MANAGEMENT OF INFORMATION SYSTEMS (DEMB13)

(MBA)

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BLOCK 1 INFORMATION FOR DECISION MAKING

This block gives an insight into the decision-making process, the various kinds of information systems existing and the management of the information resources.

Unit 1 on Decision Making explains the various kinds of managerial decisions and how they are made.

The second unit on Conceptual Foundations of Information Systems helps to appreciate the significance of information systems in an organisation.

The last unit in this block on Information Resources Management relates to the issues concerned with information resource management in the organisations within the available framework.

UNIT 1 - DECISION MAKING

Objectives

After going through this unit, you should be able to

* appreciate the nature and variety of managerial decisions
* develop decision table logic for structured and programmed decisions
* understand the decision making process
* understand the relevance of various models of individual and organisational decision making.
* give examples of how information systems support various stages of decision making.

Structure

1.1 INTRODUCTION TO DECISION MAKING

The field of decision making is vast. There have been many approaches to managerial decision making. These have ranged from the strictly quantitative as typified by the methods of operations research - to those based on human and organisational behaviour. It is only recently that those working in the area of decision making have started to combine approaches that could cater to the multiplicity of subjective and objective factors, and the multiplicity of criteria and objectives - some in conflict with one another.

Decision making is an essential part of management. Some have even suggested that management is synonymous with dicision making. Managers are decision makers and problem solvers. Whether a manager is involved in evaluating new opportunities or eliminating long standing difficulties, decision making for management is essentially problem solving. The process of deciding is intimately related to the whole process of knowing (or 'cognition'). Knowing "what the problem is" will assist in deciding "what to do about it", that is finding the best solution. This is basic for each individual personally and also for a professional manager, whose main orientation is towards the making of decisions. There is always an implicit opportunity loss associated with poor decisions. They are the foregone gains, profits or cost savings, which could have been realised had a better decision been made.

However, the process by which one arrives at a decision is quite complex; infact no one process can be applied to all decisions. Over the decades, decision - making methods have evolved. from primitive to supersophisticated, ranging from the instinctive/intuitive approach, to traditional precedent based approach, to the commonsense approach, to the scientific method. A decision involves many intuitive and deep-seated cognitive mechanisms that cannot be observed fully or directly influenced. What can be influenced are the behaviour patterns, the analytical procedures and the sequence of logic that are followed in making a decision. Ideals, objectives and goals form the background against which decisions are made.

There are many types of decisions, some that are completely specified, some partly specified and many unspecified.. We shall discuss how computers have entered in decision aiding process, who all are the end users of the systems, the different types of decisions, the decision making process and the implications for the information systems analyst. It would be our effort to minimise repetition of concepts or subjects that we have already discussed in previous courses or modules. These, however, are important and should be referred to for better understanding and appreciation.

Let us look at the different types of decisions that are encountered by managers. We would like to categorise them primarily into two categories, structured and unstructured.

1.2 STRUCTURED DECISIONS

These structured decisions are those that can programmed. They are essentially repetitive, routine and involve a definite procedure for handling them so that they do not have to be treated each time as if they were new.

It has been seen that in general at the lowest level in the organisation. viz., the operational level and the managerial staff, deal mostly with such fairly well structured problems. In the past most successful applications of information systems have come in dealing with structured, operational and management control decisions. These fall really in the domain of transaction processing and it is for this reason that some researchers prefer to call such systems as TPS - Transaction Processing Systems, rather than MIS - Management Information Systems.

Thus structured decisions which are also called programmable decisions involve situations where the procedures to follow when a decision is needed can be specified in advance. Therefore, such decisions are structured or programmed by the decision procedures or decision rules developed for them. A structured decision could possibly involve what is known as a deterministic decision or an algorithmic (step by step procedure) decision. In this case, the outcome of a decision can be determined with certainty if a specified sequence of activities, viz., the algorithm is performed. No doubt many decision situations do not all.come under deterministic criteria. There might be probabilistic decision situations. Since, in this case, enough probabilities about possible outcomes are known, a decision can be statistically taken or determined with an acceptable probablity of success.

Herbert A. Simon stresses the programmable part of the structured decisions and accordingly terms 'structured decision' as 'programmed decisions'. In the programmed decisions, a problem (or one very similar) occurs frequently enough so that afixed routine or programme is established for solving it. Programmed decisions are infact those that are made inaccordance with some policy, rule or procedure so that they do not have to be handled de novo each time they occur. Infact these decisions are generally repetitive and routine and are obviously the easiest for managers to make. It is for these reasons that such managerial problems are relegated to the supervisory level. The supervisors fall in the first entry ring of management. It gives persons of this level the slight 'kick' or morale boost as they have entered into the 'management category' No doubt the perceptions will have to change since they have moved across from the worker/operator level to the other side of the table. Decisions implemented by the supervisors might feel elated, but when compared to managers at the higher levels, the supervisory level decisions are pretty straight forward and simple because of their structured nature. These decisions are in fact routine decisions and they require little deliberation from the top man's point of view.

These routine decisions are taken against a familiar background in everyday business operations. Such decisions involve no extraordinary judgement, analysis or authority, since they are to traverse through more or less fixed avenues. On account of the experience gained or because of the trivial nature of the problems on hand, management has already established a set of rules, policies and procedures. With the organisation's goals, policies and processes established, the routine decisions demand, on the part of managers, a power of selection of the best path, as the connecting link between the given means and the established ends.

The structured decisions, often termed as programmed decisions, are labels that are derived from the jargon of the computer field, where a program is defined as a plan for the automatic solution of a problem. Programs are simply a string of instructions to accomplish an assignment. However, it is well known that all problems do not lend themselves to automatic programmed solutions. No doubt an information system analyst might be having his cherished dream of having all decisions in an oraganisation programmed or fully automatic. Then perhaps there would be no dividing line as regards variety of type of skills required by managers at various levels. You would recollect that studies have shown that more technical skills are required at the lower levels whereas more conceptual skills are required by managers at the higher levels, apart from human skills that are requierd at all levels of management.

It has been seen that by far the greatest number of business decisions are repetitive and routine ones. If this is true, then there is an overriding need to automate or program these decisions so that managers and executives could delegate such problems to lower levels and have them made by one or more techniques of programmed decisions. It is interesting to note that in some cases even upto 90% of management decisions are routine ones.

Most programmed decisions are solvable by the 'force of habit'. We go to our offices, make decisions about the in-basket or in-tray correspondence, and take dozens of actions daily that are "programmed" through sheer force of habit. Infact this is gained by 'experience' in an organisation. Whenever there are turnovers, it is this valuable experience that is lost, which could be quite costly. It usually takes time and money for newer recruits to acquire this experience.

The 'force of habit' in fact leads to certain traditions, conventions and practices which might become a platform towards formal statement of rules, procedures, policies, etc.

At this stage, it would be worthwhile to spend some time looking at what constitutes a rule, procedure or a policy.

A rule is a specific policy statement about the conduct of certain affairs. For instance, a rule may state that any person who comes in late to work will face disciplinary action. It could be that if an employee is to start his office hours from 9.00 a.m., if he comes by 9.15 a.m., he could be tolerated. Time between 9.15 a.m. to 9.30 a.m could be allowed at best say thrice in a month. Anything beyond these limits would necessitate some disciplinary action. A rule is frequently used when confronting a well structured problem. Rules are usually rigid which might specifically tell about 'do's and don'ts'. Rules are usually framed in a manner to take care of almost all situations. However, we do have instances where the rule applies - 'show me the man I'll show you the rule'. You often hear the term that 'rules are silent on this issue Indeed rules are quoted again and again depending on what is to be proved or justified or rationalised in order to take the final decision .

Activity A

Could you enumerate the rules followed in your organisation by you in seeking a temporary replacement for three days for an absent typing clerk.

....

....

....

A **procedure** is a series of steps that are sequential in nature and interrelated to address a well structured problem. A procedure is a kind of direction in using a series of steps in either diagnosing a problem or solving it. For instance, if your car is not working, the mechanic has a manual of procedures to check the trouble and follow procedures to correct it. He might like to first find out whether there is petrol in the tank. If petrol is there, he might like to check the battery terminals to see whether they are loose. With experience it is possible to have shortcuts in diagnosis, which might sometimes appear to be done on a random basis or just on a 'trail and error' basis. Now the company procedure could be written, oral or implied. Standard operating procedures provide a means for indoctrinating and training new personnel and for guiding experienced personnel in the performance of specific tasks. The procedure has the additional advantage of forcing a certain amount of detailed planning, because it cannot be adequately designed, reviewed, or implemented without careful thought.

Activity B

What would be the procedure followed by you to mend a leaking tap in your bathroom?

....

....

....

As for a policy, it is a general guideline which sets up parameters for the judgment within which to operate and is general and judgemental in nature. For instance, the policy of a company may be 'the customer is always right'. But it is left to the manager to rightfully interpret this policy in a particular situation. It is indeed possible that there could be a bias, even perhaps an emotional outburst and sometimes an immature and unrealistic response of the customer. Should the policy be implemented in true letter and spirit? Should one think of the policy in the long-run or short-run? Now if the case is to be considered under the structured programmed decision category, some definite answers would have to be provided rather than leaving it ambiguous, vague and fuzzy.

1.2.1 Decision Tables for Structured/Programmed Decisions

Let us demonstrate the use of a decision table in the context of a programmed or structured decision. Consider an accounts receivable process in which customers accounts are examined with the purpose of producing a statement and a possible reminder, of variable severity, for each account.

The analyst's first step is to decide upon the set of criteria applicable. By discussing with various relevant groups of people, three unrelated possibilities are discovered (1) that within 30 days the amount exceeds Rs.5.000/- (2) that within 60 days the amount exceeds Rs. 2,000/- and (3) there is still an amount to be paid on goods purchased more than 60 days ago. Let us denote these condition stubs as AR1, AR2, AR3 respectively.

The possible answers to each of these questions is a sample yes (Y) or no (N). Thus there are a maximum of $2^3 = 8$ rules corresponding to the possible combinations of answers. These are placed in the condition entry section of the table, one per decision rule column. There is no significance attached to the order in which the rules are written, provided that all possible entries are recorded. However, it is sometimes possible to combine two or more rules if it is known that the ensuring actions are all identical.

By further questioning, the analyst establishes the complete list of all possible actions and writes them in the action stub, one per line. Suppose that, by the time this section of the system is 'activated' a preliminary operation has bypassed all those customers not needing a statement, and has already produced a statement for those to whom one is due. The only task remaining is to produce one or more of :

* A moderate reminder (Letter A)
* A very severe reminder (Letter B)
* A very Terse Post Script to either letter (the same in each case)
* A special report on the customer for the sales manager (called Exception Report.)

Now the REPORT will no doubt be produced on some unit other than the one which will print the letters and may consequently be produced anywhere in the action sequence.

A terminal action (which leads on to the next operation to be performed) could also be included (i.e., GO TO xxx where xxx is the name of some other decision variable).

Figure 1.1 gives the completed decision table for the programmed decision situation of accounts-receivable.

CONDITION STUB	DECISION RULES							
	1	2	3	4	5	6	7	8
AR1 Rs. 5,000/-	N	Y	N	Y	N	Y	N	Y
AR2 Rs. 2,000/-	N	N	Y	Y	N	N	Y	Y
AR3 Rs. 0/-	N	N	N	N	Y	Y	Y	Y
ACTION STUB								
Letter A (Moderate Reminder)			X	X				
LetterB (Severe Reminder)					X	X	X	X
Terse Post Script				X				X
Exception Report								X
GO TO NEXT	X	X	X	X	X	X	X	X

Figure 1.1 Accounts Receivable Programmed Decision Table

The above decision table can be used for writing a program in an appropriate computer language.

It is worthwhile to note the orderly nature of the inquiries into which the analyst is led. In fact this is a most valuable discipline tending to regularize the otherwise random questioning which may occur.

Having expressed the table in as concise a form as possible, a programmer can now proceed directly with the 'encoding' process, or use the table to construct a formal flowchart. Which may then serve as a basis for coding. There are available translation programs which take a decision table as input, and produce as output a program written in a language such as FORTRAN, COBOL or PL/I, or compiled code. Example of this are the Rand Corporation's FORTAB and DBM's Decision Log Translator, both of which produce FORTRAN programs. The DETAB/65 produces a COBOL program.

The accounts receivable structured example draws heavily from the illustration provided by Brookes et al . One can refer to a large number of problem situations that are amenable to the process just illustrated. Primarily the analyst would have to understand the problem on hand by being able to determine a set of operating conditions and the amenable decisions to take by following the set of alternative rules that can be drawn up.

Decision tables are quite graphical in nature and facilitate communications between user, analyst supervisors and affected parties . As we have seen, the decision table expresses primarily a series of conditions; when the conditions are fulfilled, then a rule associated with the condition is executed. A 'header' is used to identify the table and condition stubs describe the various conditions. As already explained earlier, a rule is a procedure for checking the different conditions, and the action statement tells what action to take when a rule is true. The table is read until the conditions for a rule are met and the action described is taken. Then the next scan of the table begins.

Now to familiarise you with the topic a bit more, we illustrate two decision tables as shown in Figure 1.2 and Figure 1.3 for the 'limited entry' and 'extended entry' decision table examples. The illustration pertain to the logic for a 'credit card' purchase authorisation. In this example, a purchase under Rs. 500/- is approved automatically. Purchases between Rs. 500/- and Rs.1,000/- are given authorisation number. Finally for purchases over Rs. 1,000/-, we give an authorisation number and place a "hold" on the customer's account for the amount of purchase. The dicision tables shown in Figure 1.2 and Figure 1.3 are self-explanatory.

CREDIT CARD AUTHORIZATION

CONDITION STUB	DECISION RULES			
	1	2	3	4
Is purchase < Rs. 500/-	Y	N	N	N
Is purchase between Rs. 500/- and Rs. 1000/-		Y	N	N
Is purchase over Rs. 1000/-			Y	N
ACTION STUB Approve with no action	X			
Give authorization no.		X	X	
Place hold on account			X	
Error				X

Figure 1.2: Limited Entry Example

CREDIT CARD AUTHORIZATION

CONDITION STUB Is purchase 'P'	DECISION RULES		
	1 P > Rs. 1000/-	2 500 <P< 1000	3 O<P<500
Approve with no action			X
Give authorization	X	X	
Place hold on account	X		

Figure 1.3: Extended Entry Example

As can be seen the extended entry is somewhat more compact and allow us to use logical conditions as entries and save space. No doubt the tables shown in Figures 1.2 and 1.3 adequately describe the logic for the credit card example and that both the tables are equivalent

Care must be taken by the analyst that the rules themselves must be unique and independent; they cannot and should not contradict one another; and only one rule can apply in a given situation. It really does not matter in what sequence rules are presented, since only one set of conditions can be satisfied at a time.

It would be interesting to make an observation here at this point. Many knowledge based expert systems are also 'rule-based'. They utilise the 'if-then' type of logic. If a set of certain conditions hold', then 'the action or outcome will be...

1.3 UNSTRUCTURED DECISIONS

Thus far we have been discussing the structured programmable decisions which are very large in number and perhaps more easy to handle as compared to the unstructured or relatively less structured decisions which we would now like to discuss. Though fewer in number as compared to the structured situations, this category of decisions is more repetitive in nature, usually 'one-shot' occurrences for which standard responses are usually not available. Hence they require a creative process of problem solving which is specially tailored to meet the requirement of the situation on hand. In fact managers at higher levels in an organisation are usually faced with more such unstructured decision making situations. Some have aptly described the situations as somewhat 'strategic' in nature as compared to the 'tactical' orientation of the structured decisions at the lower levels of management.

Strategic decisions are non-repetitive, vital and important and aim at determining or changing the ends or means of the enterprise.

Since each manager, in the case of such unstructured, non-programmed decisions, may bring his own personal beliefs, attitudes and value judgments to bear on the decision process, it is possible for two managers to reach distinctly different solutions to the same problem, each claiming that he is acting rationally. In fact the ability to make good non-programmed decisions helps to distinguish effective managers from ineffective managers. Unstructured decisions are not simple. They are usually quite complex in nature. We can't shy away from them for someone has to ultimately make these decisions even though there are inherent dangers when confronting ill-structured problems. Non-programmed decisions are essentially new and unique. They have to be often solved de novo. There is no tried and true method of handling them. Unstructured decisions are those in which the decision maker must provide judgment, evaluation and insights into the problem definition.

1.4 ADDITIONAL CATEGORIES

There are many ways of categorising decisions as proposed by various persons from time to time. We have already discussed structured and unstructured situations. Some have termed them as programmed/ programmable and non-programmed/non- programmable decisions. Yet others have talked of routine/repetitive and non-routine/non repetitive decisions.

Some have stated the range of tactical and strategic decisions; others have termed them as minor and major decisions. We can easily have just two classes of decisions as follows:

Class I Unstructured, Non-programmable, Strategic, Major, Routine, Repetitive, Complex, Long - run.

Class II : Structured, Programmed, tactical, Minor, Non-routine, Non-repetitive, Simple, Short-run

1.4.1 Departmental, Inter-departmental and Enterprise Decisions

Let us discuss decisions that could be departmental, inter-departmental and enterprise decisions. For instance, sanctioning leave to an employee is a departmental decision, but making a slight change in the design of the product is an inter-departmental decision, and entering a new line of business is an enterprise decision. The department level decision is strategic in nature whereas departmental level is tactical in nature.

