backup Procedures:* Through these procedures information is provided regarding actions required to be taken to protect the system against damage.

(v) *Software Documenting Procedures:* The programmers get instructions on how to document the programs.

In designing procedures, designers should:

(a) understand the purpose and quality standard of each procedure

(b) develop a step-by-step direction for each procedure, and

(c) document all the procedures.

18.8.8 Design Documentation

Detailed design starts with the performance specifications given by the conceptual design and ends with a set of design specifications for the construction of MIS. The outputs from the detailed design, i.e. design specifications, are handed over to the programmers for writing codes to translate system specifications into a physical MIS. Therefore, the system analyst should very carefully document the detailed design. In fact, design documents should consist of comprehensive details of all the design phases. Design documentation of detailed design report, generally, consists of the following:

(i) System objectives

(ii) Design constraints

(iii) Inputs/outputs

(iv) Data files

(v) Procedures (manual)

(vi) Proposed system (a summary and detailed flow charts)

(vii) Input/output specifications

(viii) Program specifications

(ix) Database specifications

(x) Cost of installation and implementation

(xi) System test conditions

Documentation of the system should also include a user-manual and operator-manual. A user-manual is prepared to guide the user in understanding and using the system. Thus, it should be simple, easy to understand and without any technical jargon. Whereas an operator manual is written for the computer operators. Operator-manual should include an operator's view of the system, specifying start, stop and restart sequences. It should also contain various procedures which may guide the operator regarding security, privacy and integrity of data.

SUMMARY

System analysis is a detailed study of all important business aspects, of a future system, as well as the existing system. Thus, the study becomes a basis for a proposed system. In this process of system analysis, emphasis is placed on 'WHAT must be done to solve the problem'. The final product of system analysis is a set of system requirements of a proposed information system. Requirement determination, which is an important activity in system analysis, is a means of translating the ideas given by the users into a formal document. System analysis ensures that the system analyst understands the users' requirements in a clear way and thus reduces the communication gap between the user and the developer. It reduces the development cost by overcoming errors and misunderstandings early in the development and becomes a basis for reference for validation of the final product.

In order to study the existing system and to determine information requirements, there are several strategies which could be used for the purpose. These strategies may include interviews, questionnaires, record reviews and observation. As any one approach may not be sufficient for eliciting information requirements of the system, the analysts usually use a combination of all these strategies.

System analysis is carried out with the help of certain tools, usually known as structured analysis tools. The main tools, which are used for analysing and documenting the system specifications, are data flow diagram, data dictionary, structured English, decision trees and decision tables.

The main objective of the system design is to produce system specifications, which can then be converted into an information system for use in the organisation. However, the system design is a creative activity and is considered to evolve through two different levels of design, i.e. conceptual design and detailed design. The conceptual design, which is also called feasibility design, sets the direction for the MIS project and provides performance requirements. The output of the conceptual design, i.e. performance specifications are taken as an input to the detailed design to produce system specifications. The system specifications thus generated are handed over to the computer programmer for translating into a physical information system.

The system specifications, called the detailed system design or logical system design provide all details of inputs, outputs, files, database, controls and procedures. For ensuring an effective, efficient and successful MIS, the system analyst must not rush through this phase, rather each and every step must be undertaken very carefully to prepare a meticulous system design.

REVIEW QUESTIONS

1. What is meant by system analysis? Discuss its main objectives.
2. Discuss and illustrate the main strategies for eliciting information about the user's requirements. Which strategy would you like to select? Why?
3. What is structured analysis? Briefly discuss the tools used in structured analysis.
4. Describe, with the help of a suitable example, the concept and procedure used in constructing DFDs.
5. Elaborate the symbols used in constructing DFDs. Give basic rules for constructing a DFD.
6. Discuss a decision tree and a decision table. Are decision trees and data flow diagrams related? Discuss.
7. What is meant by conceptual design of MIS? Discuss various steps involved in the conceptual design of a system.
8. Do you think a conceptual design is a prerequisite to detailed design? If yes, why?
9. Elaborate the concept and role of conceptual MIS design.
10. Why is the term gross design often used to designate conceptual design? Which term do you think is more appropriate? Why?
11. Should detailed design work ever overlap the development of the conceptual design? Give problems and advantages, if any.
12. Distinguish between conceptual design and detailed design. Which is more important?

13. What objectives guide the design of output and input specifications?
14. What is meant by design specifications? Discuss various phases involved in preparing design specifications. Do you think users should be involved in preparing design specifications? Why?

ASSIGNMENTS

1. Think about any discount policy being used by an organisation. Develop a decision tree and a decision table for the same.
2. Assume Mr Sudesh is running a small confectionary shop. He makes all the purchases from a delivery van on cash basis and sells the items to his customers only on cash, i.e. no credit is allowed to his customers. Since the shop is a small business, it is a one-man show and Mr Sudesh does not require to file any income tax returns.

   On the basis of the above information, draw a DFD for his information system.
3. Develop a questionnaire to elicit information regarding study of an existing system in a manufacturing organisation.
4. Critically examine the design of the following formats:
   (i) your enrolment form
   (ii) your performance report
   (iii) annual report of your institute.
5. (i) Suppose, your Professor has asked you to prepare design specifications for Library Information System of your institution. How would you proceed in the given assignment?

   (ii) Actually prepare conceptual design and detailed design for the Library Information System of your institute.

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CASE STUDY 1

SYSTEM REQUIREMENT SPECIFICATION: AN ILLUSTRATIVE CASE

Introduction

In an organisation, the department of human resource development is responsible for a wide variety of functions like maintenance of personnel records, human resource planning, recruitment and selection, transfers, promotions, retirements/ resignations, etc.

The department provides a link to the accounts department and other departments of the organisation. The department also prepares a number of outputs like increment reports, seniority lists, expertise reports and also provides answers to various queries posed by authorities/employees of the organisation. The functions of human resource development systems are listed below.

(i) Record-keeping of the employees
(ii) Maintenance of service records
(iii) Leave-sanctioning, updating leave information
(iv) Planning for human resource
(v) Recruitment of employees
(vi) Processing resignations and retirement
(vii) Increment-processing
(viii) Keeping track of employees' expertise
(ix) Query-handling.

Following is a detailed System Requirement Specification (SRS) for a human resource development system.

Human Resource Development System

File Design

1. Employee_info_file

Employee_code	: 6N
Employee_name	: 30 C
Father_name	: 30 C
Sex	: 1 C
Joining_date	: Date
Date_of_birth	: Date
College	: 2 N
Department	: 2 N
Provision	: 1 N
Position	: 1 N
Category (SC/ST/BC/G)	: 3 C
Basic_salary	: 7.2 N
Scale	: 2 N
Next increment date	: Date
Employment_status	: 1 C
Sick_leave_available	: 2 N
Cumulative leave	: 3 N
Marital_Status	: 1 C
No_of_dependencies	: 2 N

2. Scale_file

Scale_code	: 2 N
Designation	: 2N
Starting_scale	: 4 N
Increment	: 3 N
Ending_scale	: 4 N

3. Qualification_info_file

Emp_code	: 6 N
Degree_code	: 2 N
Degree	: 10 C
Subject	: 30 C
Institute	: 30 C
From	: 8 D
To	: 8 D

Grade : 10 C

4. Past_history_info_file (Emp-Hist)
   - Emp_code : 6 N
   - Organisation : 30 C
   - Address : 30 C
   - Designation : 20 C
   - From : Date
   - To : Date
5. Expertise_info_file
   - Subject_code : 2 N
   - Subject_name : 30 C
   - Department : 2 N
   - Achievement : 30 C
   - Emp_code : 6 N
6. Staff_position_info_file
   - College : 2 N
   - Department : 2 N
   - Provision : 1 N
   - Position : 1 N
   - Total_positions : 2 N
   - Filled_up_positions : 2 N
7. Past_employees_info_file
   - Nature_of_leave : 1 C
   - Date_of_leaving : Date
8. Publication_info_file
   - Emp_code : 6 N
   - Title : 30 C
   - Published_in : 30 C
   - Subject_code : 2 N
   - Month/year
9. Leave_info_file
   - Emp_code : 6 N
   - Type : 2 N
   - From : Date
   - To : Date
   - Remarks : 30 C
   - Orders
   - Order_no : Date 3 N
   - Emp_name : 30 C
   - Father's_name : 30 C
   - Category : 3 C
   - Sex : 1 C
   - Date_of_birth : Date
   - College : 2 N
   - Department : 2 N
   - Provision : 1 N
   - Basic : 7.2 N
   - Scale : 2 N

Input/Output Forms

1. Joining_Report

1.1 Emp_info_form (I)
   - Order_no.
   - Emp_name
   - Father_name
   - Date_of_birth
   - Sex Joining_date
   - College Dept.
   - Provision Designation
   - Basic_scale
   - Employment_status
   - Marital_status
   - No._of_dependencies

1.2 Qualification_info_form (I)
   - Emp_code
   - Name
   - Degree_code
   - Degree
   - University/Institute
   - From
   - To
   - Grade/Class_obtained

1.3 Past_info_form (I)
   - Emp_code
   - Name
   - Organisation
   - Address
   - From
   - To
   - Designation
   - Remarks

1.4 Expertise_info_form (I)
   - Emp_code

Name
Subject_code
Subject_name
Department
Achievement

1.5 Publication_info_form (I)
Emp_code
Name
Title
Published_in
Month and Year
Remarks

1.6 Joining_info (0)
Emp_code
Emp_name
Designation
Joining_date
Basic_Scale
College
Department

2. Staff_position_info_form (I)
College
Department
Position
Provision
Total_posts
Filled_up_posts

3. Resignation_info

3.1 Resignation_form
Emp_code
Emp_name
Designation
Date_of_leaving
Date_of_resignation
No_dues

3.2 Resignation_info
Emp_code
Emp_name
Designation
College
Department
Date_of_leaving
No_dues Remarks

4. Retirement

4.1 Retirement_notification (0)
Emp_code
Emp_name
College
Department
Designation
Joining_date
Retiring_date
Date_of_birth

4.2 Employee_retiring_info (0)
Emp_code
Emp_name
College
Department
Designation
Joining_date
Retiring_date
Date_of_birth
No_dues

5. Report_on_increments (Monthly) (0)
Emp_code
Emp_name
Designation
Present_basic,
Scale
Increment_amount
Salary_after_increment

6. Report_on_regularised_employee (0)
Emp_code
Emp_name
Designation
Joining_date
Basic_salary
Scale
Regularised w.e.f.

7.1 Leave_application (I)
Emp_code
Emp_name
Leave_type
From
To
No_of_days

7.2 Leave_info (0)
Emp_code
Emp_name
Leave_type
From
To
No_of_days
Remarks

7.3 Seniority_list (0)
Emp_code
Emp_name
Department
College
Designation

Module Specifications for HRMS

0 Module
Is a Menu Module
- (i) Recruitments
- (ii) Resignations
- (iii) Retirements
- (iv) Reports
- (v) Queries
- (vi) Annual updation
- (vii) Exit

1. Module (Recruitments)
   - (i) Process joining reports
   - (ii) Order-entry
2. Module (Resignations)

   Inputs: Resignation_info_form
   Outputs: Resignation_report to accounts department
   Subordinates: Process_resignation_form
   Generate report for accounts department
   Purpose: Processing resignations by updating Emp_info_file and Past_emp_info_file and generating a report to accounts department.
3. Module (Retirements)

   Input: No_dues
   Output: Report_on_retiring_employee to accounts department,
   Subordinates: Get no_dues info generate report for accounts department, update retirement files
   Purpose: On production of no dues by retiring employee, files are updated and a report is sent to accounts department.
4. Module (Regular Reports)

   Sub-menu:
   - (i) Report on Increments
   - (ii) Report on Regularisations
   - (iii) Report on Retirements
   - (iv) Report on Seniority list

   Purpose: Generate regular reports
   Cash report is generated in a separate module.

5. Module (Queries)

   Sub-menu: (i) On expertise
   (ii) On publications
   (iii) On service period
   (iv) On leaves

   Purpose: Some expected queries are included and they are done in separate modules.

6. Module (Annual Updation)

   Purpose: This module updates leave_information of emp_info_file on every new year.

Detailed Specifications

1.1 Module (Joining Report Process)

Inputs: Joining_report

Output: A report on joining employee to accounts department

Submodules: Process joining_report
Generate joining info for accounts department

Purpose: When new employees joine, their joining reports are processed and the corresponding files are updated. A report is generated for the accounts department.

1.1.1 Process joining_report

Subordinates: Get emp_info_form
Generate emp_code Update recruitment_files

Purpose: It gets the data of new employee and updates various files. It also generates an employee-code for the new employee.

1.1.2 Generate joining_info

Input: Joining_report and extracted info from orders file

Output: A report on employee joining for the accounts department

Purpose: It generates a report for the accounts department consisting of details like employee-code, salary and joining date.

1.1.1.1 Get employee_info_form

Input: Data from joining report orders file

Output: Employee-data for further use

Purpose: It reads some portion of joining report in order to generate employee-code and cross checks with the orders file.

1.1.1.2 Generate emp_code

Input: Order_no., order_file, joining_report

Output: Employee_info

Purpose: To cross check with orders file and generate employee-code.

1.1.1.3 Update recruitment_files

Input: Joining_report

Output: Updated emp_info_file, qualification_info_file, past_hist_info_file expertise_info_file, publication, info_file, staff_position_info_file.

Submenus: (i) Update qualification
(ii) Update past-experience
(iii) Update expertise
(iv) Update publications

Submodules: Update staff_position

1.1.1.3.1 Update qualification

Input: Qualification_info_form

Output: Updated qualification_info_file

Submodule: Get qualification_info_form

Purpose: It reads qualification-information and adds it to the qualification_info_file.