1.4.2 Organisational and Personal Decisions

When an executive acts formally in his expected role in an organisation, he makes organisational decisions. However, when the manager takes a decision in his personal capacity and not as a member of the organisation, it is known as a personal decision. For instance, transfers that are effected by an executive are organisational decisions. However, an executive who decides to leave the present organisation is making a personal decision.

1.4.3 Individual and Group Decision Making

Decisions may be taken either by an individual or by a group or a Committee. It is difficult to say which is a better method of taking decisions. Each method has its strengths and weaknesses. We are all aware of the delaying tactics that are adopted by institution of committees in the resolution of conflicts. On the other hand, it is argued that two blockheads are better than one. There would be richer ideas and many more alternatives generated in the process. But when it comes to assessment of selection, there could be 'lot of heat' generated. How does one resolve such a situation? Is it by consensus? Or by voting?

i) Individual Decisions

According to Simon, "It is impossible for the behaviour of a single isolated individual to reach any high degree of rationality. The number of alternatives he must explore is so great, the information he would need to evaluate them so vast, that even an approximation to objective rationality is hard to conceive. The individual decision maker is an individual human being - the one factor most vital and most difficult to understand because of various factors such as age, perception, intelligence, experience in a given area, confidence in decision making, time available, resource position, upbringing, family background, and so on that could come into play.

The most mysterious factor is still this decision making individual human being. How and why an individual acts in a certain way at a certain time is still quite a mystery. The individual decision maker could have quite an amount of prejudice and bias that is inherent on account of perceptual processes which act as great filters. We only accept what we want to accept and hence only such information filters down to our senses, and secondly, the perception is highly subjective. The information gets distorted to coincide with our pre-established beliefs, attitudes and values.

These are additionally 'cognitive' constraints. Psychologically we are always uncomfortable with decision making. We are never sure if our choice of the alternative was correct and optimum, until the impact of the implication of the decision has been felt. This makes us feel very insecure and could be one of the many causes of 'stress' in individuals leading to hypertension and other health complications.

No doubt it is important to have adequate and accurate information about the situation for good quality decision making. However, it must be recognised that "an individual has constraints of nature such as physical, psychological, sociological etc. These limit the amount of information the individual can handle".

ii) Group Decisions

As for group decisions, these are usually taken for major issues in order to secure wider cooperation, acceptability and coordination. Usually in a group like situation, the chances of subjective errors are reduced and more options are thrown open. If the group is larger, such decisions suffer from unnecessary delays, deadlocks and petty party politics.

Some advantages of group decisions are

i) Increased acceptance by those affected and hence implementation is easier.

ii) Easier Coordination.

iii) Easier Communication.

iv) More information processed on account of availability of a larger number of specialists in the group.

v) Group decision making is more democratic in nature.

vi) Participative group process builds up a training group for subordinates and others which allows for smooth handover when individuals leave the scene (no vacuum is created).

Let us now enlist some of the **Disadvantages** of group decisions.

i) Group decisions take longer.

ii) Groups can be indecisive.

iii) Groups can compromise

iv) Groups can be dominated.

v) Group members may exhibit "focus effect" viz., the group may just focus on one or a few suggested alternatives and spend all the time in evaluating these and may never come up with other ideas thus limiting the choices.

1.5 DECISION MAKING PROCESS

1.5.1 Simon's Decision Making Model

Let us now look at the decision making process as proposed by Herbert A. Simon. His model is a conceptual framework that divides the decision making process into the following stages or phases:

i) **Intelligence Activities :** At the stage, a search of the environment takes place to identify events and conditions requiring decisions. Data inputs are obtained, processed and examined for clues that may identify problems or opportunities.

ii) **Design Facilities :** At this stage, alternative courses of action are developed, analysed and evaluated. This involves processes to understand the problem, to generate solutions, and to test solutions for feasibility.

iii) **Choice & Implementation Activities :** Here on has to select and alternative as course of action from those available. A choise is made, implemented and monitored.

Though intelligence, design, choise and implementation activities are sequential in nature, the decision making process includes the ability to cycle back to a previous stage as shown in Figure 1.4 Choice and implementation have been shown to be separated for better understanding.

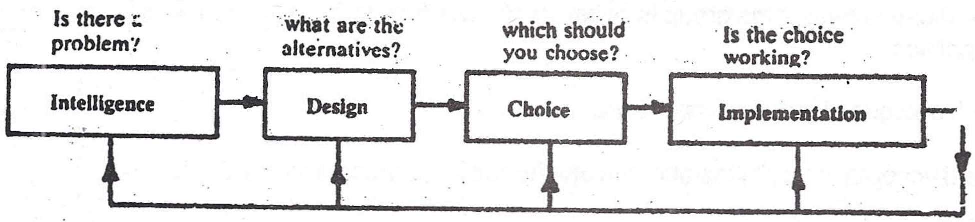

Figure 1.4: Flow Chart of Decision Process

1.5.2 Massie's Decision Making Model

Many step-wise models of the rational decision making process have been proposed over the years. One such proposal by Massie has been found to Be most representative as a five stage procedure as follows:

i) Understand situation.

ii) Diagnose and define problem

iii) Find alternatives

iv) select action and

v) Secure acceptance of decision

Figure 1.5 captures the gamut of the decision making process and is quite self-explanatory. You would have by now seen the similarities in the two decision making processes that we have just discussed. However, Simon's model seems to be more preferred to in literature and as such you would find some of the material in this unit also leaning on this model, when discussing on the implications and requirements of the various stages of the decision making process by information system analysts.

We shall not get into concept of data and information which have already been discussed in MS-7 (Information Management and Computers) Unit No.16 on Information Needs and its economics. Suffice it to say that information is the vital resource for managerial decision making.

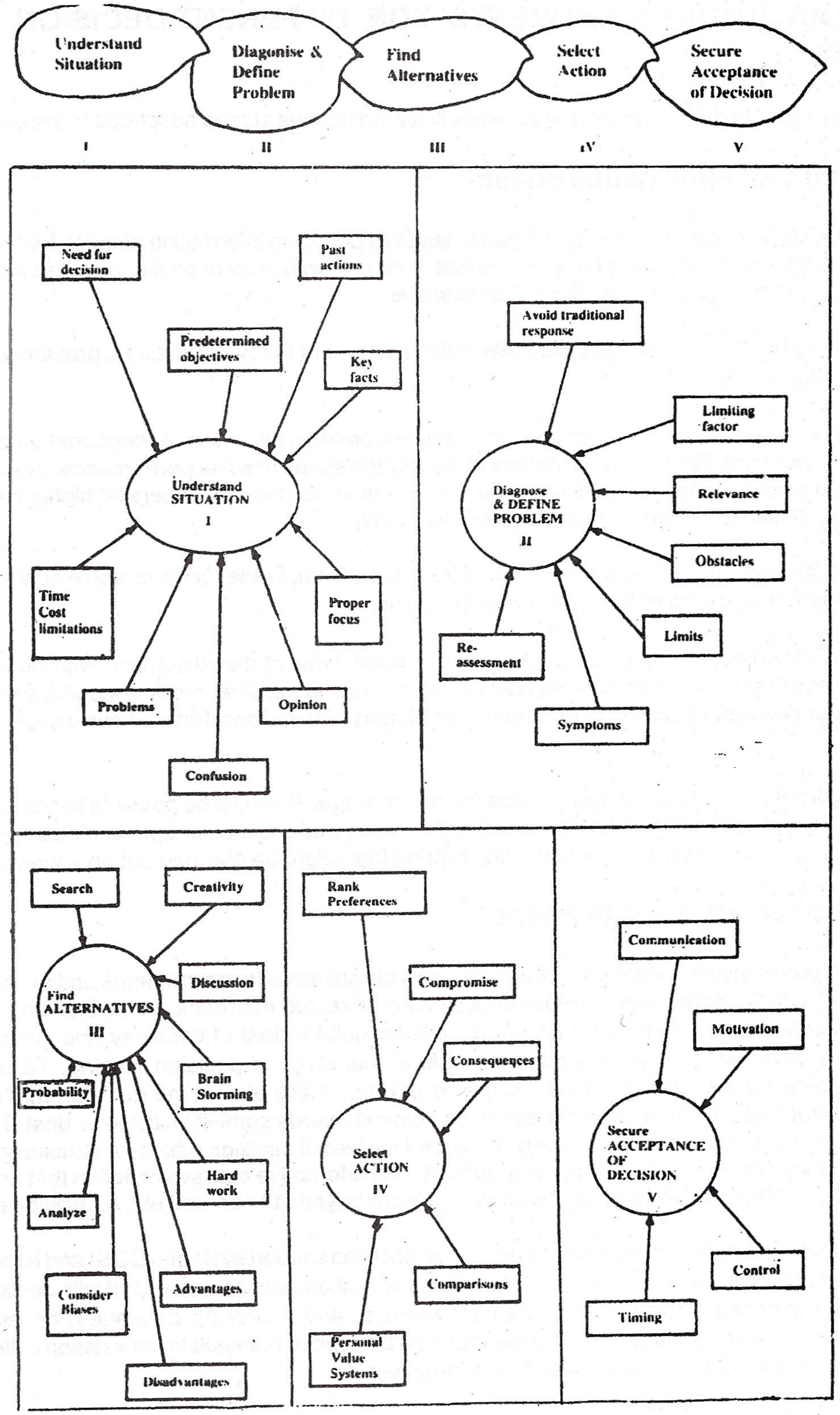

Figure 1.5 Rational Decision Making Model

1.6 INFORMATION REQUIREMENTS FOR DIFFERENT DECISION MAKING STAGES

Let us now lock into the information requirements for the various stages described in the earlier section.

1.6.1 Information for Intelligence Phase

Information Systems can help in the intelligence stage by providing information about external and internal conditions. Intelligence entails scanning the environment, either intermittantly or continuously, depending on the situation to identify potential decision situations. For example:

a) a marketing executive makes periodic visits to key customers to review possible problems and identify new customer needs;

b) Sales analysis reports can be furnished to mangers periodically, when exceptional sales situations occur, or on demand. These help managers to identify the status of sales performance. Also information from market research studies and external databases could also help managers (at higher levels) identify changes in consumer preferences of competitive activity;

c) A design engineer might attend a trade show at the International Trade Fair to observe new materials that may or could be incorporated in future product designs.

The Intelligence phase and its activities result in some type of dissatisfaction with current state or alternatively aid in the identification of potential rewards for a new state. The intelligence phase is the 'tricky' phase and embraces the unstructured non-programmed category of decisions that we have discussed earlier in this unit.

A major information system capability is needed at this stage. It should be possible to provide situation-specific information to managers when they make ad-hoc inquiries that could be unique and often unscheduled. All this should be in addition to some of the exception reports that might be churned out on a weekly basis.

1.6.2 Information for the Design Phase

The design phase involves designing of several possible solutions to the problems and evaluation of the alternate courses of action. Here more carefully specified and directed information activities and capabilities focused on specific designs are required. This stage calls for quite a deal of creativity and innovation. Idea generation and idea engineering could play a useful role in this stage of decision making. Techniques like Brainstorming, Nominal Group Technique etc., could be utilised. Here also some decision might fall in the category of highly structured, programmed situations and move towards semi-structured or unstructured non-programmed decision situations. We have already discussed the use of decision tables for structured situations. Decision trees could also be utilised by laying out graphically the alternative courses of action that are within the control of the decision maker and the states of nature, which are beyond the control of the decision maker.

As for the semi-structured or unstructured decisions, decision support systems (DDS) and expert systems (ES) can provide assistance to managers. Models of business operations can be developed with decision support software, including advanced statistical, management science, and modelling packages, or less complex spreadsheet programs. These packages and models can then be used to manipulate information collected in the intelligence stage to develop and evaluate a variety of alternatives.

Thus the information system should contain models to process data and generate alternative solutions. It should assist with checklists, templates of decision processes, scenarios etc. The models should assist in analysing the alternatives.

1.6.3 Information for the Choice Phase

In this stage a final selection of a particular course of action has to be made out of the various alternatives generated in the preceding design stage. Here a manager can use information tools than can calculate and keep track of the consequences, costs and opportunities provided by each alternative designed in the previous stage. Information systems should help managers select a proper course of action. An information system is most effective if the results of design are presented in a decision-impelling format. The final choice would depend whether there is a single criteria or objective on which it is to be decided or whether the decision situation is one which involves multiple criteria and objectives. Most decision making situationis one which involves multiple criteria and objectives. Most decision making situations fall under the multiple criteria category, which is more difficult and complex and operations researchers are just about getting into this field. The manager is hardly an optimiser now; he believes in satisficing. Worse still, one has to account for factors both subjective and objective, quantifiable and non-quantifiable, tangible and intangible. A technique called Analytic Hierarchic Process (AHP) developed by Saaty is finding a great deal of application in such situations and seems to be becoming a great boon for decision makers. An 'expert choice' software is available for the purpose of prioritisation of alternatives.

The quality of the choice stage depends very much on the quality of inputs made from the previous two stages - intelligence and design phases. It is possible that the manager, even though at the choice stage, might like to refer and return to the previous stages and reopen this issues for more data or alternatives etc.

Information systems can help managers in the choice stage in various ways. Managers can be provided with summarised and organised information emphasising major points such as major assumptions, resources requirements and expected results of each decision alternative. Some type of a 'what-if' simulation analysis could be established.

1. 6. 4 Information for the Implementation Phase

This is the final stage of the decision making process. It is concerned with implementing and monitoring. When the choice is made in the previous stage, the role of the system changes to the collections data for further feedback and assessment. The information systems must help managers monitor the successful implementation of the decision. Here managers can use a reporting system that delivers routine reports on the progress of a specific solution. Some of the difficulties that arise are resource constraints, and possible ameliorating actions. Support systems can range from full-blown Management Information Systems to much smaller systems and project planning (PERT/CPM based) software operating on micro-computers. Feedback about business operations affected by a decision helps a manager assess the decision's success or failure, and whether follow-up decisions are needed.

1.7 RATIONAL INDIVIDUAL MODELS OF DECISION MAKING

Because organisations are made up of individuals, it makes sense to build information systems that facilitate individual decision making, wherever possible. Different assumptions have been made while proposing some model or the other.

1.7.1 Rational Model

Some economists, mathematicians and management experts believe that the decisions are always made rationally because the decision maker:

* knows his or her objectives and ranks them in order of importance;
* knows all possible alternative solutions to the decision problem;
* knows the relative pros and cons of each alternative; and
* chooses the alternative that maximises attainment of the objective.

Such idealistic assumptions have their share of criticism. Decision makers are not so well informed as to consider all the alternatives or to know all consequences. Moreover, it is not just a singular objective that is pursued in real life situations. Still, despite these criticisms, the rational model remains a powerful and attractive model of human decision making.

1. 7. 2 Bounded Rationality and Satisficing

Instead of searching for all the alternatives and consequences (unlimited rationality) as in the preceding model, people limit the search process to sequentially ordered alternatives (alternatives that are not radically different from the current policy. Wherever possible they avoid new, uncertain alternatives and rely instead on tried-and true rules, standard operating procedures) and programmes. Individuals and/or organisations have multiple goals, some in conflict with each other also. Even goals are prioritised or placed in a hierarchy.. In this way rationality is bounded. Simon proposes the 'satisficing' approach rather than the 'optimising approach'

1. 7. 3 Muddling through Model

In 1959, Lindblom proposed the most radical departure from the rational model in his article on the "science of muddling through". He described this method of decision making, as one of "successive limited comparisons". Here values are chosen at the same time as policies, and no easy means - end analysis is possible. For instance labour and management can rarely agree on values, but they can agree on specific policies. Because of the limits on human rationality, Lindblom proposes, "incremental decision making ", or choosing policies most like the previous policy. Non-incremental policies are a political (not likely to bring agreement among important groups) and dangerous as nobody knows what they will lead to . Lastly, it is argued that choices are not "made". Instead decision making involves a continuous process in which final decisions are always being modified to accommodate changing objectives, environments, value preferences and policy alternatives provided by decision makers.

1.7.4 Psychological Types and Frames of Reference

The psychologists have given an additional perception to the rationality concept. They say that humans differ in how they maximise their values as well as in using the frame of reference of interpreting information and making choices. Here we hear about the 'cognitive style' that refers to underlying personality di positons in the treatment of information, the selection of alternatives and the evalution of consequences. Systematic thinkers impose order in perceptions and evaluation; intuitive thinkers are more opened unexpected information and use multiple models and perspectives when evaluating information. Neither is more rational than the other.

Some studies have found that humans have a deep seated tendency to avoid risks. when seeeking gains but to accept risks in order to aviod losses. In other words, people are more sensitive to negative outcomes than to positive ones.

1.7.5 Implications of the Models for Information System

Decision making is not a simple process and hence some guidenlines need be kept in mind when designing information system. The following characteristics of information systems could be encouraged:

- they are flexible and provide many options for handling data and evaluating information.
- they are capable of supporting a variety of styles, skills and knowledge.
- they are capable of changing as humans learn and clarify their values.
- they are powerful in the sense of having multiple analytical and intuitive models for the evaluation of data and the ability to keep track of many alternatives and consequences.

1.8 ORGANISATIONAL MODELS FOR DECISION MAKING

Just as we descussed rational individual decision making, it is useful to think also of organisational decision making. The models of organisational choice have been portrayed in Table1.