1.1.1.3.1.1 Gets qualification_info_form

Purpose: Gets the qualification_info from qualification_info_form.

1.1.1.3.2 Update experience

Input: Past_experience_info_form

Output: Updated past_hist_info_file

Submodule: Get_past_hist_info_ form

Purpose: To update past_hist_info_file with past experience of new employee.

1.1.1.3.2.1 Get past_hist_info_file

Purpose: Gets the past experience information of new employee from the screen.

1.1.1.4 Update publications

Input: Publication_info_form

Output: Updated publication_info_file

Submodule: Get pub_info_form

Purpose: Enter publications of new employee into publications_info_file.

1.1.1.4.1 Get publication_info_form

Purpose: Get the publication_info_form Publication_info_form

1.1.1.5 Update staff_position

Input: Joining_report

Output: Updated Staff_ position_info_file

Purpose: Updates staff position in the staff position_info_file.

1.2 Module (Orders Entry)

Input: Orders_form

Output: Orders_file

Purpose: Generate an order file whenever there is a recruitment. This is used as a cross check when new employees join.

2. Module (Resignations)

Input: Resignation_application

Output: A report_to_accounts department

Submodule: Process resignation_form

Generate_resignation_report

Purpose: When an employee resigns, resignation applications are processed and a report is generated to the accounts department.

2.1 Process_resignation_form

Input: Resignation_application

Output: Updated emp_info_file Updated past_emp_info_file

Submodule: Get from_resignation_form Update resignation_file

Purpose: Read resignation_info from resignation_info_form and update files.

2.1.1 Get from_resignation_form

Input:	Resignation_info_form
Purpose:	To read the resignation_info from a form

2.1.2 Update resignation_files

Input:	Resignation_form
Output:	Updated emp_info_file Updated past_emp_info_file
Submodule:	Delete from emp_info_file Add to past_emp_info_file
Purpose:	To update the above file

2.1.2.1 Delete from emp_info_file

Input:	Resignation_form
Output:	Updated emp_info_file
Purpose:	To delete the record from employee_info_file

2.1.2.2 Add to past_emp_info_file

Input:	Resignation_form
Output:	Updated past_emp_info_file
Purpose:	Add the record to past_ emp_info, etc.

2.2 Generate resignation_report

Input:	Resignation_form
Output:	Generate resignation_report
Purpose:	Generate a report on resignation to the accounts department.

3. Module (Retirements)

Input:	Emp_code, No dues
Output:	Generate retirement_report Updated emp_info_file, past_ emp_info_file
Submodules:	Get no_dues from employee Generate retirement_info Update retirement_file
Purpose:	When an employee retires, the same is communicated to accounts department.

3.1 Get no_dues from employee

Input:	Emp_code, no_dues
Purpose:	To get emp_code and no_dues from the employee

3.2 Generate retiring_info

Input:	Emp_info_file
Output:	Report on retiring_emp
Purpose:	A report is generated for the accounts department

3.3 Update_retiring_info

Input:	Emp_code
Output:	Updated emp_info_file
Submodules:	Delete from emp_info_file Add past_emp_info_file

3.3.1 Delete from emp_info_file

Input:	Emp_code
Output:	Updated emp_info_file
Purpose:	To delete emp_info from active employee_info file.

3.3.2 Add to past_emp_info file

Input: Emp_code

Output: Updated past_emp_info_file

Purpose: To add emp_info to past_ emp_ info_file.

4.1 Report on increments

Input: Emp_info_file

Output: A printout of increments report for the accounts department

Output: Updated emp_info_file

Submodules: Get emp_date from emp_ info_ file

Print emp_increment_report

Purpose: To read the emp_info from emp_info_file and by observing next_increment_date in emp_info_file, decide whether the employee is eligible for an increment or not. Also update emp_info_file with new next_increment_date.

4.1.1 Get emp_date from emp_info_file

Input: Emp_info_file

Output: Emp_date_record

Purpose: To read record by record from emp_info_file

4.1.2 Print emp_increment_report

Purpose: Prints emp_increment_report.

4.2 Regularisations of employee

Input: Emp_info_file

Output: Printed report_on_regularised_employee

Updated emp_info_file

Subordinates: Get emp_info_file

Print report_on_regularised_employee

Purpose: To get a report on regularised employee

4.2.1 Get emp_info_file

Purpose: Read emp_info_file

4.2.2 Print report_on_regularised employees

Purpose: Print report_on_regularised_employees

4.3 Report_on_Retirements

Input: Emp_info_file

Output: Printed report_on_retiring_employees

Subordinates: Get emp_info_file

Print report_on_retiring_employees

Purpose: To print a monthly report which gives details about retiring employees

4.3.1 Get_emp_info_file

Purpose: To read employee_info_file.

4.3.2 Print report_on_retiring_employees

Purpose: To print a report on retiring employees.

4.4 Report_on_seniority list

Input: Emp_info_file

Output: Printed report_on_seniority list

Subordinates: Get emp_info_file
Print seniority_list
Purpose: To prepare a seniority list.

4.4.1 Get emp_info_file
Purpose: To read employee information file.

4.4.2 Print seniority_list
Purpose: To print_seniority_list.

5.1 Query_on_experts
Input: Queries like
(i) Given a subject, give a list of experts
(ii) Given an employee-name, give a list of subjects in which he is an expert
(iii) Given a subject and department, give a list of experts.
Employee_info_file, expertise_info_file
Output: Response to the Queries Purpose: To allow queries on expertise of employees

5.2 Query_on_publications
Input: Queries like
(i) Given an employee_name, give a list of publications
(ii) Given a subject, what are the different publications
Emp_info_file, publications_info_file
Output: Response to queries
Purpose: To allow queries on publication information

5.3 Query_on_service_period
Input: Queries like
(i) Given a period, find those employees who have completed a particular years of service
(ii) Given an employee name, find the number of years of service
(iii) Given a department, find the service-period of each employee.
Output: Response to queries Purpose: To allow queries on service_ period of employees.

5.4 Query_on_leaves
Input: Queries like
(i) Given an employee_name, find the various leaves availed and the leaves remaining
(ii) Given a year, what are the leaves availed.
Output: Response to queries
Purpose: To allow queries on leave_information.

CASE STUDY 2

MIS AT XYZ BANK

XYZ bank was established in the year 1906 with its headquarters in a metropolitan city of India (name of the bank and its location have been disguised to retain anonymity.). In 1971, much after the independance, the government of India decided to nationalise it and thus it was brought under the control of Reserve Bank of India (RBI). Today the bank is one of the leading nationalised banks in India, and is governed by Banking Companies Regulation Act. The bank is a profit-earning organisation, which employs more than sixty thousand employees, has got deposits of about Rs 3,000 billion and its advances are to the tune of Rs 1,750 billion.

The bank, for its smooth functioning, is organised into circles, regional offices, divisional offices and branch offices. Figure 1 exhibits the simple schematic diagram of the hierarchy of the bank.

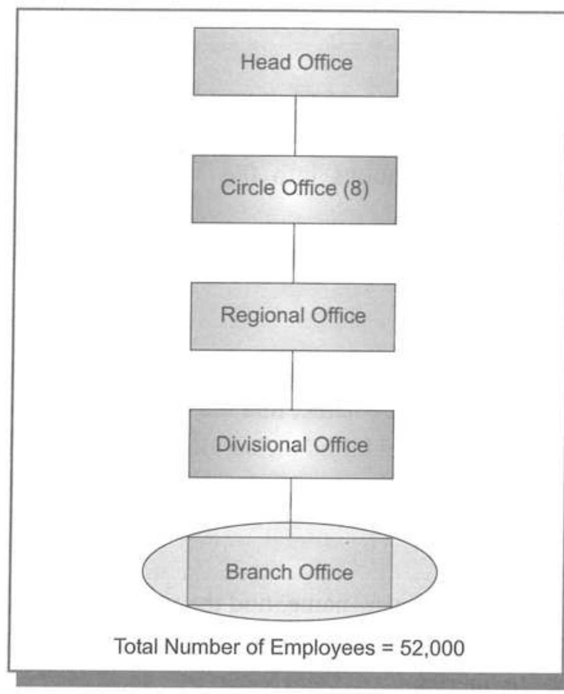

Fig. 1 Hierarchy of XYZ Bank

The bank has the following departments.

(i) Planning and Development
(ii) International Banking Division
(iii) Merchant Banking
(iv) Rural Development
(v) Inspection and Control
(vi) Loans and Advances
(vii) Accounts Department.

A Branch of XYZ Bank

One of its branch offices was established in a big city in India in the year 1985. This branch reports to its divisional office that is situated at a distance of about 80 km. The Divisional Manager, in turn, sends his reports to the regional office. The organisational chart of the branch is given in Fig. 2. The important statistics of this branch are:

Employees : 25
Deposits : Rs 10.50 crore
Advances : Rs 2.00 crore

The branch office sends a weekly report to the divisional office. The divisional office dictates to the branch office, the policy and amount of deposits and advances the branch can undertake.

Work and conduct, etc., are assessed twice a year by the Branch Manager and a report is sent to the divisional office.

Problems of a Branch Manager

Due to a substantial increase in the number of accounts and a greater need for information, there has been a considerable increase in work load. The officers are not finding it easy to access and update records in the existing system.

For a single transaction, a number of books, consisting of the entire information system, have to be updated.

The branch manager is also facing security problems relating to information contained in the books and files.

Besides the above problems, the customer has to move from counter to counter and has to wait for a considerable amount of time. The bank does not encash traveller's cheques issued by any public sector bank.

With a view to overcome the above-mentioned problems, the branch manager of XYZ Bank decided to invite a consultant from a leading business school in India to study the present system and to propose and design a new information system.

The consultant proceeded in the following way to study and propose a new information system at the branch office of XYZ Bank.

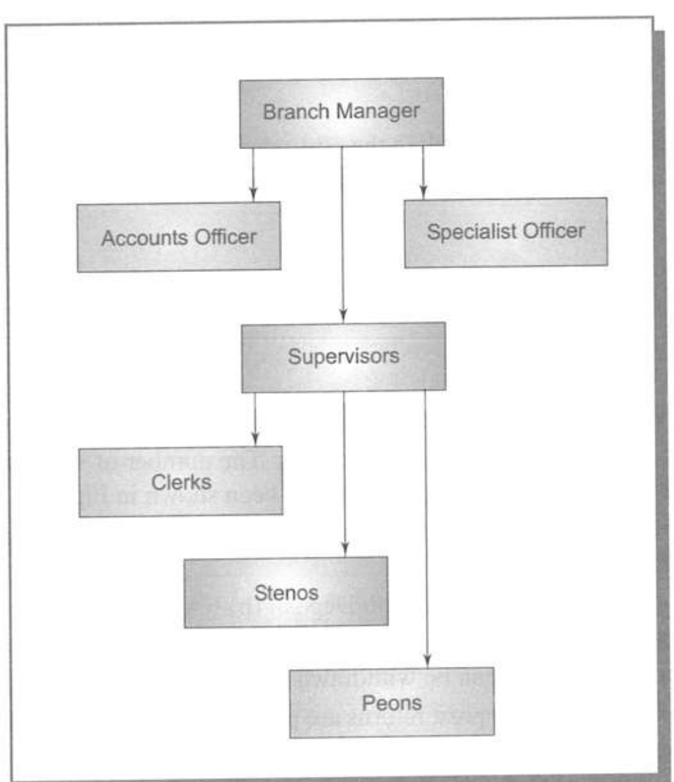

Fig. 2 Organisational Chart of the Branch

SYSTEM ANALYSIS

This is the most important phase of any system development project. The analysis stage involves studying the system requirements and dividing the whole system or concept into manageable parts and their interlinks. The analysis was performed with the following main objectives in mind:

Objectives

(i) To study the whole area concerning the accounting procedure of the branch.
(ii) To study the problems in the existing system and its drawbacks.
(iii) To study the requirements of the new system and design the new system on the basis of the sources of information and the links of the information.

Problem Definition

(i) Increased work load
(ii) Reduced efficiency
(iii) Duplication of data
(iv) Security of data.

Methodology

Unstructured Interviews

The information system was manual and the manager's knowledge about computers was minimum. An unstructured interviewing technique was adopted to elicit information from the managers/employees.

Record Searching

Study of documents, forms, registers and ledgers was undertaken from the records of the bank.

Study in Parallel Organisation

A study of the operations of another branch of another bank in the city, whose operations are almost fully computerised was undertaken. This was done in order to give an insight into the working of a computerised system.

Existing System

Functions of Bank

1. Borrowing

A bank borrows money in form of deposits from the public. The various deposit schemes are as under.

(i) *Saving Accounts*: These are the most common forms of deposits. The number of withdrawals is limited and simple interest is paid. The procedure for opening a saving account has been shown in Fig. 3.
(ii) *Current Accounts*: No interest is paid. These accounts are provided with over-draft facility and are suitable for business organisations and not individuals.
(iii) *Term Deposits*: These may be of 2 types: (a) Kamadhenu Deposit (b) Fixed Deposit
 (a) *Kamadhenu Deposits*: The money is deposited for a fixed time-period and compound interest is credited every 3 months. The interest and the principal can be withdrawn only after the completion of the deposit-period.
 (b) *Fixed Deposits*: In this case, periodical deposit returns are paid. Such a scheme is suitable for those who require a fixed amount, at regular intervals.

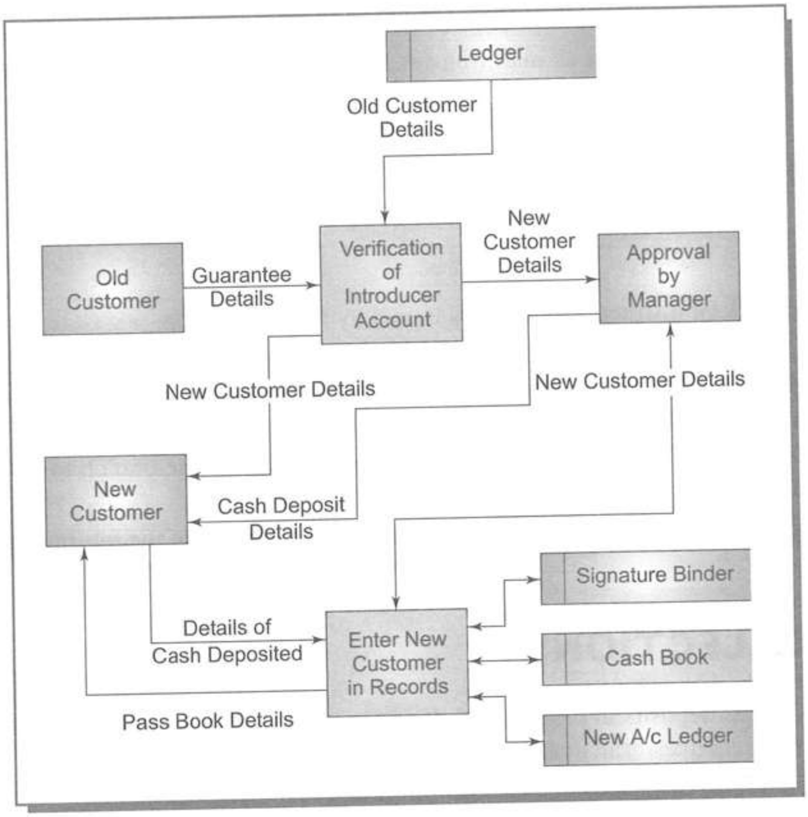

Fig. 3 DFD of the Procedure for Account Opening

(iv) Recurring Deposits: These are mainly for salaried people. They are allowed to pay a fixed sum into their account every month, or every 2 months, etc., depending upon the requirement. The amount can only be withdrawn after a fixed period of time.

(v) *Nithyanidhi Deposits*: This scheme is meant for daily-income parties such as shopkeepers, daily workers and artisans. For this purpose, the bank employs the services of an agent who visits the account holder's place of work and collects their deposits, giving them a receipt. Only a small rate of simple interest is payable.

(vi) *Foreign Currency Deposits*: This scheme is in its infancy at present. This is for those individuals and organisations who would deposit money in this account by means of foreign currency.

2. Advances

The bank grants credit to the public in the following forms:

(i) *Open Cash Credit Account*: The bank allocates a certain amount of credit to the customer. The customer draws the money as and when he needs it and the interest is charged on the actual amount utilised by him.

(ii) *Overdraft Account*: This facility is given to holders of current account. The holders are allowed to withdraw beyond the balance in their accounts up to a certain specified limit and the interest is charged on this overdrawn account. It is a short-period arrangement and the account must show a credit balance again within a few days.

(iii) *Loan Against Hypothecation of Vehicles*: Loans are granted for purchase of vehicles. The vehicle itself is the security of the loan.

(iv) *Housing Loan to Employees and Others*: Loans are given to employees and others for purchase of houses or for construction of a house. The land or the house is the security in this case.

(v) *Valuable Security Loans*: Loans are granted to individuals or organisations at the prevailing rate of interest against an asset which is the security.

Other Services

The bank also provides its customers with facilities, such as mail transfer, demand draft, stock investment, etc. Figure 4 depicts a DFD for various functions of the bank.

GENERAL OUTLINE OF INFORMATION

Maintenance and Transfer

1. A branch maintains an up-to-date book of instructions/circulars issued by the head office.
2. It maintains a daily diary for recording due dates of bills, deposits, insurance policies, etc., renewal of credit limits and documents relating to advances, standing instructions and other items requiring periodical attention. Entries are made whenever fresh transactions, instructions relating to the above items take place.
3. Each day, a member of the branch goes to the clearing house as the representative of the branch to clear drafts and cheques received from other banks.
4. The head office and regional office get an updated list of all periodical returns. Copies of the returns are maintained by the branch.

REMITTANCE AND COLLECTIONS

A customer may withdraw or get returns on his deposits in the form of cheques or may get the collected amount deposited in his account. Collections may be in form of cheques/drafts/cash.

The bank records these transactions in some form in various books. This information is given below.

A customer may be an individual, an organisation or another branch of a bank.

(i) *Cash Order:* They are used for local cash withdrawals, i.e. the customer is a resident of the branch area,

(ii) *Transfer/Pay-Order:* These are used for giving cash to any party on being informed by any other branch of the same bank.

(iii) *Demand Draft:* These are used by any outside agency other than the two listed above.

Books in Routine Use

Cash Book

This is used for recording daily deposits and withdrawals. It lies with the cashier. Transactions are recorded in this as and when they occur.

Day Book

This is updated at the end of each day. It keeps records of the total deposits and withdrawals. Data for this is taken from the cash book.

Ledger

This is used for crediting and debiting accounts. Hence it has two main entries: Debit and credit, both having the following subheadings:

(i) Cash

(ii) Transfers

(iii) Clearing Account

These books are maintained according to different procedures, mentioned as follows:

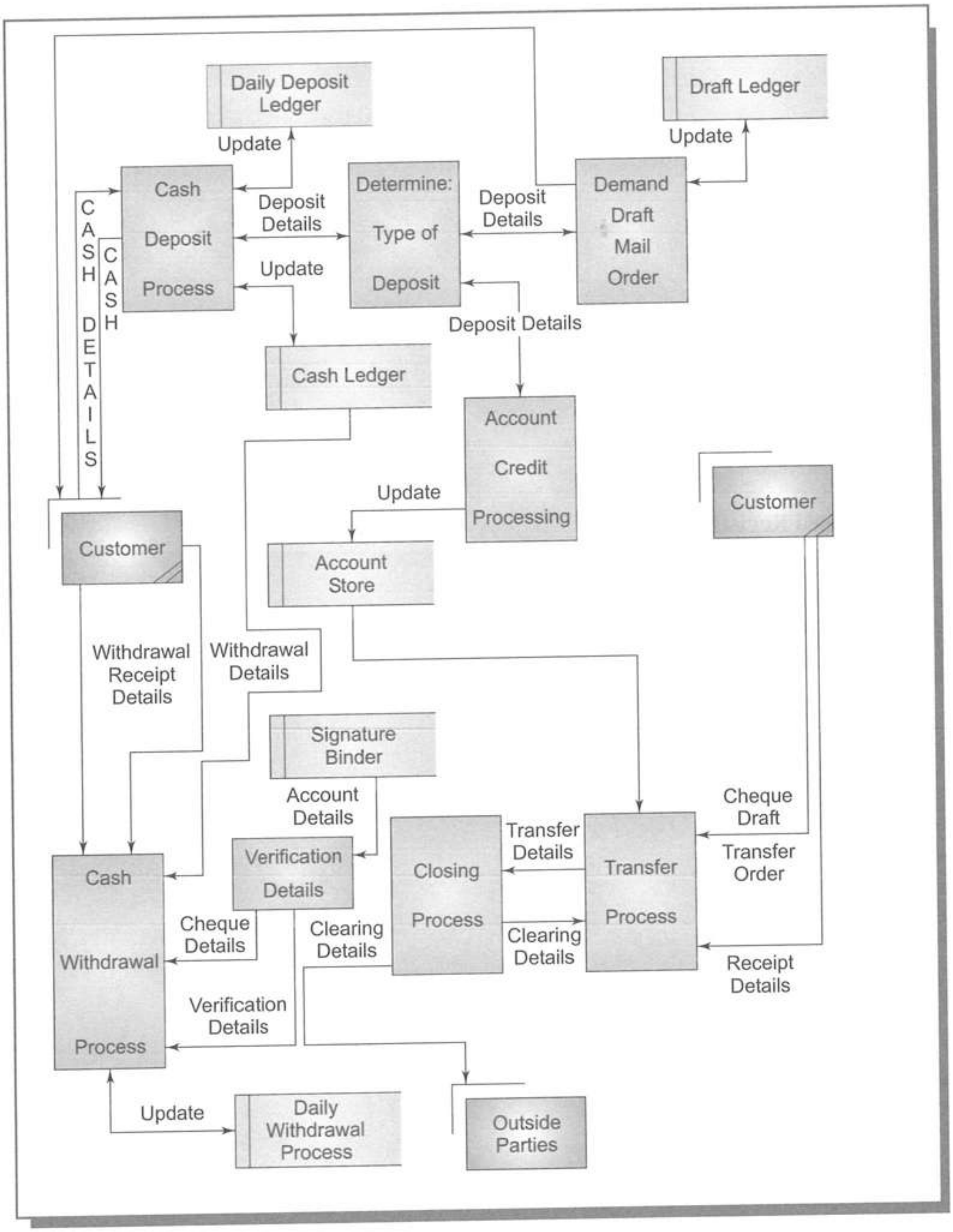

Fig. 4 DFD for Functioning of the Bank

Opening of Saving Bank A/c

Registers Required

1. Savings Bank Ledger Sheet
2. Savings Bank Pass Book
3. Savings Bank Binder
4. Specimen Signature Binder
5. Account Opened/Closed Register
6. Alphabetic Index Register.

Forms Required

1. Cash Pay-in-slip
2. Cheque Pay-in-slip
3. Account Opening Form.

Opening of Current A/c

Registers Required

1. Current Account Ledger Sheet
2. Current Binder
3. Specimen Signature Binder
4. Cheque Authority Register
5. Statement of Account
6. Pass Book
7. Current Account Opened and Closed Register.

Forms Required

1. Cash Pay-in-slip
2. Account Opening Form
3. Specimen Signature Form.

Payment of Cheques

Registers Required

1. Cheque Returning Register
2. Cheque Payment Authority Registers
3. Token Book
4. Stop Payment Register
5. Transfer Journal.

Forms Required

1. Cheque Returning Memo
2. Stop Payment Letter of Acknowledgement
3. Stop Payment Slip
4. Withdrawal Form.

Issue of Fixed Deposit Receipt

Books Required

1. Fixed Deposit Ledger
2. Fixed Deposit Interest Payable Register
3. Fixed Deposit Due Date Register
4. Transfer Journal
5. Fixed Deposit Receipt Book
6. Account Opened and Closed Register.

Forms Required

1. Account Opening Form
2. Application for Issue of FDR.

Maintenance of Customer's Account

1. Posting in Ledger
   (i) Credit Posting
   (ii) Debit Posting
2. Transfer of Accounts
3. Closing of Accounts.

Issue of Cheque Books

Register Required

1. Cheque Book Issue Register.

Payment of Drafts/Transfer Payment Order

Books Required

1. Draft Payable Ledger
2. Draft Paid Without Advice Ledger
3. Cash Order Issue Register
4. T.P.O. Payable Register.

Issue of Drafts/Transfer Payment Order

Books Required

1. Draft Leaves Consumed Register
2. Demand Draft Issue Register
3. Demand Draft Book
4. T.P.O. Issue Register
5. T.P.O. Book.

Form Required

1. Draft/T.P.O. Application Form.

Payment of Fixed Deposit Receipt/Interest

Books Required

1. Fixed Deposit Ledger
2. F.D. Due Date Register
3. F.D. Interest Payable Register
4. Overdue Fixed Deposit Ledger.

Forms Required

1. Debit/Credit (Transfer) Voucher
2. Debit Cash Voucher.

Standing Instructions and Stop Payments

Registers Required

1. Standing Instructions Register
2. Stop Payment Register.

Forms Required

1. Stop Payment Ledger of Acknowledgement
2. Stop Payment Slip
3. Cheque Returning Memo.

WEEKLY STATEMENT

A weekly report is sent each Friday to the divisional office and the head office. It sums up the status of assets and liabilities. Figure 5 shows DFD for the weekly statement.

Liabilities

(i) Demand Deposit From
- Bank
- Public
- Savings Deposit

(ii) Time Deposit From
- Bank
- Public

(iii) Other Liabilities

Drafts payable, interest payable, employees security, etc.

Assets

(i) Loans and Advances

(ii) Bill Purchased and Discounted
- Inland
- Foreign

(iii) Inter-Bank Advances

(iv) Cash-in-Hand

(v) Balances with RBI

(vi) Balances with Banks in Current Account

(vii) Fixed Deposits with Other Banks.

FUNCTIONAL AREAS COMPUTERISED

Accounting system of the branch is to be fully computerised. It should be done in the same pattern as other branches, at its circle offices, so that it is readily compatible with the system developed by the Head Quarters.

COMPUTER PERSONNEL

A completely user-friendly package is being developed so that there is no need for specialised personnel. Existing staff will have to be trained in handling the package.

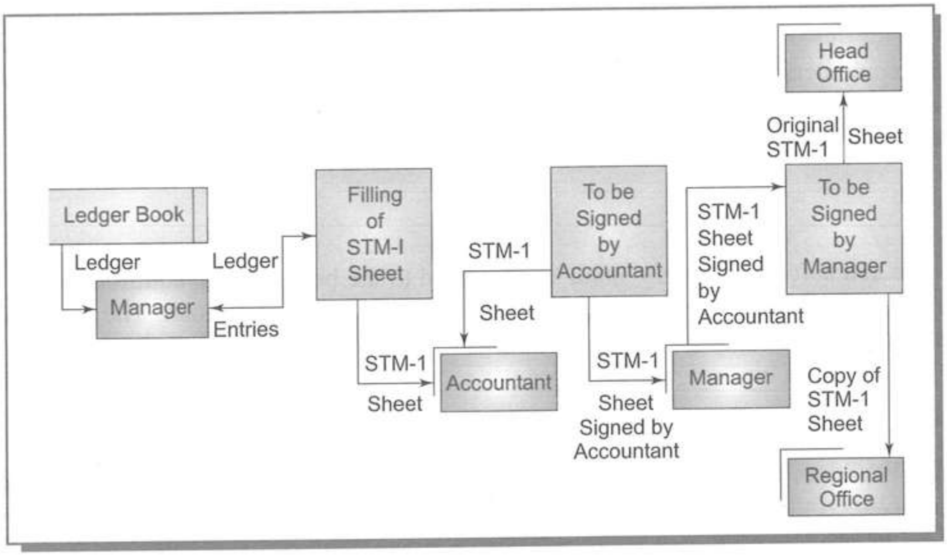

Fig. 5 DFD of Weekly Statement

SECURITY

Security should be taken care of by using of special passwords provided to select employees.