Table 1 : Models of Organisational Choise

Name	Basic Concept	Interence Pattern
Rational factor	Comprehensive rationality	Organisations select goal(s) examine all alternatives and then choose a policy that maximises the preference function.
Bureaucratic	Organisational out put	Goals are determined by resource constraints and existing human & capital resources. Standard operating procedures are combined into programs, programs into repertoires; these determine what policies will be chosen. The primary purpose of the organisation is to survive; uncertaity reducition is the principal goal. Policies are chosen that are incrementally different from the past.
Political	Political outcome	Organisational decisions result from political competition; key players are involved in a game of influence, bargaining and power. Organisational outcomes are determined by the beliefs and goals of players, their skills in playing the game, the resources they bring to bear, and the limits on their attention and power.
Garbage can	Non-adaptive organisation programs	Most organisations are non-adaptive, temporary and disappear over time. Organisational decisions result from interactions among streams of problems, potential actions, paticipants, and chance.

Source : *Kenneth C. Laudon & J.P. Laudon, Management Information Systems : A Contemporary Perspective, Collier Macmillan Pub. Co. U.K., 1988. Pg. 141 Table 5.8*

1.8.1 Implications for Information System Design

As can be seen from Table 1, the designers of systems just can't think of individual decision making models but would have to consider organisational decision making. Systems must do more than merely promote decision making. They must also include the notion of making individual managers better managers of existing routines, better players in the bureaucratic struggle for control of an organisations's agenda, and better political players. In fact also systems should help bring a measure of power to those who can attach the right solution to the right problem.

1.9 SUMMARY

Management and decision making are complex activities that involve many dimensions of human behaviour. Early classical models of management stressed the functions of managers namely planning, organising, staffing, coordinating, reporting, budgeting. Depending on the level at which managerial decision makers are, they perform a different mix of managerial functions. There are primarily three levels of management and decision making termed as strategic, technical / tactical and operational decision making.

In conclusion, management decision making quality depends on the vital input of information so as to support the functions that a manager performs, the levels at which the decision maker is, and on the type of decisions, whether structured or otherwise.

1.10 KEY WORDS

Business Systems Analyst : A systems analyst tied to an end-user business area with specialised understanding of the business information requirements of that functional area. The analyst is responsible for translating those specific business requirements into information systems for that functional area.

Cognitive Styles : Basic patterns in how people handle information and control problems.

Decision Making Process : A process of intelligence design, choice and implementation of a particular course of action (Simon's Model).

Decision Table : A method of documenting decision rules in matrix or tabular form, showing a set of conditions, and the actions that can be taken on these conditions.

Procedures : Set of instructions used by people to complete a task.

Structured Decision : Type of decision that is repetitive, routine and can be structured and programmed.

Unstructured Decision : One in which the decision maker must provide judgment, evaluation, and insight because the decision problem is novel, non-routine, and has no agreed- upon procedure for solving it and is usually unstructured and non- programmable.

1.11 SELF-ASSESSMENT EXERCISES

1. Define structured and unstructured decisions. Give four examples of each.
2. Discuss the rational individual models of decision making. What are the implications of these models to information system analysts?
3. Describe the organisational choice models. How would the design of system be affected by the choice of model employed?
4. Prepare a decision table based on the information given below :

   An educational institute wishes to make a statistical listing of all seniors. If the senior is a male and a veteran, he will have a "V" printed after his name. A male student will have his marital status printed.

If the student is a female and single, she will have her name and phone number printed if she is over 20 and less than 26 years old. Single females under 20 will only have their names printed. Single females 26 and over will have their date of birth printed. All married females will have their marital status printed.

1.12 FURTHER READINGS

Brookes, C.H.P., Grouse, P.J., Jeffrey, D.R. and Lawrence, M.J., 1982. Information Systems Design, Prentice Hall of Australia.

Chandan, J.S.,1987. Management Theory and practice, Vikas Publishing House: Delhi.

Gordon, D. and M. Olson, 1985. Management information Systems: Conceptual Foundations, Structure and Development, McGraw Hill: USA

Laudon, K.C. and J.P. Laudon, 1988. Management Information Systems: A Contemporary Perspective, Collier Macmillan:U.K.

Lucas, Jr.,H.C., 1982. Information Systems Concepts for Management,McGraw Hill International: USA.

Murdick,R.G., Ross, J.E. and Claggett, J.R., 1987. Information Systems for Modern Management, 3rd Edition, Prentice-Hall India Eastern Economy Edition.

O'Brien, J.A., 1991. Management Information Systems-A Managerial End User Perspective, Galgotia Publication (P) Limited : Delhi.

Tripathi, P. C. and P. N Reddy, 1983. Principles of Management, Tata McGraw Hill: Delhi.

Voich, Jr., Mottice, H.J and Shrode, W.A., 1975 Information Systems for Operations and Management, South Western Publishing Company: USA.

UNIT 2 CONCEPTUAL FOUNDATIONS OF INFORMATION SYSTEM

Objectives

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

* appreciate the significance of information systems in an organisation
* understand the information subsystems which could be defined within a typical organisation
* differentiate between various types and levels of information systems.

Structure

2.1 INTRODUCTION

Information has been recognised has one of the crucial corporate resources which facilitates better utilisation of other important resources such as men, machines, materials, money and methods. Managers have come to realise that without proper information - at the right time and at the right place - even the other resources may not be fully utilised. And a fully informed manager is in a position to take better decisions as compared to an uniformed one.

It was way back in 1957 that the organisations in the United States passed from the industrial era to the infomation era. It was in that year that the number of employees who were primarily handling infomation surpassed the number of industrial workers; and this number of information workers kept on increasing during the 1970s also.

To understand the use of information system, we should define the following concepts in detail. The present unit discusses various conceptual foundations related to information systems.

2.2 INFORMATION SYSTEMS

A management information system has been defined by Davis & Olson as "an integrated user-machine system designed for providing information to support operational control, management control and decision making functions in an organisaiton. The information systems make use of resources such as hardware, software, men, procedures as well as supplies." As the above given definition indicates, the information systems are meant for supplying, and not generating, the information to various managers involved in the decision making process. The imformation systems are expected to provide processed information to the decision makers at various management levels in different functional areas throughout the organisation. To understand the management information systems, it is possible to define it into three constituent components.

Management : Management has been defined as a process, a function, a profession dealing with the activity of getting the work done with and through people. The various functions of managers include directing, controlling, staffing, leading and motivating.

Information : Information could be defined as sets of facts, figures and symbols processed for the current decision making situation. The information is considered to be of significance in a particular situation.

System : A system is defined as a set of related components, activities, processes, and human beings interacting together so as to accomplish some common objective.

Putting all these three components together, it could be seen that Management Information Systems are sets of related processes, activities, individuals or entities. interacting together to provide processed data to the individual managers at various levels in different functional areas.

While defining the Management Information Systems, the following characteristics should be kept in mind:

a) The management Information Systems are primarily meant for providing information from the data after processing them. The information systems do not generate data. The data is generated, collected, recorded, stored, processed and retrieved after it has been generated by business operations in an organisation. The information systems follow the procedures designed for processing this data which has been generated within the organisation.

b) The information systems are designed for the job positions rather than for individuals. Regardless of who is the individual holding the job position, the information systems are designed keeping in mind the job responsibilities that the individual in supposed to perform and depends upon the information needs of the individual in the organisational hierarchy.

c) The information systems are designed for different levels of management - they are supposed to cater to the information needs of dicision makers at top, middle and junior levels of management.

d) The information systems are designed for supplying information to managers in different functional areas. The information is supplied to managers in the areas of marketing, finance, production, personnel, materials, logistics, etc.

e) The information systems should be integrated by way of database's. The redundancy in storage of data, processing of data and generation of reports is avoided by way of integration of information systems.

Single point data entry and updation of master data files should be ensured to minimise chances of discrepancies in the data integrity.

f) The information systems are facilitated with electronic equipments such as computers.

2.3 TYPES OF INFORMATION

Broadly, information can be divided into two different types - internal information and external information. Figure 2.1 shows the scope of internal and external informations in the context of business organisations.

Internal Information : The Internal Information can be defined as the information which has been generated from the operations of the organisation at various management levels in the various functional areas. The internal information gets summarised and processed as it goes from juniormost to the topmost levels of management. The internal information always pertains to the various operational units of the organisations. Examples of Internal Information would be production figures, sales figures, information on personnel, accounts, materials, etc. This type of information is usually consumed by middle and junior levels of management. However, summarised internal information is also consumed by top level of management.

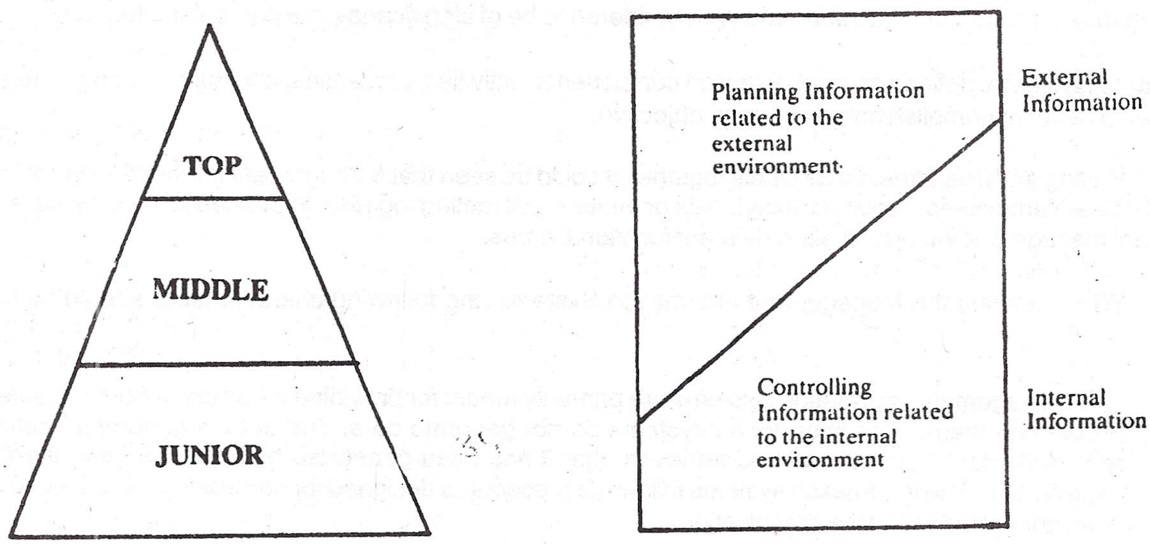

Figure 2.1: Internal & External Information

External Information : The external information is usually collected from the environment of the business organisation. External information is considered to be affecting the organisational performance from outside the organisation. Information such as government policies, competition, economic status and international market is considered to be external information. The external information is usually required by the top management cadres and is helpful in shaping the long term policy plans for the organisations.

2.4. ORGANISATION AS AN INFORMATION PROCESSING UNIT

The information gets processed within an organisation as it travels from clerical level to the top levels of management. Figure 2.2 shows how the information gets processed within an organisation. It could be seen from the figure that the data is collected from units like customers, internal operations, competition and external data on economy and market, etc. The collected data is processed so as to generate the outputs usually in the form of information reports. This output is information and leads to managerial action. The processed information is also disseminated to the members of the organisation, public at large, stockholders as well as government and egulatory agencies. It could also be seen from the figure that infomation is the only linking thread between the external environment and the internal members of the organisation.

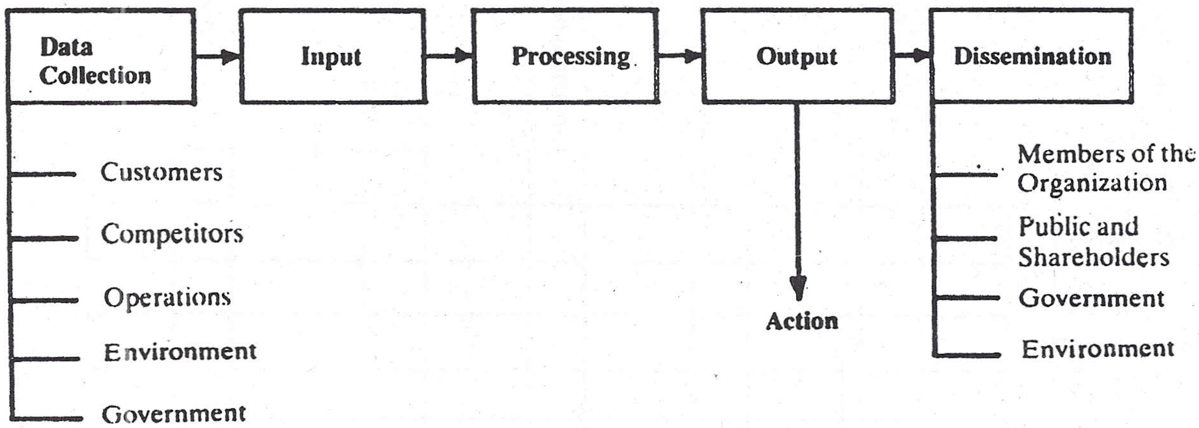

Figure 2.2: Information Processing in an Organization

MIS and Organisation

The various subsystems of any information system could be better understood by looking at it from the organisation`s point of view. The two approaches used to define the subsystems of an MIS are (1) Organisational functional subsystems and (2) Activity subsystems.

2.5 ORGANISATIONAL FUNCTIONAL SUBSYSTEMS

Figure 2.3 clearly shows the various functional areas which could be separated from the MIS point of view. The major subsystems and the typical reports generated within each functional area are given as under;

Functional subsystems	Some Typical Reports
Marketing	Sales Forecasting Report, Sales planning Reports, Customer and Sales Analysis Report
Production	Production planning and Machine Loading Report, Cost Analysis & Control Reports, Quality Control Report.
Materials	Goods on Order Report, Vendor Analysis Report, Inventory Control Report, Physical Inventory Report, ABC/XYZ Analysis Reports.
Personnel	Personnel Information Reports, Performance Appraisal Reports, Tranining & leave Records
Finance & Accounting	General Accounting Reports, Payroll Accounting Reports, Bonus & IT Reports, Financial Analysis Reports, Cost Analysis Reports, Cash Flow Statements

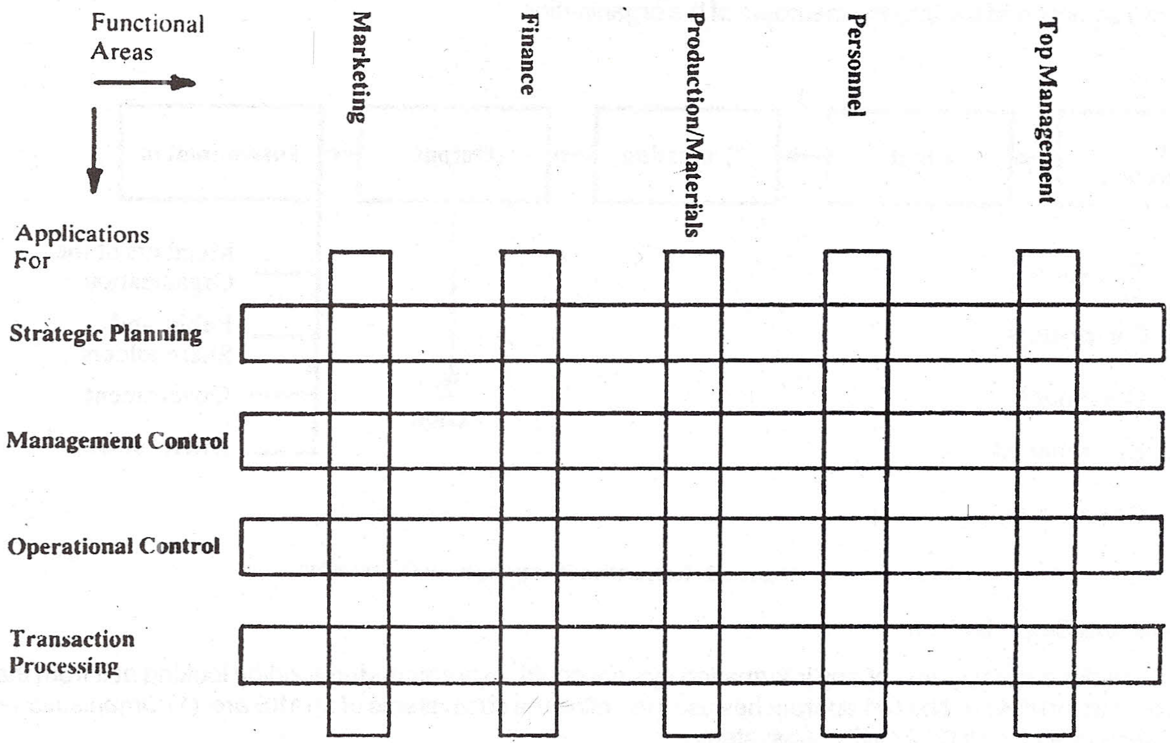

Figure 2.3 : Various Subsystems of MIS

The various functional areas are integrated through the common database which is an integral part of the information system in an organisation. The processed data from marketing function is stored in the database and whenever it is required, it is fed over to the production. Figure 2.4 shows the marketing subsystem and its interaction with other subsystems through the database.

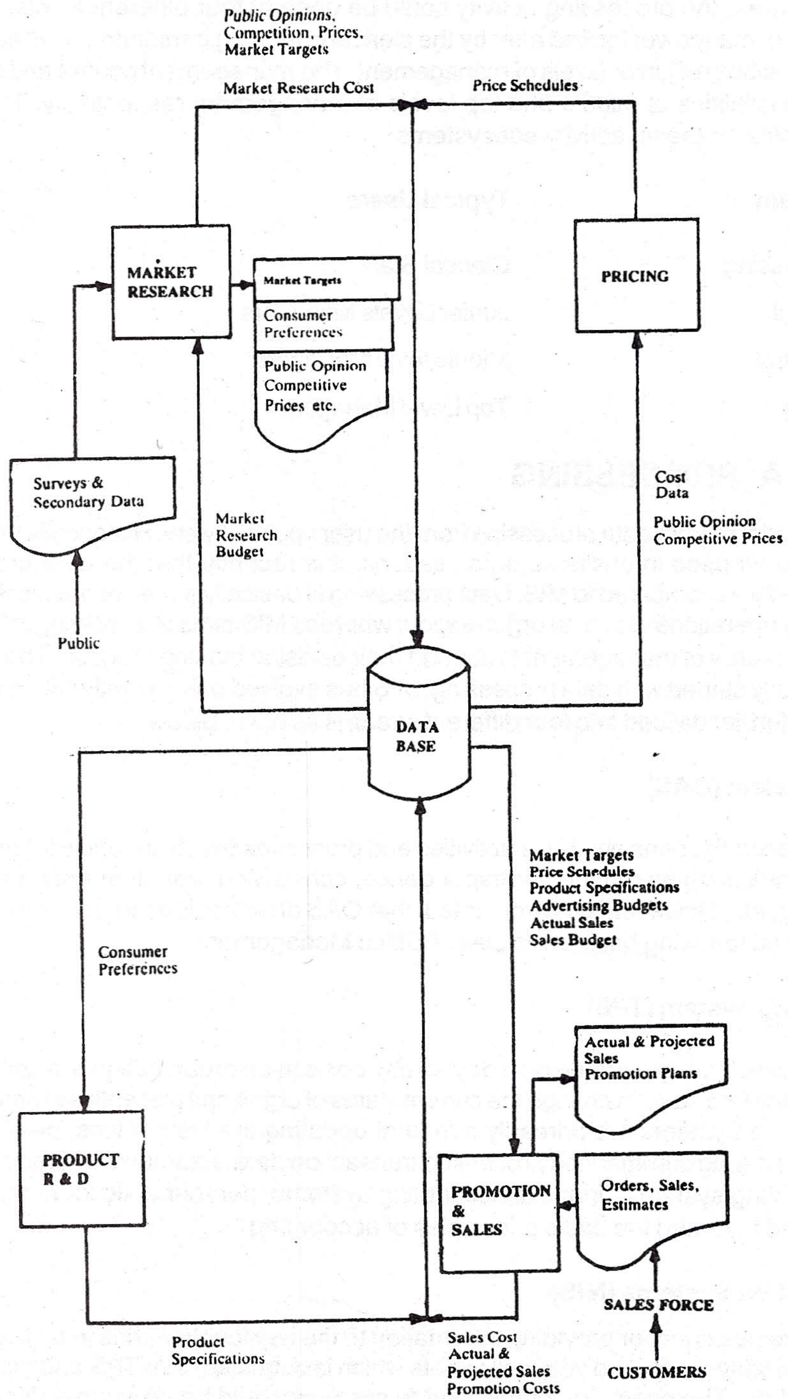

Figure 2.4: Marketing Subsystems (Information System)

The information subsystems could also be understood by looking at the subsystem from activity point of view. In each functional area, the processing activity could be done at four different levels. These levels are handled by different levels of manpower looked after by the clerical operating personnel, whereas the operational control activity is the responsibility of junior levels of management. The management control and strategic planning functions are direct responsibilities of middle and top levels of management respectively. The following table shows the typical user profile for these activity subsystems:

Activity Subsystem	Typical Users
Transaction processing	Clerical Staff
Operational control	Junior Levels Managers
Management control	Middle level Managers
Strategic planning	Top Level Managers

2.7 MIS AND DATA PROCESSING

MIS can be differentiated from data processing from the users point of view. Historically the data processing was the first subsystem to be used in business organisations. It is recently that the data processing is being treated as a lower level activity as compared to MIS. Data processing is basically aimed at processing of transactions generated from day-to-day operations within an organisation; whereas MIS aims at supplying information from the processed data to various cadres of management to support their decision making process. The use of computers for processing of data actually started with data processing; MIS has evolved only recently within the organisations. Data processing could be further divided into four different streams as given below:

a) Office Automation System (OAS)

The Office Automation Systems are those activities and processes which are undertaken on the computer to perform the office routines such as routine correspondence, scheduling, appointments, calendar functions, bulk mail, word processing, etc. However, it may be noted, that OAS does not lead to generation of data directly. These systems are designed following basic principles of Office Management.

b) Transaction Processing System (TPS)

The transactions which get generated on a day-to-day basis in an organisation are collected, stored and used for updating master data files so as to change the current status of organisational entities within an organisation. The Transaction Processing Systems are primarily aimed at updating the history files, generation of detailed transaction reports, and preparing summarised processed transaction data. Examples of Transaction processing Systems are sales accounting systems, financial accounting systems, personnel accounting systems, etc, All these systems are disigned following the basic pricnciples of accounting.

c) Management Information Systems (MIS)

These systems are designed for providing information to the key functionaries in an organisation. These systems make use of the already processed transaction data which is outputted form TPS and generate information reports after processing data. The examples of this kind fo systems could be personnel information systems, marketing information systems, sales information systems, production and operations systems, etc. These systems are designed following the prociples of organisational theory. The major group of users for this kind of systems are the middle levels of management.

d) Decision Suport System (DSS)

d) Decision Suport System (DSS)

DSS are the highest order of sytems among the computer based information systems. These systems make use of the summarised organisational data as well as external data collected from the environment of the organisation. the internal data is mostly used for studying the trends where as extenal data is mostly used for understanding the environment. These systems also make use of analytical and planning models such as management science and operations research models. These systems are mostly used for assisting the top management in taking unstructured and semi-structured decisions having long-term impact to the organisational performance.

2.8 OPERATING ELEMENTS OF INFORAMTION SYSTEMS

Any information system will make use of the following physical components :

a) **Hardware :** The equipment and devices for inputting, outputting, secondary storage, processing as well as communications in the system.

b) **Software :** The set of programmes to facilitate processing procedures; it includes systems software, a pplications software and the model base.

c) **Data Base :** The organisational data to be used by various software programmes is usually stored in the form of files and database on the physical storage media such as computer tapes, disc drives, floppy diskettes.

d) **Procedures :** The operating procedures documented in the form of physical manuals constitute an important part of MIS components. These documents could be divided into three major types: Operating Manuals, User Manuals and Systems Manuals.

e) **Operating Personnel :** The manpower operating these information systems include systems managers, systems analysts, data administrators, programmers, data entry and computer operators.

Processing Functions

The major processing functions in information systems include the following:

a) **Processing of business transactions :** To capture, collect, record, store and process the events of business interest, so that their effect should be carried over to the organisational performance records.

b) **Updation of maste files :** The effect of these transactions is carried over to the status files of the organisational performance. Master files at any given time shall reflect the status of any entity after having incorporated the impact of up-to-moment transactions.

c) **Generations of information reprots :** After having processed the transactions and updation of master files, the information reports are generated so as to assist the managers in their decision making.

d) **Processing of interactive enquiries :** On-line information processing systems provide the facility of responding to the business queries raised by the managers on the data files-both master as well as transaction files.

e) **Providing interactive analytical support :** The key decision makers not only need to interact with the data files for extracting data, with the help of scientific and planning models, they also require on-line processing support to analyse, the impact of some possible actions. When the system is able to extract data from relevant files and address this to the models chosen by the user, this leads to a Decision Support System.

2.9 MIS AND TOP MANAGEMENT

In order to relate the information systems to the corporate strategy in an organisation, it becomes important that the top management should take keen interest in the development and implementation of information systems. More often than not it has been found that the top management does not take keen interst in the development of structured, formalized and public information systems. The key managers normally tend to depend upon their informally designed private information systems. It is necrssary that, for successful implementation of information systems in an organisation, a corporate plan should be prepared covering should include a mechanism for implementation, proposed organisational structure and changes over a period of time, applicatiions to be computerised, issues relating to operations management, procurement of equipments and training of staff and effective control of information system function. Figure 2.5 shows the information systems strategic grid suggested by McFarlan and McKenney. This grid arrays a firm's existing applications against the applications which are currently under development.

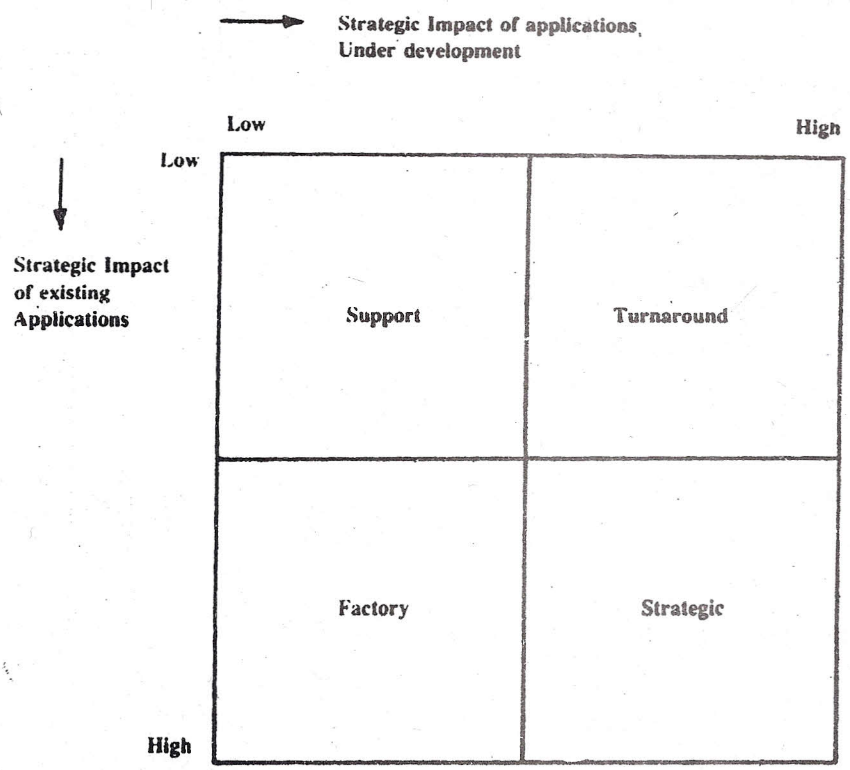

Figure 2.5: Information Systems Strategic Grid

It could be noted that the companies belonging to the *strategic cell* need to look after their processing activity more carefully whereas in *turnaround cell* the companies. might be able to convert their processing function as a major competitive weapon. In the factory setting, there is not much to plan, yet the existing applications should be continued. In *support cell,* processing is not at all critical to the success of the organisation. The top management involvement varies from critical in strategic cell to just negligible in support cell.

2.10 STRUCTURE OF INFORMATION SYSTEMS

The MIS structure could be discussed in terms of support for decision making, management activity and organizational functions. A conceptual framework would show the synthesis of these three approaches into an MIS structure. The structure could be understood by looking at the conceptual structure and physical structure.

The Conceptual Structure

The conceptual structure could be defined as an integrated system of functional subsystems each one of which could be divided into four different information processing components (1) transaction processing system (2) operational control information system, (3) managerial control information system and (4) strategic planning information system. Each of the functional subsystems in the organisation will have unique data files required for a particular subsystem, as well as each of the subsystems will also make use of general database files which can be accessed by more than one subsystem. The concept of database, which is common to more than one functional area is called a general database and is managed with the help of a database management system. A micro view of the MIS structure would also show the presence of the software programmes in addition to the specific programmes which are developed for each functional area : The MIS also makes use of a model base primarily meant for MIS reporting and decision support systems. The model base and common application software is common to a range of applications within and across the functional areas. Figure 2.6 shows the conceptual structure of and information system for a function. When application software for top management, middle management, junior management and clerical functions are put together, along with the common application software, it becomes a complete conceptual structure of an information system.

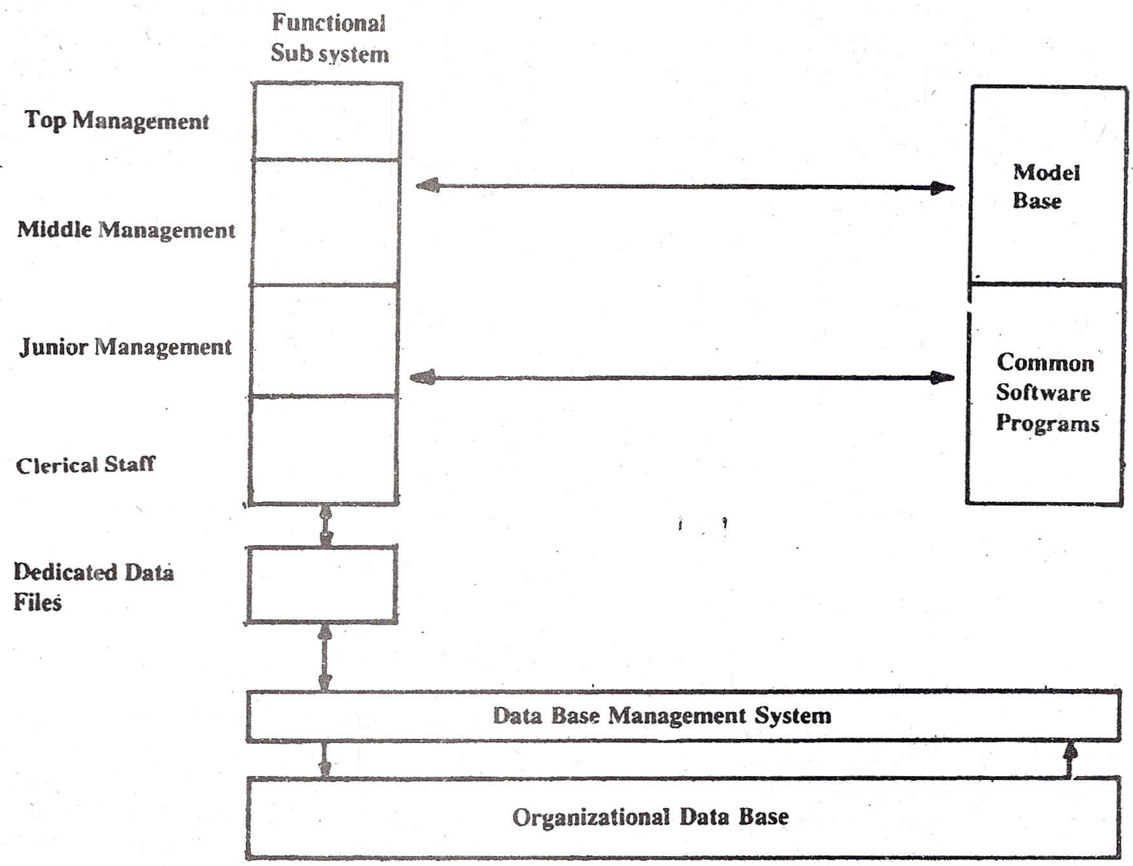

Figure 2.6: Conceptual Structure for a Functional Subsystem

The Physical Structure

It is quiet similar to the conceptual structure except that there is lot of integrated processing and it makes use of common modular software. The integration of information systems takes place through database which is normally a common database. The various subsystems and different functions interact with each other through the database. The outputs of one subsystem are stored in the common database which are subsequently used by the next subsystem as inputs. This is how the integration of information processing activity takes place across the various subsystems. To reduce duplication of efforts for development and maintenance of software as the common modules of application software are also used across the various functional areas. These modules cross the functional boundaries and are useful in more than one functions. These modules are either inserted into the system or called in by the system.

2.11 TYPES OF INFORMATION SYSTEMS

The information systems usually belong two different types i.e. structured and unstructured information systems. Formalization and publicisation of information leads to structuredness in information processing activity; whereas absence of these two leads to unstructuredness of information systems. Figure2.7 shows the various information system components in an organisation. It could be seen from the figure that public information systems are designed to provide the organisational information to the authorized persons in the organisation. Private systems, on the contrary, are designed to limit the availability of the information to the select individuals. Normally, the private information systems are meant for supplementing or duplicating the efforts of public information systems. The public information systems are characterised by the presence or formal documents and records whereas the informal information systems may or may not have any recording or predesigned process of retrieval.

	Public	Private
Formal		
Informal		

Figure 2.7: Information System Components

The information systems could also be characterised as formal and informal. Formal information systems are those which follow the hierarchical structure of the organisation. The information system where all those who are using information are authorized to use it and are also responsible for dissemination of specific information is called formal information system. Whereas information systems where unauthorized people pass on the public or private information from one level to another level are called informal systems. In informal systems, the user as well as sender may or may not be authorized users. It could be seen that when the information systems are formalized and they are developed for handling of public information, they become more and more structured with predefined frequency, content, sourece and objective; whereas absence of predefined frequency, content, source as well as justification leads to unstructured information systems. With computerisation of information systems, more and more structuredness is achieved and the information system components are affected as shown in Figure.2.8

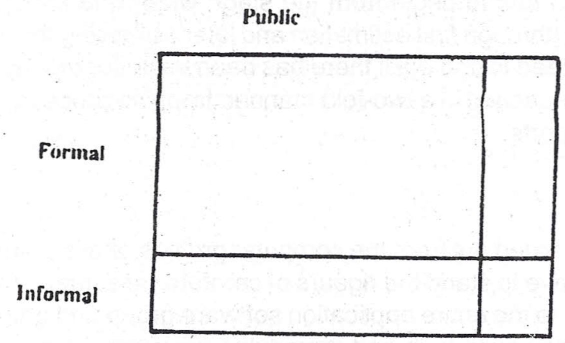

Figure 2.8: Impact of Computerization on MIS Components

2.12 EVALUATION OF MANAGEMENT INFORMATION SYSTEM

Introduction

Computerised Information systems are developed and utilized by two categories of organisations: (a) firms which have the in –house capability and (b) service-bureaus which develop them for use by the outside clients. In both cases, the basic investments.are of a high order in terms of not merely the computer system, but also site preparation involving air-conditioning, civil and electrical works followed by recruitment of manpower (computer-center manager, system analysts, programmers and operators, besides input/output, quality control, data preparations and other support staff) and their training. There can be only one objective behind making such sizeable investments and that is to provide satisfaction to the end-user, in-house or outside.