PROPOSED SYSTEM

This Bank has been functioning for approximately 90 years. Over the years, it has streamlined and improved the working of various branches. It imparts specialised training to its employees. The jobs performed by its employees are not very difficult nor do they require decision-making involving a high degree of risk. Hence, computers can easily be used to perform manual, tedious and time-consuming activities.

The aim is to make a computer package that is so user-friendly that the present staff is able to operate it. No specialised staff is to be employed to cater to the need of the new computerised system. The general working of the branch will be the same with very little or no change in its data input forms. Instead of using large ledgers, the same staff will use computers. The existing staff will cater to the needs of an increased number of customers and more volume of work. It will also become easier to verify, validate, trace and correct data.

The major benefits of computers will be realised when almost all activities of the branch are computerised and attached to a common network. Then a single entry, which finds its way into many books, will be entered once and it will automatically be posted to various files.

However, complete computerisation will entail vast amounts of money, which will not be economically feasible for a small branch. Some of the procedures, input formats, etc., will also need to be changed. It will also be difficult to test-run such a system.

So after making an elaborate study of the existing system and finding flaws in the present one, a new system is to be proposed. The introduction of computers in phases is recommended in the branch.

FEASIBILITY STUDY

Operational Feasibility

The reaction of the user will not be unfavourable. Many branches of the bank have been computerised. No layoffs have been suggested. Moreover, the work load will be reduced and monotonous tasks will be performed by the computer. The employees would view the introduction of computers as an improvement in their work environment.

Technical Feasibility

It is technically feasible to install computers, as installing two PC Pentium computers is not a big deal. These days, such computers are rather common and also cheap. The hardware maintenance support will be provided by the vendor and the user-friendly software being installed would require no technical skill on the part of the user.

Economic Feasibility

Costs associated with the hardware and software are very small as compared to the benefits. The additional costs incurred will be compensated by not increasing the workforce as a result of the increase in the work load. The same number of employees will be able to handle more work.

Hardware Requirements

There is a requirement of two PC Pentiums with 32 MB RAM, 2 MB cache memory, 8 GB hard disk and one dot matrix printer.

Software Requirements

It should have DOS operating system. It should also have Windows, MS Office, and Access or Oracle, etc., alongwith the application software.

PHASE BY PHASE COMPUTERISATION OF FUNCTIONS OF THE BRANCH

Phase I

Computerisation of deposit accounts in the following order:

(i) Saving accounts
(ii) Current accounts
(iii) Recurring accounts
(iv) Term deposit accounts.

Phase II

Computerisation of advances accounts in the following order:

(i) Open cash credit accounts
(ii) Loan against hypothecation of vehicles accounts
(iii) Housing loans to employees and public accounts
(iv) Valuable security accounts.

Phase III

Computerisation of related functions such as mail transfers, demand draft, cheque clearing activities, etc. Payroll processing and related activities and decision support system for the manager can also be added to this phase, if required.

This report will only cover a portion of Phase I of the proposed system.

VARIOUS PROCEDURES INVOLVED IN MAINTAINING A SAVINGS ACCOUNT

1. Debit of Account
   (i) Cheques
   (ii) Cash Withdrawals
   (iii) Service Charges
   (iv) Standing Instructions.
2. Credit of Account
   (i) Cheques
   (ii) Cash Deposits
   (iii) Drafts
   (iv) Transfers

   The process of debiting and crediting an account has been shown in Fig. 6.

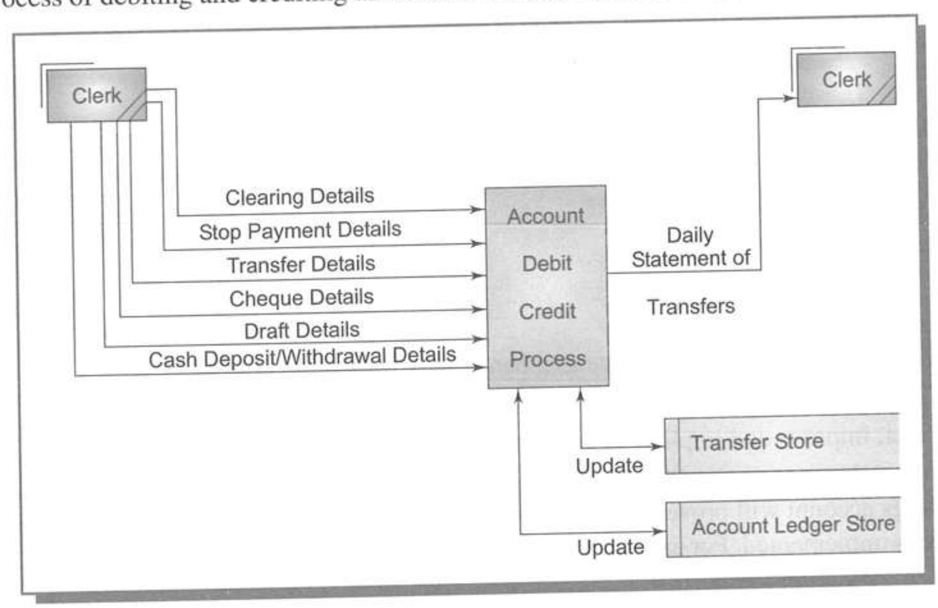

Fig. 6 Debting and Crediting Process

Figure 7 shows the maintenance of saving accounts

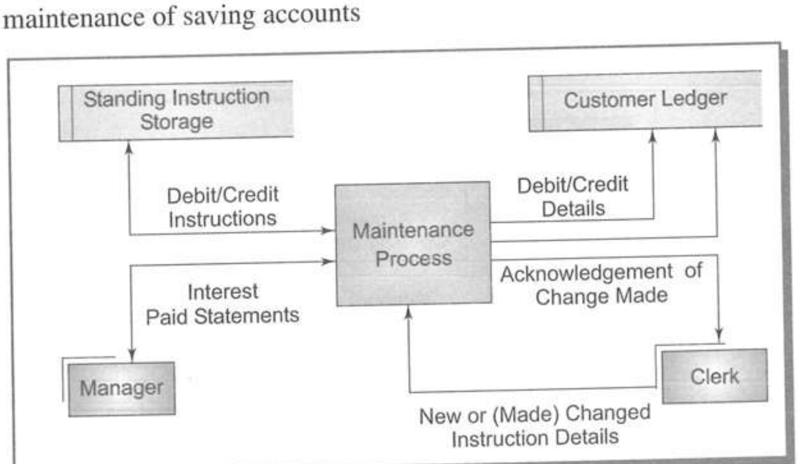

Fig. 7 DFD for Maintaining a Saving Account

3. Maintenance of Account
   (i) Interest Crediting
   (ii) Correction Entries.

4. Customer Service
   (i) Pass Book Information
   (ii) Cheque Book Information.

Figure 8 depicts the process of costumer service.

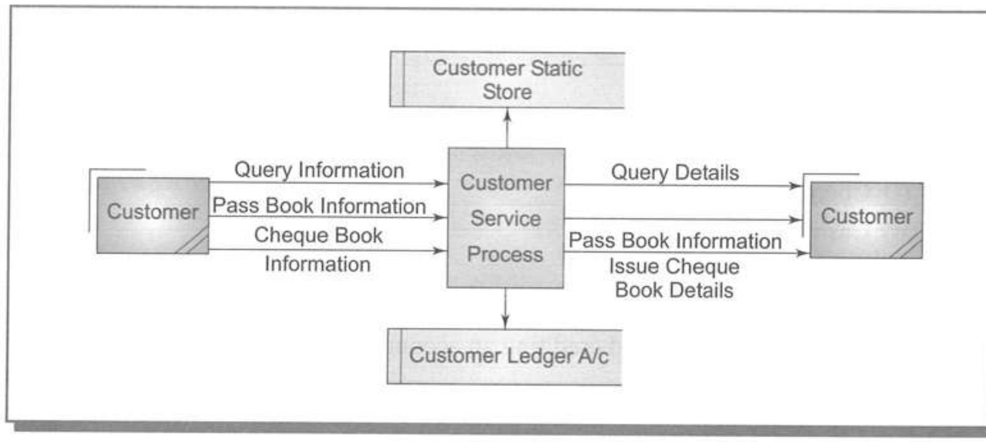

Fig. 8 Process of Customer Service

5. Opening and Closing of Account

The benefits of such a phase-by-phase computerisation are manifold. Some of these benefits are:

(i) No additional recruitment of specialised staff
(ii) Less resistance to computers by employees
(iii) No layoffs
(iv) Is economically feasible
(v) Limitations and faults in one phase will serve as a benchmark for the next phase
(vi) Additional computerisation can be detailed and the pace can be increased if suitable
(vii) It is easy to correct, improve and implement each phase.

However, it should be noted that certain deadlines should be set for the balance phases, as computerisation of a small portion of the work, say savings account will prove to be very expensive. This is because certain fixed costs will have to be incurred when the first phase is implemented. For example, investment in air conditioners, UPS, special work areas, etc., are a one-time expense.

It should also be noted that each phase should be designed keeping in view the whole system and not just the phase under study to facilitate smooth integration of each phase.

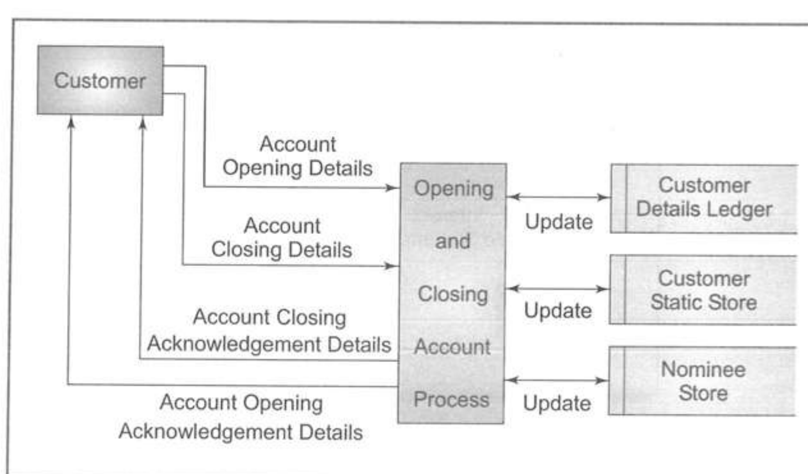

Fig. 9 Opening and Closing of Account

DATABASE DESIGN

In this part of the project, a database for the system is required to be developed. The database server several purposes – it removes redundancy, inconsistency, etc. The errors it removes are explained below.

(i) *Security:* Not all users have access to all the data. Only selected people may be given access to certain data, while some data, may be available to all.

(ii) *Redundancy:* Since all data is centralised, redundancy is reduced. All redundancy should not necessarily be eliminated but should be controlled.

(iii) *Inconsistency:* When data occurs at more than one place, there may be some occasions on which they do not agree. Such inconsistencies can be removed/reduced by reducing redundancy.

(iv) *Integrity:* The problem of integrity is the problem of ensuring that the data in the database is accurate. Inconsistency between two entries representing the same 'fact' is an example of lack of integrity.

Database design has been given in Exhibit.

ENTITY-RELATIONSHIP

Entity-relationship model of data is an informal data, model. This model is not a data model that has been used in definition languages, although it is closely related to some of these models. The relationship model does an adequate but imperfect job of modelling real world situations where database systems are likely to be used.

An entity is anything that exists and is distinguishable, i.e we can distinguish one entity from another. A group of similar entities form an entity set. Entities have properties, called attributes, which associate a value from a domain of values for that particular attribute in an entity set. An attribute whose values uniquely identify each entity in an entity set is called a key for that entity set.

A relationship among entity sets is simply an ordered list of entity sets. A particular entity set may appear more than once on a list.

In entity-relationship diagrams,

(i) rectangles represent entity sets.

(ii) circles represent attributes. They are linked to entity sets by edges.

(iii) Diamonds represent relationships. They are linked to their constituent entity sets by edges.