System Cost

Design, development and implementation of computerised information systems are done deeping the above aim in view. In most cost-conscious organizations, an initial estimate is prepared for the one-time cost of developing the system. and the recurring costs of running the system. The cost estimation has to cover such details as: routine manpower(systems, programming operations and, for service-bureau, marketing staff); manual manpower (specially employed to handle production, quality control, correction of checklists etc); data preparation (direct entry or punch entry or punch-card kind, whether done in-house or by outside agencies), consumable stores (stationery, cards or floppy disc, carbon, ribbons, etc.); computer time (actual usage hours, often logged by the computer itself); administrative expenses; logistic expenses (for conveyance of manpower, transportation of documents or output reports, etc); and miscellaneous expenses (overtime, etc.).

For a service bureau a fair basis to know if the computer is paying for itself in terms of the cost-estimate for usage per hour can be the cost of a computerised system is chargeable to the outside client and the latter's acceptance of the billed money (without asking for cancellation of billed computer time, etc.) can be a good yardstick to know if the client has turned out to be satisfied or not.

Need for Evaluation.

Whether or not service-bureaus face their irate customers, or user-organisations meet their dissatisfied departmental heads, a sound principle to run computerised information , systems is to introduce, side by side, a reliable procedure for management of hardware, software and data preparation. Such practices as regular and. time-bound spares and components do help hardware management. Attention to programming capability, scientific design and development of systems and a high-quality support for system software is invaluable for software management. Data preparation is a weak link in most organisations and quality control of entered data is a must, among other factors.

An actual evaluation plan has to begin from the stage when one knows what has been spent on a computerised information system (through first estimation and later assessing the actual cost on a monthly basis as outlined above), and then proceed to find out if there has been value for money spent. Such as evaluation is certainly not easy and can be approached in a two-fold manner: from the process side of system evaluation and from the product side of output reports.

Process Evaluation

A process evaluation is carried out from the computer professional's point of view. Design the system and the quality of programming have to stand the rigours of careful assessment. Quite often the system design is presented by the project leader to the entire application software group and gains from their friendly criticism. Programming standards are today quite high and a modular approach is far preferable to single integrated programmes. Internal or external training in efficient program-writing techniques can achieve surprisingly good results.

Another aspect of process evaluation is the utilisation of hardware resources. In all computers capable of running multiple programs, there should be adequate prior consideration to arrive at different memory partitions and to allocate input-output devices in a judicious way to each partition. The allocation of certain tapes or discs to production or development jobs often helps in obtaining an efficient and steady mix of jobs. The test for evaluation is to ensure optimal system utilisation, with the least possible idleness of any single device.

The third aspect of process evaluation is to check whether there is mininum wastage of computer-time. It may happen that well-designed systems with good quality programs are running with an apparently maximum use of hardware resources, and still they may hide many wasteful runs. This arises due to two reasons associated with development and production stages of the information system. At the development stage, lack of rigorous quality control may allow many avoidable runs of the programs. At the production stage, lack of full-scale debugging may make some programs prone to repeated runs. In fact, the best relevant check is to lay down permissible number of developmental runs and ensure fitness of the programs for release for production runs without wasting system resources.

Product Evaluation

The product evaluation is concerned with the end-user and has to ensure that the output reports (which were developed to generate the information system in the first place) are of acceptable quality and continue to be of use. Instances are not rare that computer outputs, which have long fallen out of use, are not pointed out as such by user-managers out of deference to the higher-level policy of computerisation, while the managers continue to use their little pocket –books containing relevant data. To avoid such a possibility, organisations having a fairly long tradition of computer-based information systems should, once in a while, take stock of the existing mechanisation.

One way this was done at Tata Steel sometime back was to devise a questionnaire for each user-department, outlining the group of computer applications for them. General questions related to the usefulness, quality level and achievement of promised improvement, and responses were sought on a three-tier basis. Specific questions were also framed regarding the reported items of information, frequency of reports, nature of formats and reporting levels. The purpose of the questionnaire was to elicit frank response from the user-managers on the utility of the prevailing computerised information systems.

The replies received were then tabulated and put up to the higher management for evaluation of each computerised system from three angles: should the system be continued as such? Or, should the system be curtailed or even replaced altogether by other more useful system? Or, should the system be modified to cover more ground so that its utility is enhanced?

The results of such an introspection are not always as per expectations, as managers do not feel comfortable to answer such questions, or, the questions themselves are not formulated clearly or followed up persuasively. These considerations, however, do not belittle their usefulness. In another forum provided by the public sector enterprise Hindustan Zinc, the general feeling was that a three-year interval from the time of introducing large-scale computer-based information systems could be about right to raise such searching questions and to seek answers about the utility of the computerised systems.

Conclusion

In any scheme of evaluation, pertinent attention needs ~~to be~~ paid to data integrity. It should be kept in mind that capture of data from input documents and the transition through more than one medium (say, cards and tapes) are error – prone. How good an information system is, quite often depends on how "clean" the data is. Computer-based validation techniques for accuracy, completeness, consistency, logical balance and homogeneity of data are well-proven and are an essential step to negate a garbage-in, garbage-out situation. The number of errors brought out in the checklist during the editing stage of data (i.e.,prior to running the main processing job) is quite often a measure of the dependability of the basic data. Process evaluation and product evaluation have both to follow considerations of data integrity for any information system.

2.13 SUMMARY

The unit defines the information system as an organisational system designed for the purpose of providing information to various managers in different functional areas so as to assist them in decision making. The internal information, which is mainly generated from the operations of the organisation, is consumed by lower level managers. Summarised internal and environmental information is used by the senior managers for long-term perspective planning. The organisational information systems could be studied by looking at these from the functional view point as well as from the managerial activity level. The top management interest for positioning of information processing activity has been considered important for proper use of the information resources. The information systems in an organisaton vary from totally structured to totally unstructured systems. However, they necessarily consist of physical components such as hardware, software, manuals and men.

2.14 SELF- ASSESSMENT EXERCISES

1) What is the role played by business information in an organisation?

2) Define Management Information System and discuss various characteristics expected of a good MIS.

3) "Internal information is used for day-to-day decision making whereas external information is crucial for long-term planning." Comment.

4) "The way organisations cannot exist without MIS, even information does not exist without organisation." Discuss.

5) What are the typical functional information subsystems in an organisation?

6) Differentiate between physical structure and the conceptual structure of information systems.

7) What is the impact of computerisation of the structuredness of MIS?

2.15 FURTHER READINGS

Banerjee Utpal K. and Sachdeva R. K., 1988. *Management Information System* a *Framework,* Vikas Publishing House Pvt. Ltd.: New Delhi.

Davis, Gordon B. and Margrethe H. Olson, 1985. *Management Information Systems – Conceptual Foundations, Structure, and Development* (2nd Ed.) McGraw Hill Book Company: New York.

Dickson, Gary W. and James C. Wetherbe, 1985. *The Management of Information Systems,* McGraw Hill Book Company: New York.

Lucas Henry C (Jr.) 1986. *Information Systems for Management* (3rd Ed.), McGraw Hill Book Company: New York.

Murdick. Robert G., Joel E. Ross and James R. Claggett, 1987. *Information Systems for Modern Management (3rd Ed.),* Prentice Hall of India : New Delhi.

UNIT 3 INFORMATION RESOURCES MANAGEMENT

Objectives

After going through this unit, a student should be able to :

* Understand the growth processes related to MIS function in an organisation:
* Relate the issues concerned with Information Resource Management in the organisations with available frameworks.

Structure

3.1 INTRODUCTION

Information has already been recognised as one of the crucial corporate resources, and that it needs to produce more information, available to a wider array of users, is being realised in the recent years. The investors need information about the financial position of the company and the vendors, and the creditors need information on the financial health of the organisation before extending any credit facility to the organisation. The Government agencies need information national planning and industry control. The organisations have long since realised the need for the availability of information resource for the interested groups, as well as, individuals.

The corporate look for the MIS function has undergone a major change. The management of information resource has also been subjected to a lot of thinking, and the organisations have been made to think seriously the growth and development of this function as an independent support function rather than as part of a major function, such as, finance and accounting. Serious thought has been given to the involvement of the users in the information processing activity, as well as, to the conversion of the function to a profit centre by developing and implementing charge-out systems for the services rendered to the user groups.

To develop an understanding about the information resource management in organisations and other related issues, the present study discusses various concepts related to the information systems management.

3.2 INFORMATION AND THE ORGANISATION

The organisational factors play a major role in what type of information is to be processed and communicated to the decision-makers. These factors include nature of the organisation, category of the organisation, structure of the organisation, size of the organisation and the management style followed in the organisation.

Information is the primary tool that will help the management, its products and services in the competitive environment. It should be clearly understood that the information technology and quality information are not the goals but merely the competitive weapons that support the organisations in their activities.Without quality information organisations are operating in a world of uncertainty, and quality information, could be produced by taking a number of steps and making sure that the information generated and presented to the decision-makers is accurate, timely and relevant.

3.3 FUNCTIONAL NOMENCLATURE

There has been a subtle but definite in the way the MIS function is looked upon in organisations. This change is characterised by the change in the nomenclature of the titles under which the function exists in various organisations. Initially, the executive looking after the function of data processing with the help of the computer was referred to as the computer manager, and, in the sixties the same position was renamed as Electronic Data Processing Manager. During this period, the department was also named as the EDP Department. It is during the seventies and eighties that the function has been recognised as MIS function and the manager is called the MIS Manager. There are other titles also given to the information processing function. Some of the common ones are Management Services Division, Corporate Services Division and Information Resource Management.

3.4 MIS GROWTH

Growth of the MIS activity in an organisation could be studied best by applying the model developed by Richard Nolan in 1979, popularly known as the Stage Growth Hypothesis. This six-stage model very clearly explains the stage by stage development of the MIS function in an organisation. This model provides a framework for the analyst to understand the reasons for success or failure of the MIS function in an organisation and also assists in developing solutions to take the functions ahead.

According to this model, there are distinctive features associated with each and every stage of the growth of the MIS function in an organisation from which the decision-makers can understand the growth pattern and use the MIS function to the strategic advantage of the organisation. Figure 3.1 depicts the framework suggested by Nolan. In this figure, the horizontal axis shows the stages of growth and the vertical axis shows the growth processes of the MIS function. The curve on the graph shows the trend of the MIS budgets. It could be noted that the budget curve shows an upward trend till the third stage, and becomes more level towards the beginning of the fifth stage onwards. The different stages discussed in the model are as under:

Stage - 1 : Initiation

The first time the organisation buys and installs a computer system, the MIS function in the organisation has entered this phase. SInce most medium and large-sized companies have installations of the computer systems, this stage is already reached as far as the majority of the organisations are concerned. During this stage, the following features may be distinctive:

a) Functional cost reduction application ;

b) Specialist DP organisation for technological learnig ;

c) Lack of strict Planning and control in the MIS function ;

d) Hands-off training for user awareness.

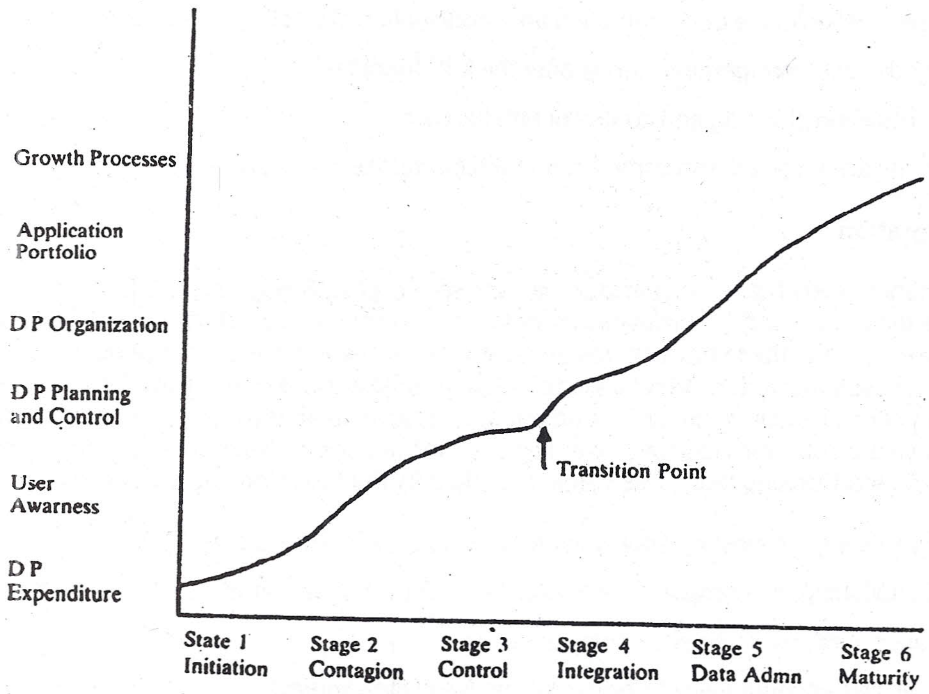

Figure 3.1: Nolan Six Stage Growth Model

Stage - 2 : Contagion

The second stage involves a rapid proliferation of the computer resource all over the organisation, sometimes based on the actual organisational needs and sometimes just to add some equipment to feel important in the organisation. This is the phase when most of the organisational units feel that they should have an access to the computer hardware, develop software and have the trained manpower working in their units. Every unit head wishes to have some computer resource controlled exclusively by himself. Due to this non-planned proliferation, this MIS function grows disproportionately and, there is, absolutely no control on the MIS budgets resulting in confusion in the organisation. The budgets go shooting up without any controls . The applications are developed in an independent manner, and this result in duplicated efforts and systems. This stage is marked by the following characteristics:

a) Proliferation of applications,

b) User-oriented departmental programmers,

c) More relaxed planning and control of MIS function,

d) Users are superficially enthusiastic without sincere involvement.

Stage - 3 : Control

It is towards the end of the second stage that the management gets conscious of the fact that the benefits being derived are not in proportion to the actual expenditure on the MIS activity, and the organisation starts exercising controls and some restraint in sanctioning the budgets. The management takes serious interest in planning the function, and it results in a better control on the activity. The MIS budgets get checked with the result that the users also get aware of the fact that information technology should be used to some meaning rather than just having some infrastructure under them. The major highlights of this stage are:

a) Upgradation of the documentation and modification of existing applications

b) Middle level mangement to look after the MIS function,

c) Formalized planning and control of MIS function,

d) Users are involved with some accountability imposed on them.

Stage - 4 : Intergration

After the management has been able to provide the control guidelines to the MIS function, the organisation starts thinking in terms of integrated applications so as to aovid the duplication of efforts and systems, as well as, providing better levels of integrity to the systems and data. Data-based systems are used and the applications are designed as subsystems of the organisational system, unlike the earlier ones. The interfunctional and intrafunctional integration is ensured through the database. Capable database management systems are used to manage the data, and the data communication facilities are used ot trausfer data from one location to another. The budgets, once again, start looking high. This stage is marked by the following characteristics :

a) Retrofitting the existing applications using data base technology,

b) Establishing the computer utility and the user accounts teams,

c) Tailor-made planning and control systems,

d) The user accountability to learn and involve in the systems.

Stage - 5 : Data Administration

With the integration of the applications using a data base environment in the fourth stage, the MIS function in the organisation undergoes a major change in the functional outlook. The technical expertise looses over to the management process and responsiveness to the users, and the data becomes the most crucial resource in the organisation to be managed. Since the data is being stored, used, manipulated and processed from integrated files in the database administrator to plan, supervise, provide, control and secure the data becomes most important. The stage is characterised by the following features:

a) The applications are further integrated as per the organisational requirements,

b) The data-processing organisation is for the data administration,

c) The systems are based on data and system sharing basis,

d) The user becomes effectively accountable for the MIS systems.

Stage - 6 : Maturity

It is almost impossible to attain the sixth stage of maturity when everything has been achieved, and the MIS systems will never fail themselves or fail the organisations. The applications by this stage have been incorporated into the organisational functioning and these are as per the strategic requirements of the organisation. The techonology has become an integral part of the organisational thinking, philosophy and systems. Some of the major features related to this stage are:

a) Integration of applications mirrors the organisational strategic choices,

b) The emphasis is on the data resource management rather than on the system management,

c) Data resource has become the key factor in strategic planning,

d) The users and data-processing professionals share the responsibility of the MIS function, jointly and willingly.