ENTITIES

CUSTOMER

Name	CHAR (20)
Address	CHAR (40)
Father's Name	CHAR (20)
Telephone	NUMERIC (9)
Occupation	CHAR (15)
Date of Birth	DATE (DD/MM/YY)

(Note: underscore indicates primary key)

ACCOUNT OPEN

Account No.	NUMERIC (5)
Operating Instructions	CHAR (50)
Mode of Signature	CHAR (10)
Introduced by	CHAR (30)
Date	DATE (DD/MM/YY)
Amount	NUMERIC (10)
Stop Payment Instructions	CHAR (50)

ACCOUNT TYPE

Type	CHAR (8)

CHEQUE BOOK

Serial No.	NUMERIC (7)

CASH SCROLL

Date	DATE (DD/MM/YY)
Serial No.	NUMERIC (4)
Particulars	CHAR (20)
Amount	NUMERIC (10)

TRANSFER SCROLL

Date	DATE (DD/MM/YY)
Serial No.	NUMERIC (10)

Particulars	CHAR (20)
Amount	NUMERIC (10)
Bank Name	CHAR (30)

CLEARING SCROLL

Date	DATE (DD/MM/YY)
Cheque No.	NUMERIC (20)
Particulars	CHAR (20)
Bank Name	CHAR (30)
Amount	NUMERIC (10)

EMPLOYEE

<u>Code</u>	NUMERIC (7)
Designation	CHAR (20)
Salary	NUMERIC (5)
Qualification	CHAR (20)

NOMINEE

Name	CHAR (20)
Address	CHAR (40)
Relationship	CHAR (20)
Date of Birth	DATE (MM/DD/YY)
<u>Witness Name</u>	CHAR (20)
Witness Address	CHAR (20)

CUSTOMER ACCOUNT LEDGER

Ledger Folio No.	NUMERIC (6)
Date	DATE (MM/DD/YY)
Particulars	CHAR (20)
Debit	NUMERIC (10)
Credit	NUMERIC (10)
Balance	NUMERIC (10)
No. of Months	NUMERIC (12)
Product	NUMERIC (7)
Interest	NUMERIC (10)

CASH BOOK

Date	DATE (MM/DD/YY)
Voucher No.	NUMERIC (7)
Particulars	CHAR (7)
Debit	NUMERIC (10)
Credit	NUMERIC (10)
Balance	NUMERIC (10)

ACCOUNT CLOSE

Date	DATE (MM/DD/YY)
<u>Account No.</u>	NUMERIC (5)
Reasons for Closing	CHAR (50)
Mode of Payment	CHAR (10)

RELATIONSHIPS

Opens

One-one relationship between CUSTOMER and ACCOUNT OPEN. It indicates what account number is assigned to a customer.

Entered In

One-one relationship from customer and ACCOUNT OPEN to CUSTOMER ACCOUNT LEDGER. It indicates what ledger-folio number is assigned to the account number of a customer.

Issue

One-one relationship from CHEQUE BOOK to ACCOUNT OPEN. It indicates the serial number of the cheque book assigned to account.

Is Of

One-one relationship between ACCOUNT OPEN and ACCOUNT TYPE. The type of account is indicated.

Nomination

Many-one relationship between NOMINEE and ACCOUNT OPEN. The successor is nominated by customer for his deposit in the account.

Transaction

Between CUSTOMER, CASH BOOK and CUSTOMER ACCOUNT LEDGER. It shows the transactions being performed by a customer on his account. The entry is made in both CUSTOMER ACCOUNT LEDGER and CASH BOOK.

By Cash

One-one from CASH BOOK to CASH SCROLL. The cash transactions for a day are selected from CASH BOOK and recorded in CASH SCROLL.

By Transfer

One-one from CASH BOOK to TRANSFER SCROLL. The transactions by draft for the day are selected from CASH BOOK and recorded in TRANSFER SCROLL.

By Clearing

One-one from CASH BOOK to CLEARING SCROLL. The transactions by cheque for the day are selected from CASH BOOK and recorded in CLEARING SCROLL.

Closes

One-one from CUSTOMER, ACC-OPEN, CUST-ACC-LEDGER to ACC-CLOSE. The customer details and remaining balance are related. The closing of account entry is made in ACC-CLOSE register. Entity Relationship Diagram has been shown in Fig. 10.

Exhibit 1 Structure for database: **custdet.dbf**

Field	*Field Name*	*Type*	*Width*	*Dec*
01.	ACNO	Numeric	5	
02.	NAME	Character	20	
03.	ADDRESS	Character	40	
04.	FNAME	Character	20	
05.	TELEPHONE	Numeric	10	
06.	OCCUPATION	Character	15	
07.	DOB	Date	8	
08.	INTRODUCER	Character	30	
09.	AMOUNT	Numeric	10	2
10.	OP_MODE	Character	1	
11.	ACC_DATE	Date	8	
12.	NOMINEE	Character	20	
13.	NADD	Character	20	
14.	RELSHIP	Character	10	
15.	NDOB	Date	8	
16.	WITNAME	Character	20	
17.	WITADD	Character	40	

Structure for database: **clo_acc.dbf**				
Field	*Field Name*	*Type*	*Width*	*Dec*
01.	ACNO	Numeric	5	
02.	DATE	Date	8	
03.	REASON	Character	20	

Structure for database: **stdinst.dbf**				
Field	*Field Name*	*Type*	*Width*	*Dec*
01.	ACNO	Numeric	5	
02.	TACNO	Numeric	5	
03.	AMOUNT	Numeric	10	
04.	DONE	Character	1	
05.	DATE	Date	8	

Structure for database: **savings.dbf**				
Field	*Field Name*	*Type*	*Width*	*Dec*
01.	ACNO	Numeric	5	
02.	DEBIT	Numeric	10	2
03.	CREDIT	Numeric	10	2
04.	MINIMUM	Numeric	10	2

Structure for database: **cash.dbf**				
Field	*Field Name*	*Type*	*Width*	*Dec*
01.	ACNO	Numeric	5	
02.	VNO	Character	20	
03.	DATE	Date	8	
04.	TYPE	Character	1	
05.	AMOUNT	Numeric	10	2

Structure for database: **cheque.dbf**				
Field	*Field Name*	*Type*	*Width*	*Dec*
01.	ACNO	Numeric	5	
02.	CHNO	Character	20	
03.	DATE	Date	8	
04.	TYPE	Character	1	
05.	CHARGES	Numeric	10	2
06.	AMOUNT	Numeric	10	2

Structure for database, **draft.dbf**				
Field	*Field Name*	*Type*	*Width*	*Dec*
01.	ACNO	Numeric	5	
02.	DNO	Character	20	
03.	DATE	Date	8	
04.	AMOUNT	Numeric	10	2

Structure for database: **interest.dbf**				
Field	*Field Name*	*Type*	*Width*	*Dec*
01.	ACNO	Numeric	5	
02.	PRODUCT	Numeric	10	2
03.	INTEREST	Numeric	10	2
04.	DATE	Date	8	

QUESTIONS FOR DISCUSSION

1. Identify the limitations of the study.
2. Comment on the methodology adopted by the consultant for studying and designing the system.
3. Design a questionnaire to elicit information requirements from the user. Do you approve of the unstructured interviewing technique adopted by the consultant in this case? If not, why?
4. Suggest networking technology required for linking the branch under study with other branches/offices of the bank.
5. If you are to design the database for the system using other database packages/softwares, how differently will you proceed? Give database structure for each of the package (say Foxpro, Oracle, etc.).

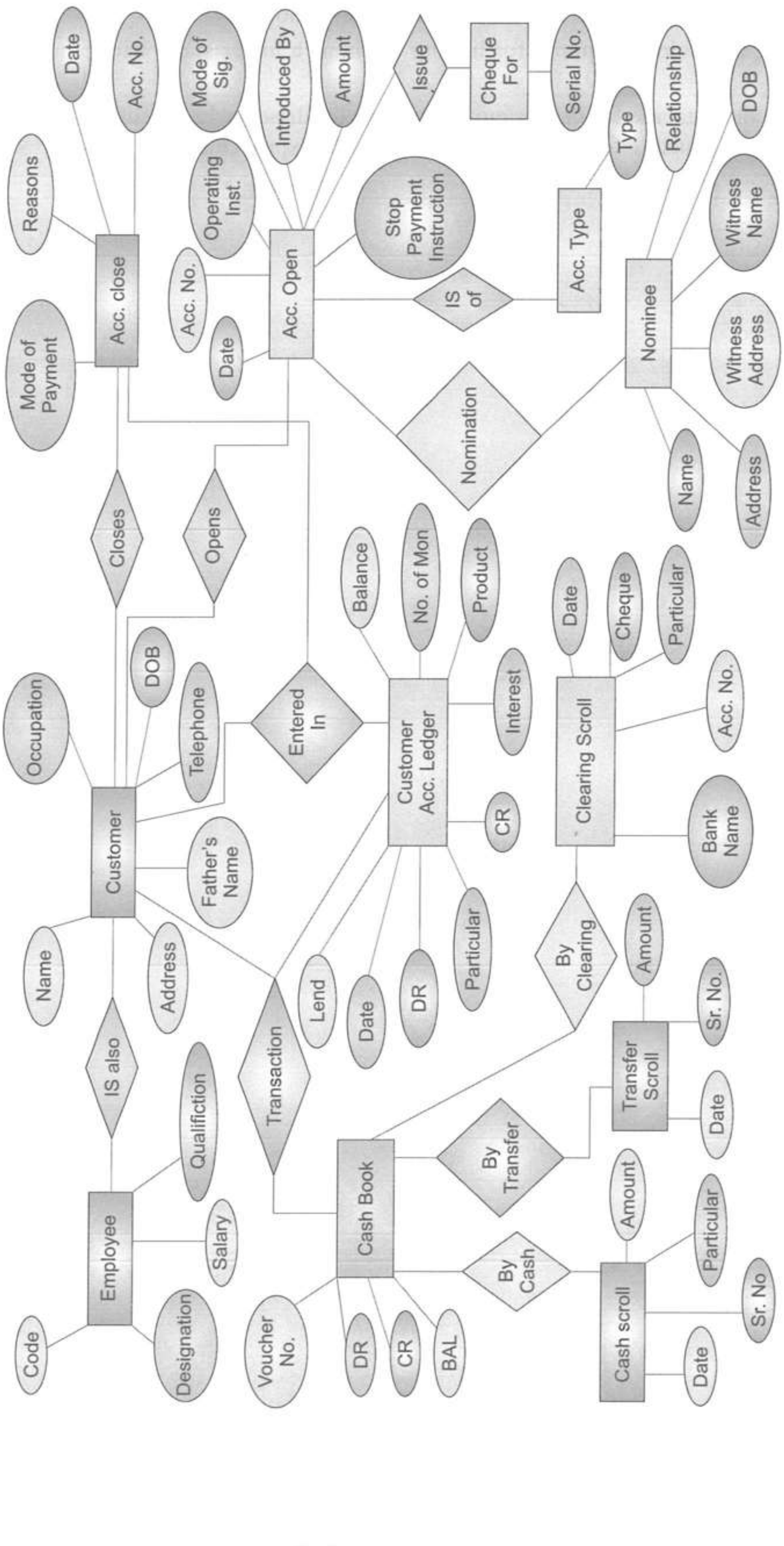

Fig. 10 Entity Relationship Diagram

CASE STUDY 3

PURCHASE ORDER SYSTEM: APPLICATION CASE STUDY

A project to develop a purchase order system in ORACLE 7.0 environment was assigned to a team of six students at a reputed technology institute in India. The main objective of the project was to expose the students to the entire methodology of development under the RDBMS environment. The project was carried out as discussed below.

The first stage was to analyse the manual system. During the DESIGN stage, each entity and all its corresponding attributes were identified. Based on their interdependencies, relations normalized up to the third normal form were derived. Besides the design of these relations/tables, the design of the entire application was planned. The application was to consist of indent processing, enquiry generation, quotation processing, generating comparative statements and approving quotations, order placement and supplier selection. All these tasks were divided amongst the six persons, with two persons working on one option at a time and each pair taking up two options. The design was completed in one month.

Having decided upon the application design, the actual coding was done using SQL FORMS, SQL MENU, SQL REPORT WRITER and PL SQL. Some additional features of ORACLE 7.0, namely database triggers and specifying integrity constraints at the definition level were used. This task of coding was also accomplished using the same stratergy of six persons working in pairs with each pair taking up two or three options. The modules developed individually were then interlinked. Test data was prepared and the entire system was tested. Coding and testing was completed in a time span of one and a half months.

The whole system was developed in nearly three and a half months, i.e. it required around twenty-one persons a month to complete the system.

INTRODUCTION

A purchase order system typically consists of the following components:

(i) Raising indents
(ii) Selecting suppliers
(iii) Sending enquiries
(iv) Processing quotations
(v) Generating comparative statements
(vi) Placing orders
(vii) Awarding rate contract/proprietary item.

Functionality Description

The purchase order system designe contains two main master files.

(i) Supplier Master
(ii) Item Master.

The supplier master has all the details of the suppliers. The primary key for this table is the 'supplier-code' which is a unique code given by the system to each supplier of the purchase order system.

The item master has all the details of the items. This table has two indicators. One indicates whether the goods are capital goods and the other indicates if there is a rate contract valid for this item.

These two master tables are linked with each other through a relation 'Item Supplier' which links a particular supplier to the items he supplies, and vice-versa.

As indents are generated, they are stored in two tables:

(i) Indent Master

(ii) Indent Item.

Indent master is a master table for all the indents generated. It contains the indent level details of all the indents received. The primary key for this table is the concatenation of 'Indent Department Code', 'Indent Year', 'Indent Serial Number'.

The item-level details of the indents are stored in indent item. The primary key for this table is the concatenation of the primary key of indent master, 'Item group code' and 'Item code'. This table gives the details of the different items in an indent, like the required quantity and the state up to which the indent of a particular item has reached (status).

It also has a field that indicates whether this particular indent item was purchased in cash.

If the cash purchase indicator is set then an entry in 'Cash Purchase' table is made. This table gives the detail of the cash purchase.

If the item in the indent is a capital good then an entry in the 'Capital Sanction' table is made. This table has the date and description of the capital sanction.

The item-level details of the enquiry, quotation, order are placed in 'Enquiry Item'. This table has an indicator for the approved quotation from which one can know if a particular quotation was approved. Like enquiry master, this table also has a 'change indicator'.

The enquiry and indents are linked with each other through a relation 'Enquiry Indent Item'.