It is towards the end of the third stage that the information technology becomes a turning point for the strategic performance of the organisation and the full benefits of the information tecnology are realized by the organisation. Some of the organisations are able to go beyond this point, but some organisations may never reach this point at all. Such organisations can never have the advantages of the techonology, and may find it difficult to survive in the competitive environment.

3.5 STRATEGIC PLANNING FOR MIS

Planning of the MIS effort is very crucial for organisations. Absence of proper planning may result in the sky-rocketing of MIS budgets, thereby leading to a resource crunch during the later stages of MIS growth. In the initial stages, the application development projects and operations of completed application systems are the focus of the planning efforts. As the MIS activities grow in an organisation, the planning shifts its attention from operational planning to strategic planning. For operational planning of MIS, common techniques such as structural flow, charting, structured programming and walk throughs are used. For managerial and strategic planning of MIS, formation of steering committees composed of key executives from the user and MIS groups in a common practice. These steering committees are generally created to monitor proper functioning of MIS activity towards the achievement of long range organisational goals. Organisations commonly face the following problems in MIS planning :

a) The MIS plan may not be complete with the overall strategies and objectives of the organisation,

b) The framework of MIS structure may be difficult to design,

c) Allocations of development resources to various applications may be difficult,

d) Project management, to control time and cost schedules, may be lacking.

The overall objectives of planning for MIS have changed from linking processing strategy with business strategy in 1970s to linking the information technology strategy with the business strategy in 1980s.

3.6 TOP MANAGEMENT INTEREST AND A CORPORATE MIS PLAN

For successful growth of the MIS activities in any organisation, the top management's continuous interest as well as involvement is crucial. Not only that the top management should be involved in computerisation, it should also insist on having a corporate plan for MIS activities. The top management involvement could be in the following areas:

- Provide appropriate infrastructural facility.
- Linking with business activities.

- Monitor the level of user awareness and understanding.
- Making strategies understood among users.
- Monitoring the financial/capital requirements of all application areas on a time frame basis.
- Provide flexibility for future design.
- Review major system changes.
- Establish overall schedules for implementation.

One of the greatest hurdles to using information technology for strategic purposes, has been inability of the top management to appreciate and manage the information systems. Mostly it has been due to lack of understanding on part of the top management and a fear of uncontrollability of information system, which leads to a lower level of interest.

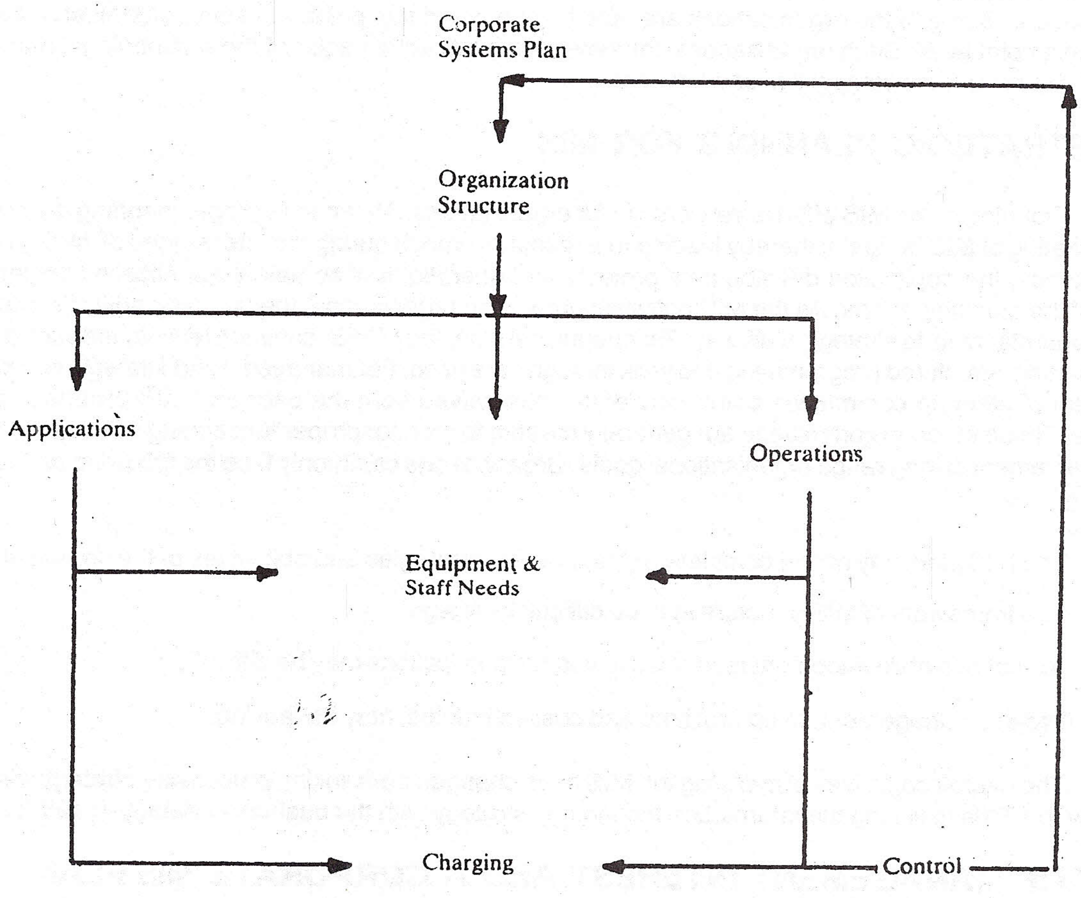

Figure 3.2: Framework for Managing IR (Information Resource)

For the top management to be involved in information processing activities, a framework for managing information systems has been suggested as shown in Figure 3.2. Positive top management action is needed in all these areas to avoid decisions by default. Since information technology affects the entire business from organisation structure to product market strategies, chief executives should not skip the corporate policy decisions by delegating or postponing.

3.7 INFORMATION REQUIREMENTS ANALYSIS

Once the overall MIS goals and strategy have been laid down, the next stage is to ascertain organisational information requirements. Information requirerments are vital for MIS planning, application, identification and planning an information architecture. Three levels at which the information requirements need to be established for design and implementation of CBIS have been identified:

- Organisation level to define the overall information system, and to specify a portfolio of applications and data bases,
- Database level to specify data models and other specifications,
- Traditional approaches adopted by system analysts to assess information requirements are as follows:
  a) Asking questions from the usres by available methods
  b) Deriving from an existing system, or from descriptions in textbooks/hand books,
  c) By object system analysis,
  d) Experimentation with an evolving information system.

3.8 CRITICAL SUCCESS FACTOR (CSF) METHOD

John F. Rockart, while advocating the "CSF" approacah, evaluated the existing four methods of determining executive information needs. viz., the by-product technique, the null approach, the key indicator system and the total study process.

These four techniques have their relative merits and demerits, and to overcome the disadvantages, the Research Team at Sloan School of Management, suggested a creative approach termed as CSF approach for information requirement, analysis. Its application was found effective and response-provoking amongst the executives. As a part of the exercise, the executive goals and the CSFs are identified and reviewed to the satisfaction of both the executives and the system analysts.

The CSFs for any business are the limited number of areas in which results, if they are satisfactory, will ensure succesfull competitive perfomance for the organisation. These are a few areas where the things "must go right" for the business to flourish. The CSFs must receive constant and consistent attention from the management as well as individual managers. CSFs differ from company to company and from manager to manager and like organisations may have differing CSFs. There are four prime soures for identifying the CSFs as listed below:

- Structure of the particular industry,
- Competitive strategy, industry position and geographical location of the company,
- Environmental factors,
- Temporal organisational factors needing immediate attention.

The CSFs, are generally not meant for strategic planning, since the data requirerments are impossible to pre-plan. The CSF method centres around information needs for management control where data requirements could be defined and pre planned. Most executive have four to eight CSFs.

3.9 RESOUREcE ALLOCATION

Allocation of resources is one of the important issues related to the MIS function in an organisation. It is during this stage that we prioritise the application and decide on their implementation schedules. The following four factors should be kept in mind while allocating resourecs to different applications:

- Quantifiable returns,
- Judgmental benefits,
- Institutional factors of constraints,
- System priority factors.

Intangible benefits, such as, improved levels of service, better financial control, standardisation and better quality of information are also considered important while considering resource allocation.

3.10 CHARGING FOR SERVICES

It is an accounting approach for allocating costs of information systems to their users. There are two different ways of charging the users of the information services:

- Charging by allocation of costs to the users as corporate overhead, and
- Charging for services the individual users get.

The second approach is based on the users's willingness to buy the information sevices and willingness to pay for the new system development.

The reasons for having a charge-out system include cost assignment, control, incentives and budgeting. The different techniques which are used for allocating costs are·

i) No Charge-out,

ii) Complete Charge-out,

iii) Partial Charge-out.

3.11 INFORMATION RESOURCE ASSESSMENT

The lower arrow in Figure 3.3 represents 'Information Resource Assessment' (IRA) - a process of using information and knowledge to support the developement of the organisation's strategic business direction. In effect, it is the mirror image of 'Strategic Planning for Information Resource', in the sense that it is the process through which information and knowledge are used to identify the strategic comparative advantages and to create and evaluate new strategies, i.e., to influence change in the 'Organisational Strategy Set'

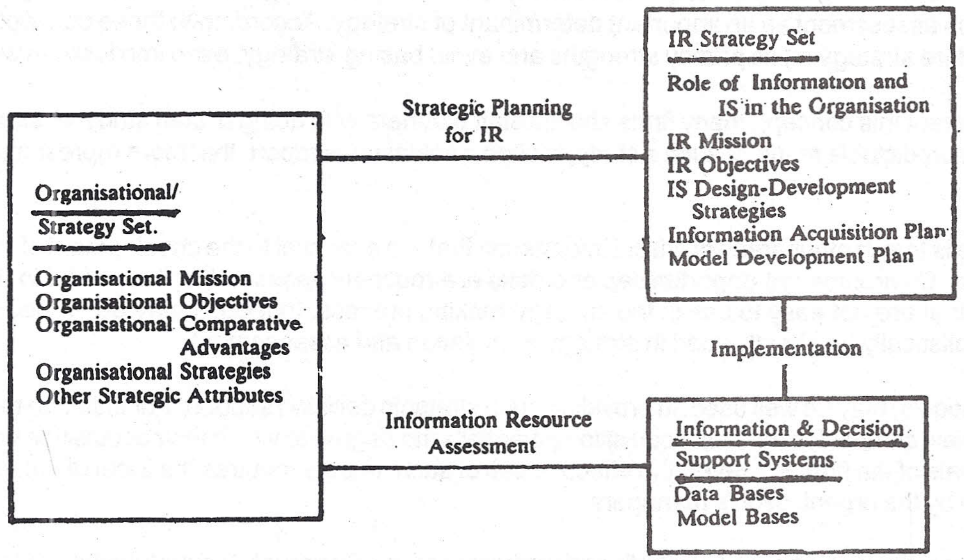

Figure 3.3: Operationalizing Information as a Strategic Resource

(SOURCE : Management Information Systems : The Technology Challenge Edited by Nigel Piercy; Croom Helm London & Sydney Nichols Publishing Company New York; 1987 Pg.240 Figure 11.1)

Figure 3.3 shows that this influence does not come directly from the Infromation Resource (IR) Stategy Set, but rather from the Information Systems (IS) databases and model-bases that have been created to implement the 'IR Strategy Set'.

The basic IRA process is one of identifying information that is crucial, or potentially crucial to the organisation's strategy set. This may be of the nature of 'new' information, that has not previously been used to advantage, or it may be information that has been re-evaluated and updated. Such information and knowledge may be put to use in creating information products or in developing new and more effective business strategies, or organisational missions.

One variety of IRA influences the creation of information that is available to the firm through its IS.

However, the creation of information products is only one of the ways in which information can be made to be a strategic resource. King and Cleland, (1978) have developed a technique of 'strategic databases' that may be used to illustrate the way in which IRA can be conducted. The basic idea is that much of the data on which the organisation's strategy may be based is often routinely collected and analysed as 'data', rather than as strategic 'information'. The distinction between data and information may appear to be pedantic, but it is a useful one to be made in this instance.

Data are the numbers, letters and other symbols that are used to represent events, activities, entities, etc. (The best-known set of organised data may be the telephone directory.) Information is data that has been evaluated for some use or purpose. (For instance, a name and phone number on a message that says that your offer to purchase a house has been accepted, is information rather than data.)

Information is clearly required for the effective support of strategic planning and for the making of good decisions in an organisation. Yet, many of the processes that are directed towards decision-support utilise and present data rather than information.

Illustrative of this, are the strength-weakness assessments that are frequently made by a firm in support of its strategic decision-making and planning. Most concepts of strategic management and plannning incorporate strength-weakness assessment as an important determinant of strategy. According to these concepts, the firm should base its future strategy on its primay strengths and avoid basing strategy, even implicitly on weakness.

To implement this concept, many firms charge staff planners with doing a 'staff study' of strengths and weaknesses. The predictable result of such a study, is often a voluminous report, that more represents data than information.

The same is true in other areas of critical information that are essential to the development of an effective business strategy. Environmental opportunities and risks are routinely assessed and reported in the form of voluminous data that are not easy to use in the strategy-making process. Indeed, it may be argued, that such reports cannot realistically be directly used in strategy formulation and assesement.

Formal models, may be well used, in providing such strategic decision support. For instance models may 'automatically' review companies for their 'acquisition potential' - the degree to which their acquisition would serve to enhance the goals of the firm. However, the effective use of such models requires the input of criteria that can only be generated by the organisation's managers.

These 'acquisition criteria', like strength and weaknesses, environmental opportunities, and a variety of other strategic information, must be developed through the organisational processes that are here termed as 'IRA'. The 'Strategic data bases' represent one way to implement IRA. They are concise statements of the **most significant** strategic parameters that will guide the use of the models that are in the IS and their application to the development of strategy. A set of criteria to be used in the evaluation of the acquisition of the candidates is a strategic database (SDB), if it is developed through an organisational process that ensures that the different points of view of the managers of various functions and poduct-market groups have been taken into account, that there is a reasonable degree of organisational consensus concerning it, and that it is accepted by the organisation's managers. So too may a concise of organisational strengths and weaknesses be a strategic database, if it has the same characteristics.

To illustrate this, consider, for example, the traditional process that might be used in an organisation to conduct a strength-weakness assessment. This approach commonly relies on staff analysts, who gather data and prepare documents which are to serve as background information for the support of planning activities and strategic choices. Because the planners and analysts, who perform these tasks, often have neither the managerial expertise nor the authority to make the significant choices that are involved in any information evaluation process, the typical output of such an exercise is a document, which seems to have been prepared on the basis of 'not leaving anything out'.

Such an emphasis on ensuring that nothing relevant is omitted rather than on attempting to distinguish the most strategically relevant information from the mass of the less relevant serves only to perpetuate the existing state of affairs regarding the informational support provided to managers at all levels: top executives and planners are deluged with irrelevant information, while, at the same time, they are unable to find the elements of information which are crucial to the identification of comparative advantages and to the determination of strategy.

The 'strategic database' approach to implementing IRA, on the other hand, involves the institutionalisation of ongoing process in which task forces, each of which is made up of managers representing various of the parochial interests, within the organiation, are charged with gathering and evaluating the data in strategic areas, such as, strength-weakness analysis, acquisition criteria, etc. In effect, these task forces use the information resources of the organisation to change and up-date its organisational stragegy set. Such 'strategic databases' prodcue and represent information in its most valuable form rather than data since, in this process, large quantities of data have been evaluated and condensed to a form which can be feasibly used in the direct support of strategic decision-making.

The strength-weakness, SDB may be, used as an illustration. A task force, composed of key managers in each of the major functional and product sub-units of the organisation, is charged with developing a **concise *concensus list of the most important strengths on which the company (business) should base its future* and the most significant,weaknesses on which it should avoid having its future become dependent.** Thus, a team is given the job of producing the strength-weakness 'answers' and of making the strategic information choices of those strengths and weaknesses on which the future will depend.

This team of managers, supported by their staff, is charged with arriving at conclusions concerning a specified approximate number (usually from 10 to 15) of the most important strengths and weaknesses which should influence the future of the organisation.

The development of conclusions on the 10 to 15 most important organisational strengths and weaknesses can be, as any experienced manager knows, a difficult task, when it involves managers representing various organisational interests and points of view. Developing a twenty page list of strengths and weaknesses could be accomplished relatively easily, but a list of the 10 to 15, most significant ones requires substantial analysis, debate and negotiation among the various individuals and interest areas that are involved. This is so both because of the judgements which are needed and the potential organisational impact which such a list will inevitably have as it is used in the development of strategy.

The strength-weakness, SDB, that may be so developed, is clearly a substantial basis for assessing potential comparative advantages, and for evaluating proposed strategies. For instance, once such an SDB is in place, proposed strategies. can be screened, using it as a standard, in a somewhat mechanical fashion, just as a proposed acquisition candidate might be 'automatically'screened using an 'acquisition criteria' SDB that has been similarly developed. In the case of the strength-weakness SDB, this would be done through the routine application of a set of questions:

a) Which specific strength of our firm does the proposed strategy build on?

b) What is the relative importance of each strength to using the proposed strategy in achieving the firm's goals?

c) Does the proposed strategy, implicitly or explicitly, assume the existence of some strength that the firm does not possess?

d) Is the proposed strategy explicitly or implicitly dependent on any weakness, even though it may be primarily based on strengths?