If there is a rate contract for an item with a supplier then details like the indent and enquiry are divided into two parts and stored in 'Rate Contract Master' and the 'Rate Contract Item'. The 'Rate Contract Item' also acts as a link between the item and the supplier with which the rate contract is executed.

The order delivery details are stored in the 'Order Item' table. This table gives the details about the installments and the quantity received for that particular item order.

The enquiry, just like the indent, is divided into two parts. 'Enquiry Master' contains all the enquiry-level details. The enquiry item-level details are stored in a separate table called 'Enquiry Item'.

An enquiry is generated for a batch of indents and is unique for each and every supplier. Each enquiry is given a unique code generated by the system. This 'Enquiry Code' is the primary key for 'Enquiry Master'. 'Enquiry Master' has a 'change indicator', which is set to show if there is a change in the enquiry or quotation or order. If a change occurs, then an entry is put in the change table.

SCHEMA DESIGN

The following 3NF tables are created and used in the system.

```
CREATE TABLE ITEM_MASTER          (
CONSTRAINT pk_item_master         PRIMARY KEY (item_group_code, item_code),
ITEM_GROUP_CODE                   NUMBER (3),
ITEM_CODE                         NUMBER (6),
ITEM_DESCRIPTION                  VARCHAR2 (240) NOT NULL,
ITEM_TYPE                         VARCHAR2 (1),
ITEM_CLASS                        VARCHAR2 (1),
PROCESS_DATE                      DATE,
UNIT_OF_MEASUREMENT               VARCHAR2 (6),
CAPITAL_GOOD_INDICATOR            VARCHAR2 (1))
CREATE TABLE SUPP_MASTER          (
```

```
CONSTRAINT pk_supp_mas          PRIMARY KEY (supp_code),
SUPP_CODE                       NUMBER (6),
SUPP_PROC_DATE                  DATE,
SUPP_ADDRESS                    VARCHAR2 (120),
SUPP_PINCODE                    CHAR (6),
SUPP_OUT_STATE_IND              CHAR (1),
SUPP_MFG_IND                    CHAR (1),
SUPP_NAME                       VARCHAR2(40),
SUPP_PHONE_STD                  NUMBER (8),
SUPP_PHONE_NO                   VARCHAR2 (15),
SUPP_TELEX                      VARCHAR2 (13),
SUPP_TELEGRAM                   VARCHAR2 (12),
SUPP_FAXNUMBER                  VARCHAR2 (12),
SUPP_TAX_REGNO                  VARCHAR2 (30),
SUPP_MGMT_RATING                NUMBER (1),
SUPP_TOT_RATING                 NUMBER (1),
SUPP_VAL_LIMIT                  NUMBER (10),
SUPP_STATUS                     CHAR(1),
SUPP_REGISTER_IND               CHAR(1),
SUPP_REGISTER_DATE              DATE,
SUPP_CLASS_IND                  CHAR(1),
SUPP_STAT_CHADATE               DATE,

CREATE TABLE INDENT_MASTER      (
CONSTRAINT pk_ind_mas           PRIMARY KEY (indent_department_code, indent_year,
                                indent_serial_number),
INDENT_DEPARTMENT_CODE          NUMBER (3),
INDENT_YEAR                     NUMBER (2),
INDENT_SERIAL_NUMBER            NUMBER (4),
INDENT_DATE                     DATE,
INDENT_PROCESS_DATE             DATE DEFAULT SYSDATE,
INDENT_TYPE                     VARCHAR2 (1),
INDENT_RECEIVED_DATE            DATE)

CREATE TABLE INDENT_ITEM        (
CONSTRAINT pk_ind_item          PRIMARY KEY (indent_department_code,
                                indent_year, indent_serial_number,
                                indent_item_group_code, indent_item_code),
CONSTRAINT fk_indit_ind         FOREIGN KEY (indent_department_code,
                                indent_year, indent_serial_number)
                                REFERENCES indent_master
                                (indent_department_code, indent_year,
                                indent_serial_number),
CONSTRAINT fk_indit_item            FOREIGN KEY (indent_item_group_code,
                                    indent_item_code)
```

```
                                         REFERENCES item_master
                                         (item_group_code, item_code),
INDENT_DEPARTMENT_CODE                   NUMBER (2),
INDENT_YEAR                              NUMBER (2),
INDENT_SERIAL_NUMBER                     NUMBER (4),
INDENT_ITEM_GROUP_CODE                   CHAR(3),
INDENT_ITEM_CODE                         CHAR (6),
INDENT_ITEM_DESCRIPTION                  VARCHAR2 (240) NOT NULL,
UNIT_OF_MEASUREMENT                      VARCHAR2 (6),
INDENT_REQUIRED_ITEM_QUANTITY            NUMBER (6, 2) NOT NULL,
INDENT_ESTIMATED_VALUE                   NUMBER (8, 2) NOT NULL,
INDENT_REQUIRED_DELIVERY_DATE            DATE
INDENT_REASON_CODE                       VARCHAR2 (2),
INDENT_ITEM_MAKE_DESCRIPTION             VARCHAR2 (10),
INDENT_MMD_INITIAL                       VARCHAR2 (3),
INDENT_COMP_STAT_NUMBER                  NUMBER (5),
INDENT_COMP_STAT_DATE                    DATE,
INDENT_ITEM_STATUS                       CHAR (1),
INDENT_STATUS_DATE                       DATE,
CASH_PURCHASE_INDENTICATOR               VARCHAR2 (1))

CREATE TABLE RC_MASTER                   (
CONSTRAINT pk_rc_master                  PRIMARY KEY (supp_code),
SUPP_CODE                                NUMBER (6),
                                         REFERENCES supp_master (supp_code),
RC_DATE                                  DATE,
R_P_IND                                  CHAR (1),
RC_PROCESS_DATE                          DATE,
RC_VAL_DATE                              DATE,
RC_TENDER_DATE                           DATE,
RC_TENDER_REF_NO                         CHAR (6),
APPROVAL_REF                             CHAR (8),
APPR_DATE                                DATE,
ED_PAY_CODE                              CHAR (1),
ED_AMT                                   NUMBER (5, 2),
ADD_ED_PAY_CODE                          CHAR (1),
ADD_ED_AMT                               NUMBER (5, 2),
CST_PAY_CODE                             CHAR (1),
CST_AMT                                  NUMBER (5, 2),
SST_PAY_CODE                             CHAR (1),
SST_AMT                                  NUMBER (5, 2),
ADD_SST_PAY_CODE                         CHAR (1),
ADD_SST_AMT                              NUMBER (5, 2),
OCTROI_PAY_CODE                          CHAR (1),
OCTROI_AMT                               NUMBER (5, 2),
```

```
PF_PAY_CODE                  CHAR (1),
PF_AMT                       NUMBER (5, 2),
FRT_PAY_CODE                 CHAR (1),
FRT_AMT                      NUMBER (5, 2),
MISC_PAY_CODE                CHAR (1),
MISC_AMT                     NUMBER (5, 2),
DELV_CODE                    CHAR (1),
DELV_DEST                    VARCHAR2 (20),
ADV_PAY_PC                   NUMBER (3),
ADV_PAY_DUE_DATE             DATE,
ONBILL_PAY_PC                NUMBER (3),
ONBILL PAY DUE DATE          DATE,
GOODS_RCD_PC                 NUMBER (3),
GOODS_RCD_DUE_DATE           DATE)

CREATE TABLE RC_ITEM         (
CONSTRAINT pk_rc_item        PRIMARY KEY (item_grp_code, supp_code,
                             item_code)
CONSTRAINT fk_rc_itgrp       FOREIGN KEY (item_grp_code, item_code)
                             REFERENCES item_master
                             (item_group_code, item_code),
SUPPLIER_CODE                NUMBER (6) REFERENCES rc_mast (supp_code),
ITEM_GRP_CODE                NUMBER (3) NOT NULL,
ITEM_CODE                    NUMBER (6) NOT NULL,
ITEM_MAKE_DESC               VARCHAR2 (10),
RC_QTY_ORD                   NUMBER (10, 2),
RC_QTY_CONT                  NUMBER (10, 2),
RC_VAL_CONT                  NUMBER (10, 2),
RC_VAL_ORD                   NUMBER (10, 2),
RC_UNIT_RATE                 NUMBER (8, 2),
SALES_TAX_CODE               CHAR (1),
SALES_TAX_PC_CODE            CHAR (1),
SALES_TAX_AMT                NUMBER (5,2),
ED_CODE                      CHAR (1),
ED_PC_CODE                   CHAR (1),
ED_AMT                       NUMBER (5,2),
DISCOUNT_PC_CODE             CHAR (1),
DISCOUNT_AMT                 NUMBER (4,2))

CREATE TABLE ITEM_SUPP       (
CONSTRAINT pk_tem_supp       PRIMARY KEY (item_grp_code, item_code,
                             supp_code),
CONSTRAINT fk_itemsupp_item  FOREIGN KEY (item_grp_code, item_code)
                             REFERENCES item_master
```

```
                                      (item_group_code, item_code),
CONSTRAINT fk_itemsupp_supp           FOREIGN KEY (supp_code)
                                      REFERENCES supp_master (supp_code),
ITEM_GRP_CODE                         NUMBER (3),
ITEM_CODE                             NUMBER (6),
SUPP_CODE                             NUMBER (6))

CREATE TABLE GRP_SUPP                 (
CONSTRAINT pk_grp_supp                PRIMARY KEY (grp_code, supp_code),
CONSTRAINT fk_grpsupp_grp             FOREIGN KEY (grp_code)
                                      REFERENCES grp_table (grp_code),
CONSTRAINT fk_grpsupp_supp            FOREIGN KEY (supp_code)
                                      REFERENCES supp_master (supp_code),
GRP_CODE                              NUMBER (3),
SUPP_CODE                             NUMBER (6))

CREATE TABLE GRP_TABLE                (
CONSTAINT pk_grp_table                PRIMARY KEY (grp_code),
GRP_CODE                              NUMBER (3),
GRP_DESC                              CHAR (25) NOT NULL,
PROCESS_DATE                          DATE,
ADM_LEAD_TIME                         CHAR (10),
MANU_LEAD_TIME                        CHAR (10),
TRANSP_LEAD_TIME                      CHAR (10))

CREATE TABLE CAPITAL_SANC             (
CONTRAINT pk_cap_sanc                 PRIMARY KEY (indent_department_code,
                                      indent_year, indent_serial_number,
                                      item_grp_code, item_code),
CONSTRAINT fk_cap_sanc_ind            FOREIGN KEY (indent_department_code,
                                      indent_year, indent_serial_number)
                                      REFERENCES indent_master
                                      (indent_department_code, indent_year,
                                      indent_serial_number),
CONSTRAINT fk_cap_sanc_it             FOREIGN KEY (indent_item_group_code,
                                      indent_item_code)
                                      REFERENCES item_master
                                      (item_group_code, item_code),
INDENT_DEPARTMENT_CODE                NUMBER (3),
INDENT_YEAR                           NUMBER (2),
INDENT_SERIAL_NUMBER                  NUMBER (4),
INDENT_ITEM_GROUP_CODE                NUMBER (3),
INDENT_ITEM_CODE                      NUMBER (6),
CAPITAL_SANC                          VARCHAR2 (15),
CAPITAL_SANC_DATE                     DATE)
```

CREATE TABLE CASH_PURCHASE	(
CONSTRAINT pk_cap_sanc	PRIMARY KEY (indent_department_code, indent_year, indent_serial_number, item_grp_code, item_code),
CONSTRAINT fk_cap_sanc_ind	FOREIGN KEY (indent_department_code, indent_year, indent_serial_number) REFERENCES indent_master (indent_department_code, indent_year, indent_serial_number),
CONSTRAINT fk_cap_sanc_it	FOREIGN KEY (indent_item_group_code, indent_item_code) REFERENCES item_master (item_group_code, item_code),
INDENT_DEPARTMENT_CODE	NUMBER (3),
INDENT_YEAR	NUMBER (2),
INDENT_SERIAL_NUMBER	NUMBER (4),
INDENT_ITEM_GROUP_CODE	NUMBER (3),
INDENT_ITEM_CODE	NUMBER (6),
CASH_PURCHASE_DR	NUMBER (5, 2),
CASH_PURCHASE_CR	NUMBER (5, 2),
CASH_PURCHASE_AMT	NUMBER (5, 2),
CP_6631_6632_IND	NUMBER (1))

CREATE TABLE ITEM_INFO	(
CONSTRAINT pk_item_info	PRIMARY KEY (item_grp_code, item_code),
CONSTRAINT fk_item_info	FOREIGN KEY (item_grp_code, item_code) REFERENCES item_master (item_group_code, item_code),
ITEM_GRP_CODE	NUMBER (3),
ITEM_CODE	NUMBER (6),
NO_OF_INDENT	NUMBER (3),
NO_OF_ENQUIRY	NUMBER (3),
NO_OF_QUOTATION	NUMBER (3),
NO_OF_ORDER	NUMBER (3))

CREATE TABLE LAST_3_ORDER	(
CONSTRAINT pk_last_3_order	PRIMARY KEY (item_grp_code, item_code),
CONSTRAINT fk_last_3_order	FOREIGN KEY (item_grp_code, item_code) REFERENCES item_master (item_group_code, item_code),
ITEM_GRP_CODE	NUMBER (3),
ITEM_CODE	NUMBER (6),
LAST_ORDER	NUMBER (8),
SECOND_LAST_ORDER	NUMBER (8),
THIRD_LAST_ORDER	NUMBER (8))

DETAILED MODULE DESIGN

Indent

Indent Operations

The following operations are performed on indents:

(i) Fresh Data Entry of Indents

Form used: INDENT_A

Tables used: INDENT_MASTER, INDENT_ITEM, ITEM_MASTER, CASH_PUR, CAP_SANC

Data entry of the indent is done through form INDENT_A. An indent is raised by the department. There can be several items in an indent. It can be of type Normal, Rate Contract, Proprietary or Repeat. For each indent there is an indent code which consists of department code, indent year and indent serial number.