This illustration of a strength-weakness SDB process illustrates the information resources assessment process of Figure 3.3. It is a routine organisational process that is used to translate the informational resources of the organisation into sources of potential strategic comparative advantage.

It is, in effect, the mirror-image of the 'strategic planning for information resources' process, which makes the reverse transformation to ensure that business strategies are supported by appropriate information and knowledge bases.

3.12 MANAGEMENT STEERING COMMITTEES

Due to active involvement of human beings, organisational powers, needs and politics in the functioning of the MIS department, a steering committee composed of senior personnel from various user groups, such as, the finance and EDP function proves to be a better alternative to prepare the priority list for allocation of resources. Though this method also suffers from major disadvantages, such as, the time wasted on meetings and negotiations and powerful group politicking, some of the experts have considered the steering committee approach as the most suitable approach to get the best results in the MIS function. The user involvement can be ensured by having their representatives on the steering commiittee. A steering committee formed under the chairmanship of the chief executive with 5-10 members has been found to be an effective experience.

3.13 LOCATION OF MIS FUNCTION IN ORGANISATION

One of the issues of crucial organisational importance is that of the positioning of the MIS function in an organisation. Some researchers prefer a direct reporting of the chief of MIS function to the Chief EXecutive, whereas others have favoured a decentralized user group reporting. The alternative locations of the MIS function suggested by experts are as shown in Figure 3.4. The top executive of MIS could be:

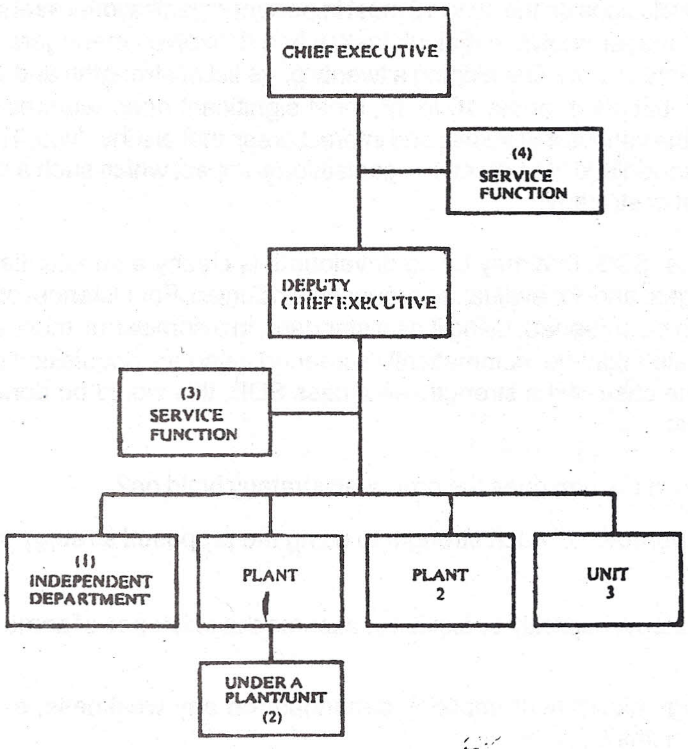

Figure 3.4: Alternative Locations for MIS Function

- a manager holding an independent charge of the MIS function equivalent to other line functions,
- a senior executive reporting to the user line managers,
- a service function reporting to the level of the top management,
- a service function reporting to the chief executive.

Partly due to historical reasons and mainly due to frequency and quantum of use, the MIS function is always found to be reporting to the accounting and finance function. The focus of the MIS function and its importance in any organisation is indicated by the reporting relationship. The MIS function pays more attention to the department, where it is located. Usually, the MIS function when placed under an independent charge is likely to do much more than providing just DP services. The following guidelines for fitting the MIS function into the overall organisation could be of help to the organisation :

- The level of reporting has a correlation with the performance of the MIS function. The organisation where MIS function reports to Chief Executive has showed a higher success rate; and,

- For enhancing capabilities of the MIS function beyond providing services to a select user group or limited range of services, it is very important to have MIS as an independent function.

3.14 THE FUTURE

Indeed, even the newly-emerging computer systems concept of 'information resource management' (IRM) merely 'upgrades' the computer system and its attendant information to the position of a resource that is to be husbanded and administered, much as are other organisational resources, such as, raw materials and labour.

Even Nolan's (1979) notion of evolutionary stages in the life-cycle of integrating data processing into an organisation does not deal with the realisation of the real potential of computers. In his 'last stage (VI) - Maturity' - he speaks of 'data resources management' in terms of 'the applications portfolio being complete' with its structure 'mirroring' the organisation and the information flows in the company. Thus even in the most advanced stage of development in Nolan's model, the computer resource is still treated as a service function rather than a strategic resource.

Such notions as IRM and a maturity state at which the computer system is operating synchronously with the organisation have clear merit. During the era when the computer was relegated to the back-room, it was not subjected to the same levels of 'hard nosed' management as was virtually every other element of the business firm. A basic management technique, such as, perfomance quotas which are common in areas as diverse as production and sales, have been only recently instituted in the computer area. Thus, better management is a clear need that has begun to be understood and implemented.

However, the potential for information management is much greater than that which is the province of IRM. There is a stage of development, only beginning to be perceived and realised, that goes beyond Nolan's notion of 'maturity'. The role of computer systems in organisations is beginning to change dramatically. With this changing role will come the potential for vast change in the impact of computers and for the realisation of a knowledge society.

This emerging role of computer technology in business is easy to envision. One need only view a major business firm to see that new computer-based technology is being introduced in quantity at many locations-word processing systems, electronic mail and filing, electronic communications networks, desk top computers, etc. Moreover, these technologies are rapidly being linked together into more comprehensive systems. For instance, the concept of a decision support system (DSS) reflects the integration of a number of technologies that have existed for some time.

A major implication of this explosion of technology is that far more people- from clerks to executive-will be directly involved with the computer system than ever were before. Computers and appurtenant technology will no longer be relegated to the 'back-room' as a specialised service function that has little to do with the day-to-day activities of most people in the firm. They will be 'out in front in virtually every office, workstation and production.

In the past, only a small number of computer specialists were in direct contact with, and were direct 'users' of, the computer system. In many organisations, one member of each department or unit has been specifically identified to perform this role.

With the technological revolution that is occurring, virtually everyone will be a 'user' of the computer system. This widespread 'intrusion of computers into the lives of so many, will have a profound impact, and while it will not be without problems, it will tend to increase understanding, reduce apprehensions, and enable many more people to better envision the widespread potential for computer applications. Heretofore, many such applications have been envisioned only by computer specialists, who often had difficulty selling their ideas to management or have gone unseen because computer specialists lacked the requisite business knowledge and experience to relate computer capabilities to business needs.

This pervasiveness of computers and the increasing familiarity of people at all levels of the organisation with them will, inevitably lead to a wide variety of new computer applications. More importantly, however, will be the amplification and acceleration of a phenomenon that is already beginning to be experienced - **the creation of a comparative business advantage through information.**

3.15 SUMMARY

The unit discusses various issues related to the management of information resource in organisations. Nolan's Six Stage Growth Hypothesis has been discussed to show how the MIS function grows in an organisation. Initially, the organisations commit their financial resources little realising that these commitments have to be carried on even subsequently. The control stage of this model explains the relevance of management intervention in the functioning of the MIS department, so as to develop certain control measures to avoid the unplanned growth of the MIS resource. It is during the second part of the growth cycle from the fourth stage onwards that the actual benefits of technology could be realised in organisations. There is a long felt need to plan for the growth of the MIS activity in the organisation. Top management interest is indicated by way of steering committees, set up to forward the cause of the MIS function and the relative organisational position of the chief of MIS function. A policy for charging for the services rendered to the users could be in the interest of the MIS function, because only then the function can justify its existence. Critical success factor analysis has been identified as the best approach to assess the need for this function in any organisation.

3.16 SELF-ASSESSMENT EXERCISES

1) How do you trace the growth of MIS function in an organisation?

2) What is the relevance of the Nolan's Stage Growth Model for the study of information systems in today's organisation?

3) "The success of MIS function in any organisation will depend upon the relative position of the Chief of the MIS function in that organisation." Comment.

4) What are the different ways of allocating resources to different applications in an organisation?

5) "Management Steering Committees are the biggest hurdle in the growth of MIS function in an organisation." Discuss.

6) Evaluate Critical Success Factor Method for the purpose of Information Requirement Analysis.

3.17 FURTHER READINGS

`Davis, Gordon B. and Margrethe H.Olson, 1985. *Management Information Systems - Conceptual Foundations, Structure and Development (2nd Ed.),* McGraw Hill Book Company.

Dickson, Gary W. and James C. Wetherbe, 1985. *The Management of Information Systems,* McGraw Hill Book Company.

Jackson, Ivan F., 1986. *Corporate Information Management,* New Jersey, Prentice Hall.

Nolan, Richard L., *"Managing the Crisis in Data Processing,"* in Harvard Business Review, March-April, 1979.

Nolan, Richard L., "*Managing the Information Systems by Committee,"* in Harvard Business Review, July-August, 1982.

Management Information Systems : The Technology Challenge Edited by Nigel Piercy, 1987; Croom Helm London & Sydney Nichols Publishing Company : New York.

BLOCK 2

SYSTEM DEVELOPMENT

This block attempts to give you an understanding of the various aspects of system analysis, design, development and implementation of various kinds of computerised systems.

Unit 4 describes various kinds of systems, the steps involved in system analysis and how to design a system.

Unit 5 on System Development Life Cycle explains the system development life cycle and stresses the importance of each stage.

Unit 6 on Designing On-line and Distributed Environments explains the system design features of an on-line system and how the various computer system concepts are related to it.

The seventh and the last unit in this book on Implementation and Control of Projects describes the various options which can be adopted in implementing a system and the related problems of security and control.

UNIT 4

OVERVIEW OF SYSTEMS ANALYSIS AND DESIGNS

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

- understand the concept of System
- understand what and why of Systems Analysis
- develop a broad appreciation of Systems Design.

Structure

4.1 INTRODUCTION

You have already received a fairly good idea of System in Unit 17 of MS-7. If you have forgotten about it, you will need to recollect it. This unit, apart from briefly repeating some of the ideas, further builds upon them.

Some definitions:

- Webster unabridged dictionary describes system as a set or arrangement of things so related or conneted to form a unity or organization
- A system is an organized, interacting, interdependent and integrated set of components variables parts. A system has objectives or goals (Lucas, 1985, p.5)
- A system is a set of elements forming an activity or a processing procedure or a scheme, seeking a common goal or goals by operating on data/and/or energy and or matter (inputs) in a time reference to yield information and/or energy and/or matter (output) (Murdic Ross and Claggett, 1990, p. 15).

4.2 SYSTEMS CONCEPT

There are several ways of classifying systems. Three such classifications are: (1) natural of man-made; (2) closed or open; and (3) conceptual or physical.

NATURAL SYSTEMS occur in nature e.g., solar system. On the other hand **man-made systems** are deliberately created for specific objectives. For example, Defence System, Disposal System, Organizations etc.

Closed systems theoretically, are self-sufficient and have no interaction with their environment. In practice, those, which are relatively cut off from the environment are termed as closed. For example. Dry Battery Cell.

Whereas **open systems** exchange information and or energy and or material with their environments. As members (parts) of a system they receive from the environment as inputs and give to the environment as outputs. For example, Man, Living Beings, Business Organizations.

Conceptual systems are theoretical in nature and deal with concepts which may or may not physically exist. Somtimes it may be possible to convert a conceptual system to a physical system, for example, Social System, Econimic Theory etc. In contrast **physical systems** physically exit in real world. They are generally man made, e.g., Production System, Power Generating System, Fire Control System etc.

These classifications are not exclusive. For example, there can be a system which is man made, open and physical.

Characteristics of a System as outlined by Schroderbek are:

1) A system is a whole.
2) Components of a system interact.
3) Systems are goal seeking.
4) Systems have input/output.
5) Systems transform inputs to yield output.
6) Systems exhibit entropy.
7) Systems must be controlled.
8) Systems form a hierarchy.
9) Systems exhibit differentiation.
10) Systems exhibit equifinality.

In subsequent sections, we will be particularly interested in open, physical man made systems such as Organizations an Mangement Information Systems.

4.3 SYSTEMS ANALYSIS – WHAT AND WHY

What is Systems Analysis?

Harry Goode and Robert Machol's view of Systems analysis is quoted below:

For more than a decade, engineers and administrators have witnessed the emergence of a broadening approach to the problem of designing equipment. This phenomenon has been poorly understood and loosely described. It has been called **Systems design, Systems analysis** and often the **Systems approach.** Rarely does the speaker using these terms intend to convey those concepts which are brought to the minds of his hearers, nor for that matter are any two hearers likely to be in agreement.

Analysis of the system means identification, understanding and critically examining the systems and its parts (sub-systems) for the purpose of achieving the goals (objectives) set for the system as a whole, through modifications, changed interrelationships of components, deleting or merging or separating, or break up of components. It may also involve upgrading the system as a whole.

The methodology of systems analysis involves (1) identification of the system (setting system boundary), the system objectives, the system elements (components); and (2) understanding the role and interrelationship of elements with other elements of the same system.

Through this identification and understanding process; (1) the capability (or background) to analyse and compare various alternatives regarding components and (2) system functioning vis- a- vis the system objectives, is generated. Outcome of the systems analysis job is a set of recommendations towards creating a system which best meets its objectives giving due regard to cost-effectiveness and the risks.

Systems analysis, thus, emerges as a means through which the total system is conceived, designed, implemented and made operational to achieve the desired objectives. The basic objective of systems analysis is to understand and modify the system in some way to improve its functioning. The modification may require one or more of the following : change the outputs, change the goals of the system, make it more efficient, have different set of inputs of improve in some other way or even create a new system.

Why Systems Analysis?

The understanding of what systems analysis is in itself provides an insight into its importance and why it is needed. Systems analysis basically is an approach towards viewing the processes, activities and complex problems in their totality. Thus specifically:

- It offers a means to greater understanding of the complex structures
- It is a means to trade off between functional requirements of a subsystem (component) and its immediately related subsystems.
- It helps in understanding and comparing functional impacts of subsystems to the total system
- It helps in achieving inter-compatibility and unity of purpose of **subsystems**
- It helps in discovering means to design systems where subsystems may have apparently conflicting objectives
- Finally, it heps in placing each subsystem in its proper perspective and context, so that the system as a whole may best achieve its objectives with minimum available resources. It thus creates synchronization between systems and objectives.

Thus, systems analysis is one of the important techniques that provides a systematic and broader outlook to understanding, examining and creating or modifying systems to meet specific objectives. Systems analysis and design is an interactive and creative process.

4.4 OVERVIEW OF SYSTEMS DESIGN

Having seen what is systems analysis and why it is done, let us examine how the objectives of the organization influence the objectives of Systems Design and then examine in stepwise manner how it is done in this section.

4.4.1 Objectives of Systems Design vs Objectives of the Organisation

Many authors have discussed the term and the process of system design from the viewpoint of developing specific computer applications or programs. Though the broad steps are basicaly the same, the magnitude of the task is much larger when viewed from the point of developing MIS for the organization as a whole. Usually the steps follow what is termed as 'life cycle stages'. Since basicaly a Management Information System is expected to help the organization and the management in the discharge of their functions it is imperative that the MIS system development effort begins by understanding the organizations's objectives. For these are required to be translated to constitute objectives of the MIS.

The following schematic diagram (Figure 4.1) gives an overview of the broad steps involved in MIS design/ development process. For better understanding of the design process, it has been divided into these broad categories. Essentially a designer will have to think of all stages simultaneously irrespective of the fact at which stage he is. He doesn't proceed by completing one stage and moving on to the next stage and not considering previous or subsequent stages.

Overview of MIS Development

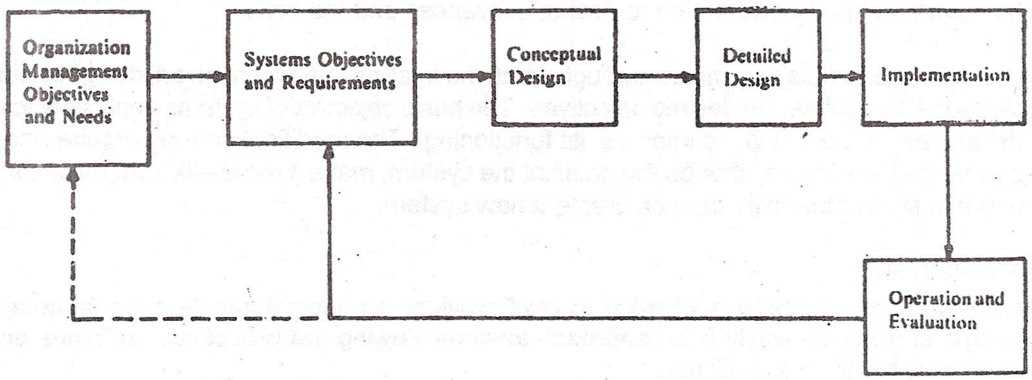

Figure 4.1

The broad stages involved in MIS development as depicted in Figure 4.1 are : Organization, Management objectives and needs, which are converted to systems objectives (and corresponding broad requirements to meet these objectives are estimated) followed by a conceptual design, feasibility of various alternative ideas for each of the system elements in the light of the systems objectives and the resources available is tried out at this level. This conceptual design is converted into detailed design specifying each action in precise and physical context for each element of the system. Finally system implementation and evaluation takes place, which continues over a period of time. If need be, the whole process from stage 2 is repeated. In exceptional circumstances, generally when major changes at organizational level, or technological level or in the environment take place the connection to stage I is shown through dotted lines. This would mean that a new system is to be designed and the whole process repeated.