The type of the indent and the item type should be compatible, i.e. if the indent is of the normal type, then the items in that indent can be normal, repeat, rate contract or proprietary. But if the indent is rate contract then all the items in this indent should be of the type rate contract (there should exist a rate contract with suppliers for the respective items).

Each item has a group code and an item code. Indent for a new item can also be raised, but the supplier for the group of the new item should exist. The supplier to this item is linked through the supplier item linkage option before the enquiry is sent.

The item description and units can be changed for that indent. If the item is purchased in cash then the cash purchase details are required. If the item is capital sanction then the capital sanction details are required.

The data from this form is inserted into tables INDENT_MASTER, INDENT_ITEM (item details), CASH_PUR (cash purchase details), CAP_SANC (capital sanction details) and in ITEM_MASTER if the item is new. The item status is set to 'T' in the INDENT_ITEM.

(ii) Insertion of Item in an Indent

Form used: INDENT_I

Table used: INDENT_MASTER, INDENT_ITEM, ITEM_MASTER, CASH_PUR, CAP_SANC

More items can be inserted in previously raised indents. The indent code is to be entered by the user and if the enquiry for that indent has not been sent then the indent details are automatically displayed on the screen. Data entry of the inserted items are treated exactly like fresh data entry.

(iii) Modification of Item in an Indent

Form used: INDENT_M

Table used: INDENT_MASTER, INDENT_ITEM, ITEM_MASTER, CASH_PUR, CAP_SANC

The indent code is to be entered by the user and if the enquiry for that indent has not been sent then the indent details are automatically displayed on the screen. The item code and group code are entered and the item details are displayed on the screen. Any field such as rate, quantity, etc., can be modified by the user.

The modified data from this form is updated into tables INDENT_ITEM, CASH_PUR and CAP_SANC.

(iv) Deletion of Item from an Indent

Form used: INDENT_D

Tables used: INDENT_MASTER, INDENT_ITEM, ITEM_MASTER, CAP_SANC

A complete indent or a particular item from the indent can be deleted.

To delete the whole indent, enter the indent code. The indent would be deleted if the enquiry has not been sent. To delete items from the indent, enter the indent code, group code and item code.

The tuple corresponding to that indent code and item code is deleted from INDENT_ITEM, CASH_PUR, CAP_SANC tables in case an item is deleted. If the whole indent is deleted, the tuple corresponding to that indent code is deleted.

Edit

This option prints report of all indents raised through the first option.

(i) Supplier Selection/Enquiry Generation

Form used: REMARKS
Procedure used: ENQ
Tables used: INDENT_MASTER, INDENT_ITEM, ITEM_MASTER, ITEM_SUPP, SUPP_MASTER, ENQ_MASTER, ENQ_IND_ITEM, ENQ_ITEM, REMARKS

This form is used to accept the due date and remarks for enquiries which have to be sent immediately. Both the things are stored in the table 'REMARKS'.

The procedure selects 10 suppliers from ITEM_SUPP for each item separately for which item status in INDENT_ITEM is 'I'. But for these items, the indent type in INDENT_MASTER must be 'N' (normal). The status of each selected supplier must not be 'B' (blacklisted) or 'D' (deleted). This procedure also selects other details related to the selected suppliers. It reads the maximum enquiry number from ENQ_MASTER. If the first four digits of the enquiry number (enquiry year) are the same as the current year, then the new enquiry number would be one plus the previous, otherwise the new number would be the current year, followed by six zeroes.

Now for each unique enquiry, numbers are generated according to the above-mentioned rule, and all the related details are stored in ENQ_MASTER, ENQ_IND_ITEM and ENQ_ITEM tables. Item status in INDENT_ITEM will be updated to 'E'.

(ii) Printing of Enquiries

This option prints different reports related to the generated enquiries. These reports are:

1. PFl: This report prints the detail of enquiries generated for each selected supplier on pre-printed stationary.
2. PF2: This report prints a supplier-wise list of enquiries floated as on the date, with details like the indent number (department code, year, serial number), item code, group code, description, quantity, unit, supplier and enquiry numbers.
3. PF3: This report prints an item-wise list of enquiries floated as on the date with details like indent number, item code, item description, unit, quantity, supplier and enquiry numbers.
4. PF4: This report prints a summary of enquiries raised in the lot with details like process date, indent number and enquiry number.
5. PF5: This report prints an item-wise list of enquiries floated as on the date with details like indent number, item code, item description, unit, quantity, supplier and enquiry numbers.
6. PF6: This report prints a list of suppliers with addresses to whom the enquiries are sent.

Quotations

Quotation Data Entry

Quotations sent by the suppliers are processed in this option, the main operations are:

(i) Fresh Data Entry of Quotations

Form used: QUOT

Table used: ENQ_MASTER, ENQ_ITEM, ENQ_IND_ITEM,
SUPP_MASTER, INDENT_ITEM

This form is used for the data entry of quotations. The quotations are sent by suppliers in response to an enquiry.

The entire quotation can be regretted or a specified item can be regretted. If an entire quotation is regretted, the same may be entered as 'R' in the regret indicator field. All items under that enquiry are regretted for that party. In case an item under that quotation is regretted, the same can be entered in the item_details.

The item description in the quotation sometimes varies from that in the enquiry. The deviation indicator can represent the deviation from the original description. A party can send a changed quotation three times and that too before the quotation has been approved. The field 'change quot' indicates the number of times the party has sent its quotation. It can have values 0, 1, 2 and after a value of 2, no more changes in the quotation are acceptable. The data is inserted in ENQ_MASTER and ENQ_ITEM tables. The item status in the INDENT_ITEM table is now changed to 'Q'.

(ii) Modification of Quotations

Modifications are valid until the quotation is not approved. The main operations are:

1. INSERTION
   (a) QUOTATION INSERTION:
   This is the same as fresh data entry of quotations.
   (b) ITEM INSERTION:
   Form used: QUOT_ITEM_ADD
   Table used: ENQ_MASTER, ENQ_ITEM, ENQ_IND_ITEM,
   SUPP_MASTER, INDENT_ITEM
   Report Generated: QUOT_REP
   This form is used for entering, in the quotation, the items that already exists. The enquiry number corresponding to that quotation has to be entered in which the item is to be inserted. Other details of the quotation are displayed automatically. The item details entered are inserted into the table ENQ_ITEM.
2. DELETION
   (a) QUOTATION DELETION:
   Form used: QUOT_DEL
   Table used: ENQ_MASTER, ENQ_ITEM, ENQ_IND_ITEM,
   SUPP_MASTER, INDENT_ITEM
   Report Generated: QUOT_REP
   This form is used for quotation deletion. The user can delete a quotation that has not been approved. The user has to enter the enquiry number corresponding to the quotation to be deleted. All other details are displayed automatically on the screen. The following prompt is displayed and the answer to it is accepted:
   'Do you want to delete this quotation?'.
   If 'Y' is pressed, the quotation is deleted from the table
   ENQ_MASTER along with its item details in table ENQ_ITEM.
   (b) ITEM DELETION:
   Form used: QUOT_ITEM_DEL
   Table used: ENQ_MASTER, ENQ_ITEM, ENQ_IND_ITEM,
   SUPP_MASTER, INDENT_ITEM

Report Generated: QUOT_REP

This form is used for the deletion of some items from a quotation. The user can delete an item from a quotation has not been approved. The user has to enter the enquiry number corresponding to the quotation from which the item is to be deleted. Next, the user enters the item group code and item code of the item to be deleted. All other details of this item are automatically displayed on the screen. The following prompt is displayed and the answer to it is accepted.

'Do you want to delete this item?'

If 'Y' is pressed, this item is deleted from the table ENQ_ITEM.

3. UPDATION

Form used: QUOT_UPDT

Table used: ENQ_MASTER, ENQ_ITEM,

ENQ_IND_ITEM, SUPP_MASTER,

INDENT_ITEM

Report Generated: QUOT_REP

This form is used to modify the quotation that is already present. The user cannot modify the quotation which has been approved. The user has to enter the enquiry number corresponding to the quotation to be modified. All details of this form are displayed automatically on the screen. The user can modify any field and the changes go to the tables ENQ_MASTER and ENQ_ITEM.

Edit

A report is generated in the option where it prints all the quotations that are entered for that particular day.

Comparative Statement

Report Generated: COMP_STMT

Tables used: INDENT_ITEM, LAST_3_ORDER, ENQ_MASTER,

SUPP_MASTER, ITEM_MASTER, ENQ_ITEM

A comparative statement is generated after the data entry of the received quotations. The comparative statement number is generated by incrementing the previous comparative statement number by 1. This is accomplished by using a 'sequence'.

The comparative statement consists of an item_wise list of all parties quoted. The comparative statement is a summary of all the quotations. Even if a quotation is not received from a supplier to whom an enquiry was sent or if it is regretted, the same appears in the comparative statement. The comparative statement displays the indent and item identification. It also consists several last order details of this item in the indent.

The last order details include the order number, quantity, date, supplier name and unit rate of the last order. Further, it consists of details from all quotations sent by the suppliers. These details include the quantity, unit rate, supplier name, excise duty specifications, sales tax and discount specifications, freight specifications, the delivery code and place, terms of advance/on bill/on verification payment, etc.

Approved Quotation

Data Entry of Approved Quotation

Form used: QUOT_APP

Table used: ENQ_MASTER, ENQ_ITEM, INDENT_ITEM

Report generated: QUOT_REP

This form is used for the data entry of an approved quotation. It consists of three fields: enquiry number, item code and item group code. In fact the items are studied manually and approved manually. All items that are approved by the company are entered under this option. Help is provided by showing a list of values in all these three fields. The field approved indicator of the item which has been approved is set to 'A'. The item status field in the table INDENT_ITEM is set to 'A'.

Edit

A report is generated, which gives detailed information of all quotations that have been approved.

Suppliers

Supplier Updation

Form used: SUPP_UPDATE

Tables used: SUPP_MASTER, GRP_SUPP

This form is used to add new suppliers to the SUPP_MASTER table or to update already existing suppliers. In case of addition, supplier code is accepted and that should not be blank or zero. Name, address, pin code, status must be entered. All other details are optional but if entered, they must be valid. This new supplier can be linked to more than one group. Group codes are accepted and these group codes must exist in GRP_TABLE. These group codes and supplier codes are added to GRP_SUPP. In case of deletion, the supplier status is made 'D' (no physical deletion is performed).

Supplier Linkage to Item Updation

Form used: SUPP_LINK

Tables used: ITEM_MASTER, SUPP_MASTER, ITEM_SUPP

This form is used to update, i.e. to add additional suppliers to an item or delete a supplier link to an item. The item must exist in ITEM_MASTER. Blacklisted or deleted suppliers are not considered, i.e. suppliers for whom supplier status is 'B' or 'D' are not linked with an item. In case of deletion, supplier codes are made zero. These are added in the table ITEM_SUPP.

SCREEN LAYOUTS

THE ABC MANUFACTURING CO. LTD

Purchase Order System

1. Indent
2. Enquiry
3. Quotation
4. Comparative Statement
5. Approved Quotation
6. Order Placement
7. Rate Contract/Proprietary
8. Supplier
9. Exit

Enter your choice: 1

MAIN MENU

THE ABC MANUFACTURING CO. LTD
ITEM-WISE CONSOLIDATED STATEMENT OF ENQUIRIES FLOATED
15-MAY-97 DUE ON 20-MAY-97
REMARK: THIS IS A TEST REPORT

Dept	*Year*	*Sr. no.*	*Group Code*	*Item Code*	*Unit*	*Qty.*	*Supp. Code*	*Supplier Name*	*Enquiry Code*
100	97	18	28	60005	NOS	5	910008	National Trader (Ind)	1994000034
							910021	Everest Building Pro	1994000036
151	97	14	1	100100	NOS	10	910504	General Engineers Co.	1994000038
							910602	Hathiwala Company	1994000039
							910902	Kashmir H/W Stores	1994000040
151	97	14	975	387106	NOS	200	910007	Aruna Scientific Co.	1994000033
							910013	Advani Oerlikon Ltd.	1994000035
							910042	Ahmedabad Induction	1994000037
							910504	General Engineers Co.	1994000038

THE ABC MANUFACTURING CO. LTD
SUMMARY OF ENQUIRIES SENT
15-MAY-97 DUE ON 20-MAY-97
REMARK: THIS IS A TEST REPORT

Dept. Code	*Year*	*Sr. No.*	*Enquiry Code*	*Supplier Name*
100	97	18	1994000034	National Traders (India) Ltd
			1994000036	Everest Building Products Ltd
151	97	14	1994000033	Aruna Scientific Co.
			1994000035	Advani Oerlikon Ltd
			1994000037	Ahmedabad Induction Alloys Pvt. td
			1994000038	General Engineers Corporation
			1994000039	Hathiwala Company
			1994000040	Kashmir H/W Stores

THE ABC MANUFACTURING CO. LTD
WPL-WISE CONSOLIDATED STATEMENT OF ENQUIRIES FLOATED
15-MAY-97 DUE ON 20-MAY-97
REMARK: THIS IS A TEST REPORT

Ind Dept Code	*Ind. Yr. Srno.*	*Ind. Code*	*Item Grp.*	*Item Code*	*Reqd.*	*Enq. Code*
100	97	18	28	60005	5	194000034
						194000036
151	97	14	1	100100	10	194000038
						194000039
						194000040
151	97	14	975	387106	200	194000033
						194000035
						194000037
						194000038

THE ABC MANUFACTURING CO. LTD DETAILS OF ENQ. POSTED 15-MAY-97		
1994000033/910007	1994000034/910008	1994000035/91001
Aruna Scientific Co.	National Traders (India) Ltd	Advani Oerlikon
9/32, Purani Basti, Katni	Karamchand Chowk, Jabalpur	Industrial Area, Patiala
483501	482002	492001
1994000036/910021	1994000037/910042	1994000038/9105
Everest Building Products Ltd	Ahmedabad Induction Alloys Pvt. Ltd	General Engineer
Kymore	235/236, G.V.M.M. Estate Odhav Road, Ahmedabad	8/7-8 Civic Centalpur
483880	382410	482002
1994000039/910602	1994000040/910902	
Hathiwala Company	Kashmir H/W Stores	
331 Marhatal, Jabalpur	Gole Bazar, Katni	
482002	483501	

THE ABC MANUFACTURING CO. LTD
Item-wise suppliers list
15-MAY-97

Item Code	*Item Description*	*Units*	*Type*	*Supp. CD*	*Supplier Name*
123			N	910004	AQUA ALLOYS PVT. LTD
12345			N	12334	KK ENGINEERS
387102		kg	N	910504	GENERAL ENGINEERS CO.
				912607	ASHOK & CO.
				910007	ARUNA SCIENTIFIC CO
				910021	EVEREST BUILDING PRO
				910013	ADVANI OERLIKON LTD
				910042	AHMEDABAD INDUCTION
				129454	GOYAL TRADERS
				910008	NATIONAL TRADERS (IND)
325910			N	910504	GENERAL ENGINEERS CO.
				123445	VENUS AGENCIES
				910013	ADVANI OERLIKON LTD
				910008	NATIONAL TRADERS (IND)
				910042	AHMEDABAD INDUCTION
60005	Line Tester with SCR	NOS	N	910008	NATIONAL TRADERS (IND)
				910004	AQUA ALLOYS PVT. LTD
				910021	EVEREST BUILDING PRO
1002			N	123445	VENUS AGENCIES
1004			N	910854	JAI HIND STORES
9999			N	912485	SARAF TRADING COMPANY
				910801	JAGWANI H/W STORES
				910854	JAI HIND STORES
				911128	MUNNALAL PASARI

387106	BAJAJ BULB	NOS	R	910504	GENERAL ENGINEERS CO.
				910004	AQUA ALLOYS PVT. LTD
				910007	ARUNA SCIENTIFIC CO.
				910042	AHMEDABAD INDUCTION
				910013	ADVANI OERLIKON LTD
100		NOS	N	910504	GENERAL ENGINEERS CO.
				910602	HATHIWALA COMPANY
				910801	JAGWANI H/W STORES
				910854	JAI HIND STORES
				910902	KASHMIR H/W STORES
				911128	MUNNALAL PASARI
				911170	MADAN MOHAN VINODKUM
1001		NOS	N	910902	KASHMIR H/W STORES
				911128	MUNNALAL PASARI
				911170	MADAN MOHAN VINODKUM
				911701	TEJWALA ENGINEERING
				912485	SARAF TRADING COMPANY
100100		NOS	N	910902	KASHMIR H/W STORES
				910602	HATHIWALA COMPANY
				910504	GENERAL ENGINEERS CO.
387106			R	910504	GENERAL ENGINEERS CO.
				910004	AQUA ALLOYS PVT. LTD
				910007	ARUNA SCIENTIFIC CO.
				910042	AHMEDABAD INDUCTION
				910013	ADVANI OERLIKON LTD
387102				910504	GENERAL ENGINEERS CO.
					912607 KUMAR IMPEX
				910007	ARUNA SCIENTIFIC CO.

QUESTIONS FOR DISCUSSION

1. Do you think, the team followed the right methodology in developing the purchase order system? Identify the weaknesses of the system.
2. If you were the team leader, how differently would you have worked on the system development?
3. Based on this case study, prepare a brief report on the following aspects.
   (i) What information is missing in this case? and
   (ii) What information is not required in this case?
4. Draw data flow diagrams required to analyse and design the system.
5. To market the system, what price would you like to fix for the system? Give the rationale for fixing the price.
6. Work out the format and contents of the following sample reports.
   (i) Indent Raised
   (ii) Comparative Statement
   (iii) Approved Quotations
   (iv) Quotation Data Entry.

THE ABC MANUFACTURING CO. LTD

Indent

1. Indent Operations
2. Edit
3. Quit

Enter your choice: 1

THE ABC MANUFACTURING CO. LTD

Data Entry of Indent

1. Fresh Data Entry
2. Insertion
3. Modification
4. Deletion
5. Exit

Enter your choice: 1

THE ABC MANUFACTURING CO. LTD

Fresh Data Entry-Indents 13-MAY-97

DEPARTMENT CODE	151	GROUP CODE	28
INDENT YEAR	94	ITEM CODE	6005
INDENT SERIAL NO.	13	ITEM DESCRIPTION	BULB
INDENT TYPE	N	ITEM UNIT	NOS ITEM CLAS A
INDENT DATE	13-MAY-97	REQUIRED QUANTITY	100
RECEIVED DATE	13-MAY-97	ESTIMATED VALUE	10000
PROCESS DATE	13-MAY-97	DELIVERY DATE	15-MAY-97
LAST ORDER NO.	19940001	MAKE DESCRIPTION	PHILIPS
LAST ORDER DATE	10-JAN-97	REASON CODE	OUT OF STOCK
LAST ORDER RATE	100	MMD INITIAL	ABC
CASH PURCHASE DR	8000	CASH PURCHASE	Y
CASH PURCHASE CR	250	CAPITAL GOODS	Y
CASH PURCHASE AMT	500	CAPITAL SANC REF	BANK OF INDIA
CP 6631 6632 IND	1	CAPITAL SANC DATE	10-MAY-97

THE ABC MANUFACTURING CO. LTD

Enquiry

1. Supplier Selection/Enquiry Generation
2. Printing of Enquiries
3. Quit

Enter your choice: 1

10-may-97

THE ABC MANUFACTURING CO. LTD

Enquiry

Please enter the Due Date for enquiries 15-May-97

Do you want to enter remark? Y

THE ABC MANUFACTURING CO. LTD

Quotation

1. Quotation Data Entry
2. Edit
3. Quit

Enter your choice: 1

10-MAY-97

THE ABC MANUFACTURING CO. LTD

Data Entry of Quotation

1. Fresh Data Entry
2. Modification
3. Exit

Enter your choice: 1

THE ABC MANUFACTURING CO. LTD

F4: EXIT — Quotation Data Entry — 14-MAY-97

ENQUIRY CODE	1994000020 C 0	ITEM CODE	60005
QUOTATION NO	ABC-94-20	ITEM GROUP CODE	28
QUOT DATE	14-MAY-97 REGRET	REQUIRED QUANTITY	110
QUOTVALDATE	14-MAY-97 PROCDATE 14-MAY-97	REQD DELI DATE	15-MAY-97
OCTROICODE	1 OCTROIAMT 10	UNIT RATE	20
PF PAY CODE	2 PF AMT 100	SALES TAX CODE	6
FRT PAY CODE	3 FRT AMT 100	SALES TAX PER 1 AMT	10
MISC PAY CODE	4 MISC AMT 100	EXCISE DUTY CODE	2
DELV_CODE	2 DELV_DESTI MUMBAI	EXCISE DUTY PC 2AMT	100_

THE ABC MANUFACTURING CO. LTD

Modification of Quotation

1. Add Quotation
2. Delete Quotation
3. Update Quotation
4. Add Item
5. Delete Item
6. Update Item
7. Exit

Enter your choice: 1

THE ABC MANUFACTURING CO. LTD

Approved Quotation

1. Data Entry
2. Edit
3. Quit

Enter your choice: 1

10-MAY-97

THE ABC MANUFACTURING CO. LTD

Data Entry for Approved Quotations

ENQUIRY CODE	1994000020
ITEM CODE	60005
ITEM GROUP CODE	28

Do You Want to Continue: N

14-MAY-97

THE ABC MANUFACTURING CO. LTD

Order Placement

1. Normal Orders
2. Rate Contract/Proprietary
3. Repeat Orders
4. Exit

Enter your choice: 2

RATE CONTRACT/PROPRIETARY ORDER PLACEMENT — 14-MAY-97

ITEM GROUP CODE	915	SUPPLIER CODE	300000
ITEM CODE	387106	SUPPLIER NAME	JAMNALAL AND CO.
ITEM DESCRIPTION	BULB	MAKE DESCRIP.	PHILIPS
ITEM UNITS	NOS	QTY CONTRACT	500
REQUIRED QUANTITY	200	VALUE CONTRACT	25000
ESTIMATED VALUE	15000	UNIT RATE	50
DELIVERY DATE	20-MAY-97	SALES TAX CODE	1
REASON CODE	OUT OF STOCK	SALES TAX PC CODE	1
MAKE DESCRIPTION	PHILIPS	SALES TAX AMOUNT	10
MMD INITIAL	ABC	EXCISE DUTY CODE	2
CASH PURCHASE IND.	N	EXCISE DUTY PC CODE	10
		EXCISE DUTY AMOUNT	10
ORDER NO	1994000011	DISCOUNT PC CODE	3
		DISCOUNT AMOUNT	5
START DELIVERY DATE	20-MAY-97	END DELIVERY DATE	20-MAY-97
NO OF INSTALMENTS	1 QUANTITY TO ORDER	200	
IS THE DATA CORRECT	Y		

THE ABC MANUFACTURING CO. LTD
Rate Contract/Proprietary
1. Updation
2. Edit
3. Quit
Enter your choice: 1

THE ABC MANUFACTURING CO. LTD
Rate Contract/Proprietary
1. Rate Contract Updation
2. Proprietary Updation
3. Quit
Enter your choice: 1

THE ABC MANUFACTURING CO. LTD
Rate Contract/Proprietary
1. Insert Rate Contract
2. Modify Rate Contract
3. Delete Rate Contract
4. Insert Item in Rate Contract
5. Modify Item in Rate Contract
6. Delete Item in Rate Contract
7. Quit
Enter your choice: 1

THE ABC MANUFACTURING CO. LTD
R.C./Prop. Updation 10-MAY-97

GROUP CODE	1	SUPP. CODE	123445	ITEM CODE
R.C. DT	5-MAY-97	PROCESS DT	10-MAY-97	ITEM MAKE DESC.
P.T. REF	2LTR94	P.T.R. DT.	5-MAY-97	QTY. ORDERED
VALID. DT	10-MAY-97			QTY. CONTRACTED
APPR. REF.	ABCDEF	APPR. DT.	7-MAY-97	VALUE ORDERED
OCTROI PAY CODE	1	AMOUNT	077.0	VALUE CONTRACTED
PACKING PAY CODE	2	AMOUNT	999.0	UNIT RATE
FREIGHT PAY CODE	3	AMOUNT		SALES TAX CODE
MISC. PAY CODE	4	AMOUNT		SALES TAX PAY CODE
ADVANCE PAY %	50	DUE DATE	10-JUNE-94	SALES TAX AMOUNT
ON BILL PAY %	30	DUE DATE	20-JUN-94	EXCISE DUTY PAY CODE
GOODS RECD. %	20	DUE DATE		EXCISE DUTY AMOUNT
DELIVERY CODE	1	DEST. DELIVERY	D	EXCISE AMOUNT
S.S.T. PAY CODE	1	AMOUNT	012.0	DISCOUNT PAY CODE
ADD. SST PAY CODE	2	AMOUNT	232.0	DISCOUNT AMOUNT
C.S.T. PAY CODE	3	AMOUNT		
E.D. PAY CODE	2			
ADD. E.D. PAY CODE	1	Do You Want To	Modify [Y/N]	N

10-may-97
THE ABC MANUFACTURING CO. LTD
Supplier Insertion/Modification
1. Insert Supplier
2. Modify/Blacklist/Delete Supplier
3. Exit
Enter your choice: 1

THE ABC MANUFACTURING CO. LTD
Supplier
1. Updation
2. Supplier Linkage to Item Updation
3. Item List with Suppliers
4. Quit
Enter your choice: 1

SAMPLE REPORTS

THE ABC MANUFACTURING CO. LTD
INDENTS RAISED

Date: 15-May-97

Indent Depart-ment Code	*Indent Year*	*Indent Serial Number*	*Indent Type*	*Indent Item Group Code*	*Unit of Measure-ment*	*Indent Required Item Quantity*	*Indent Estimated Value*	*Indent Required Delivery Date*
100	97	15	R	915	kg	10	100	10-JUN-97
100	97	15	R	915	kg	10	100	10-JUN-97
151	97	14	N	1	Nos	10	1000	03-JUN-97
100	97	18	N	28	Nos	5	2300	16-JUN-97

15-May-97

THE ABC MANUFACTURING CO. LTD
ITEM-WISE CONSOLIDATED STATEMENT OF
ENQUIRIES FLOATED DUE ON 20-MAY-97

REMARK: THIS IS A TEST REPORT

Enquiry Code	*Supp. Code*	*Dept. Code*	*Year*	*Sr. No.*	*Group Code*	*Item Code*	*Unit*	*Quantity*
1994000033	910007	151	97	14	975	387106	NOS	200
1994000034	910008	100	97	18	28	60005	NOS	5
1994000035	910013	151	97	14	975	387106	NOS	200
1994000036	910021	100	97	18	28	60005	NOS	5
1994000037	910042	151	97	14	975	387106	NOS	200
1994000038	910504	151	97	14	1	100100	NOS	10
		151	97	14	975	387106	NOS	200
1994000039	910602	151	97	14	1	100100	NOS	10
1994000040	910902	151	97	14	1	100100	NOS	10

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Adama Science & Technology
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