In the first stage, the understanding of the organization's and management's objectives leads to appreciation of key areas or the thrust areas of the organization and is helpful in setting broad objectives for the MIS such as major reliance on models, development of forecasting techniques, or large storage and retrieval capability, or faster on line requirements, or may be in some cases the major activity would be routing reporting and storage. Any one or combination of these broad **objectives of MIS** would be possible, only through management and organization objectives. These broad objectives would be further refined and specified in detail running through various levels of management and various functions of the organization.

MIS objectives must be consistent with the corporate plans. A set of corporate strategic guidelines will help generate MIS objectives and should coincide with the corporate operational schedules with respect to timings.

4.4.2 Study of Existing System

Unless it is entirely a new activity or new organization for which MIS is to be developed, there is always some existing system, formal or informal or even trivial. As such there is need for intensive study and critical examination of the existing system.

Since the need for a new system has arisen either because of some type of dissatisfaction with the existing system, or the objectives and need of organization as well as MIS have been drastically changed, change in the existing system or a new system is required.

There are two schools of thought regarding whether, for development of a system, the old system should be studied or not? One school of thought is for and the other against. The argument against is that it inhibits the generation of new ideas and may bias the designer towards the same logic which is contained in the old system. Whereas the other school argues that through study of existing system one learns about its shortcomings and may use this knowledge to avoid committing the same mistakes again. Both arguments are valid. We suggest the study of the existing system, if any, to learn more about the total system.

The study of the existing system should cover its objectives, processing procedures, equipment and facilities, organization, system documentation, conduct of operations, files and records, volume and types of information processing, and inputs and outputs and their frequencies. All these need to be studied in detail in relation to the objectives of the existing system and also in relation to the revised objectives which have been framed as discussed in the previous section. It should create intimate understanding of the existing system - to what extent it was able to meet the existing objectives, what were its shortcomings and what more is required (modifications/comeplete change) to meet the revised objectives.

4.4.3 Conceptual Design/Feasibility Study

The term conceptual design has been interchangeably used with gross design, feasibility study, high level design, and in some cases, even with preliminary design by various authors. The use of these different terms gives a broad idea of the fuctions performed in this phase of conceptual design.

These functions, at this stage, are at a very general level. Finer and finer details are taken up as we progress through detailed design/physical design implementation, evaluation etc. Here we consider various broad alternatives to match the system objectives, user's requirements with due regard to cost and saving factor. The outcome of this stage is in the form of broad suggestions e.g., central data base/distributed data base; batch processing/on-line processing; etc. It could also specify upper and/or lower limits of peak and average processing loads. Thus the accent is on comparing, analysing, matching various alternatives and combinations.

Even though system objectives in relation to managenent/organization objectives have already been discussed, they are again reviewed and made more specific with respect to peak level processing loads, complexity of processing, time frame for various types and categories of output, frequencies of occurrences, communication needs etc.

On the other side,assessment is also made of the restrictions or constraints on the freedom to develop MIS. These restrictions may be external or internal and may be with respect to content, processing requirements, procedures, inut/output formats,data frequency; data accuracy, units of measurement etc.

External constrains may be due to government, customers, suppliers, unions, social groups etc. Internal constraints can be due to the areas of operations of the organization, its policies, attitude and support of top management, the prevalent work culture within the organization, cost and resources for the proposed system, willingness of the user employees, availability of required skilled manpower, internally and externally, etc.

Identification, recognition and understanding of both internal and external constraints is **curcial** to designing a viable system. As part of the design effort, the designer provides for these restrictions and knows to some extent what he can do and what he cannot do to attain the stipulated objectives of the system. In the process, sometimes he may have to review/or prune the systems objectives or he may try to overcome some of the restrictions. This exercise is also a basic part of feasibility analysis at a general level.

The systems objectives are transformed into specific information needs of the organization or, for that matter, of the manager users. A clear understanding and aggregative view of management's information needs is the base on which the whole structure/design of MIS is erected. Thus information needs which can really help the management in discharge of their functions are identified.

Special efforts are needed for assessment of organization as well as user manager's information needs. Various approaches are recommended:

i) Detailed study of existing output reports, processings, records, memos, files etc. with respect to important positions in the organisations;

ii) Analysis of existing organization structure of the company to understand the job responsibilities and job functions performed by each position in the company; this knowledge is later converted to information needs. The understanding of organization struture is supplemented by study of nature of the company, the business the company is in and its critical areas of operation;

iii) Interview of individual managers, to understand their specific requirements. This approach may prove to be by far the most ticklish because usually managers are not in a position to pin-point what they need and when they need it. The MIS designer/analyst has to approach and interview managers with utmost caution and after having done thorough homework.

iv) Circulate questionnaires to get an idea of information needs.

There are several other approaches, but the designers have to take a judicious decision regarding an approach or a combination of approaches to understand clearly the management's information needs.

These information needs are required to be evaluated to ascertain the sources of information (for identifying input data--what, from where, when,what format etc.) and storage pattern and requirements. Also information needs are required to be translated and matched to processing requirements and capacities.

For determining sources of information, almost same approaches are applicable as have been discussed for need assessment; but not necessarily the same combination is applicable here. The internal records, files, books, blueprints, statistical and accounting documents, and understanding of the internal operations of the company are all helpful in this regard.

Preparation and use of input-output charts, information flow charts, activity flow charts, operation flow charts, multidimensional flow charts are helpful and add to the understanding of sources flow and information processing requirements. **External** sources vis-a-vis management requirements are also a critical avenue for investigation. These are vital at the highest level of management for policy planning and strategic functions. Figures 4.2 and 4.3 are examples of input-output charts and information flow charts.

The repeated identification and analysis of sources and processes requirements iteratively **leads to a match** against previously determined information needs. All these steps and the use of various techniques discussed so far, also help in identifying origins and destination of information and help in establishing progression of information through the organization. They also help in arriving at better understanding and estimates of frequency, volume, time processing, storage, cost and communication requirements.

In the context of understanding generated with respect to MIS objectives, information needs, sources and processings; the conceptual design development activity is taken up. Conceptual design is a sketch of the structure of MIS listing broad guiding policies as well as restrictions within which the detailed design development can be undertaken.

The conceptual design, or for that matter any design, is a creative activity. It should come out with broad viable alternative combinations of input, storage, processing, communication and output to be able to generate various conceptual designs of MIS. viz.

INPUT / OUTPUT — BEFORE ANALYSIS

INPUT	Pay checks	Payroll file	Payroll Summary	FICA report	FICA tax	Fed report	Fed tax	Union relations	Govt. Audit	Legal	Overtime management	Credit Union	Absentee management
Time card													
Name	•	•		•		•			•	•	•	•	•
Start time	•							•		•	•		•
Stop time	•							•		•	•		•
Hours worked	•		•					•	•	•			
Overtime	•		•					•	•	•			•
Payroll File	•												
Name	•			•		•							
Exemptions	•								•				
Wage rate	•							•					
Wages paid	•	•	•	•	•	•	•		•	•		•	
FICA paid	•	•	•	•	•				•	•			
Fed tax	•	•	•			•	•		•	•			
Badge door control													
Name	•							•			•		•
Time in	•							•			•		•
Time out	•							•			•		•
Fed tax tables	•												
Mgt report													
Name	•							•			•		•
Vacation								•					•
Illness								•					•
Overtime	•							•			•		•

INPUT / OUTPUT — AFTER ANALYSIS

INPUT	Pay checks	Payroll file	Payroll Summary	FICA report	FICA tax	Fed report	Fed tax	Union relations	Govt. Audit	Legal	Overtime management	Credit Union	Absentee management
Name	•	•		•		•		•	•	•	•	•	•
Start time	•		•					•	•	•	•		•
Stop time	•		•					•	•	•	•		•
Exemptions	•												
Wage rate	•							•					
Wages paid	•	•	•	•	•	•	•		•	•		•	
FICA paid	•	•	•	•	•				•	•			
Fed tax	•	•	•			•	•		•	•			
Fed tax tables	•												
Vacation								•					•
Illness								•					•

Fig. 4.2 : Input/Output Chart (Payroll System)

Source : Murdic and Ross, **Information System for Modern Management.** Prentice Hall of India, N. Delhi

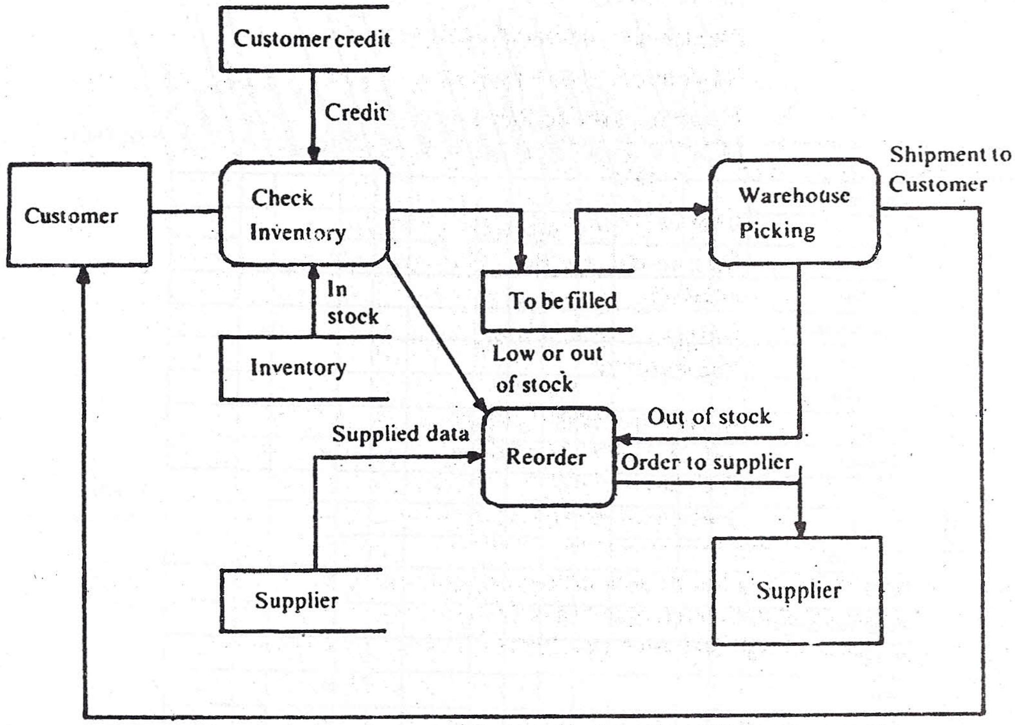

Figure 4.3: Information Flow Chart (Reordering)

Source Lucas : *The Analysis Design and Implimentation of Information System.* McGraw Hill Book Company. N.Y.

Element		**Alternatives**
Inputs	-	Largely internal/external or both, specifying whether emphasis is on internal or external sources.
	-	Specific, routine or presently not known
	-	Accuracy levels - high/medium/approximations or combinations
	-	Time lag of capture-instant, immediate or delayed (say,per shift, hourly, daily, weekly).
Data base	-	Centralised/distributed
	-	Large capacity/medium capacity/low capacity
	-	Retrieval - Random access storage/sequential access storage
	-	Is it largely sequential/relational/relational/etc.?
Processing		Largely batch/on-line/or a combination
	-	Complex, e.g. use of sophisticated models/ scientific requirements/ graphics/CAD/CAM etc; Not complex e.g. word processing
Communication and output	-	Instant/time lag/specified intervals
	-	Written/verbal/visual (VDU) / Graphic etc.

- Direct/routed through
- Frequency - instant/daily/weekly etc.
- Routine/ad hoc/on demand
- Reports/query/dialogue, etc.

For example, one of the outcomes could suggest:

Input	-	Internal, highly accurate, instant
Data base	-	Distributed, random & sequential access, medium capacity at each location.
Processing	-	Complex, scientific application. on-line printing as well as graphic requirements
Communication and output	-	On-line between various depts: text and VDU, both. direct; routine and ad hoc both: reports, query and dialogue but more emphasis on query and dialogue between de partments as well as man machine.

Thus, for the same match of information needs, processing and source (input) requirements, there could be several such alternative combinations, each alternative being viable. These alternatives need to be compared to choose one so that detailed design and later on implementation could be started. The basis of comparison could be:

1) **Anticipated performance :** Each alternative should be objectively assessed at conceptual level as to what extent it meets the MIS objectives stated earlier and to what extent it meets the company requirements.

2) **Cost-effectiveness :** Some type of cost-benefit analysis is performed for each alternative. Rough projections of equipment requirments and costs, operational, costs, manpower costs, maintenance costs etc. need to be made. Projections of potential tangible as well intangible benefits are also needed to be made. For example, tangible benefits can result from such modes as reduction in present or future manpower requirements, savings resultant to a particular alternative such as reduced inventory, reduced scrap, faster receipts faster reconciliation, reduction in loss due to frauds e.g., in banking etc. Some intangible benefits are ability to obtain information which was previously not available, faster or timely receipt of information, improved or better decision making, improvement in planning and control etc.

3) **Operational Basis :** For each alternative, analyasis required to assess the strong and weak points in respect to quality of data base, quality of information, ability to withstand peak loads of storge as well as processing, ability to anticipate preparedness to take up ad hoc demands, avoidance of duplication etc. Broadly, what needs to be assessed is, "will it work when implemented and to what extent?"

4) **Technical Basis :** It is also important to project each alternative with respect to technological requirements in storage, processing, commuication, output etc.,and assess: Are they easily available? Will they be within the budget? Does it match the present and future needs? Is it too sophisticated for the staff of MIS to handle and accept? Is it too complicated for the users? These are some of the questions, that need to be asked and answered to compare various alternatives on technical basis.

The final chosen conceptual alternative, is meticulously documented in specific terms. It also contains as attachments the charts, forms,and comparison analysis which has been performed to arrive at the final outcome. The top management of the company reviews it in consultation with systems people. If approved, then detailed design activity is undertaken.

4.4.4 Detailed Design and Implementation - Brief Description

These two phases of the total system design activity will be discussed at length in later units. specially implementation phase in unit 7. A brief description is felt necessary at this point, so that you appreciate that the conceptual design in itself is not the end of the design activity.

The basic task of a detailed design task is to convert the broad concepts of the earlier phase into very specific and detailed description of all the activities needed to produce a physical system that actually operates. Thus the outcome of this activity is specific unlike earlier phase i.e.. conceptual design/ feasibility study which gave vague broad guidelines.

Thus, detailed design phase will provide detail specifics with reespect to:

Input/out put forms: What information, from where, when, in what format would be entered; similarly for outputs.

Data Bank: It includes the exact description of storage of input information including the equipments, the input devices and procedures and output devices and procedures. On the whole, the Data Bank Management in its totality would also include detailed file descriptions and design.

Processing: Description of models, procedures and handling/ manipulation of information to come out with adequate outputs.

Equipment (Hardware): Computer capabilities, capacities, requirements, input devices, output devices, communication devices, and other supporting devices.

Procedures (Software) : Rules, standards and procedures, application and systems programs.

Internal Organization: Organization structure to operate and maintain the system department should include job descriptions, number of personnel at each level and the skills, may be payment packages etc.

The final outcome is in the form of a completely documented report which on implementation results in a real physical operating system. It is like an engineering specification of blueprint of products made available to production shops for manfacturing.

When detailed design specifications are available the implementation activity phase starts. The basic function of this phase is to transform the specifications into physical realities- to come up with a physically operating system. as per specification, on schedule, within stipulated costs, to match the system and company requirements.

Briefly the activities performed in implementatin phase are:

- prepare the implementation plan-use or Gnatt Charts of CPM/PERT networks advisable.
- acquire and layout floor space.
- recruit personnel.
- train the operating and user people.
- obtain and install hardware equipment.
- develop and test software including programs, design of forms (input as well as output). files, data base etc., and
- finally testing and re-testing various components of the system before the operation maintenance phase.

All these would be discussed in greater detail in Unit 7.

4.5 SUMMARY

There are three types of systems:(1) natural or man-made (2) closed or open; and (3) conceptual or physical. In this unit we referred to open: physical man-made systems such as Organizations and Management Information Systems. After examining the 'what' and 'why' of systems analysis, it was seen that analysis of the system involves identification, understanding and critically examining the system and its parts (subsystems) for the purpose of achieving the objectives set for the system as a whole, through suitable modification of its components. Finally, actual system design is done by identifying system objectives and boundaries, conducting feasibility study, developing the system design in detail and the implementing it at the user site.

4.6 SELF-ASSESSMENT EXERCISES

1) Explain a system. why is systems view justified towards organizational information needs?
2) Why analyse a system?
3) Describe the major phases in MIS design. Can you compare these phases with Research and development projects?
4) Why is conceptual design also sometimes called feasibility study?
5) Prepare an information flow chart for a major/minor activity that you are performing in your job or you are familiar with.
6) Prepare a complete list of information requirements related to your job - also specify timings, that is, when do you need them.
7) Is it possible to design and implement a mini MIS related to your job activities? Try to design one.

4.7 FURTHER READINGS

Bhatnagar, S.C. and K.V. Ramani, 1989. *Computers and Information Management- A Printer for Practising Managers.* Prentice Hall of India, New Delhi.

Davis, G.B. and M.H. Afson, 1985. *Management Information Systems: Conceptual Foundations, Structure and Development,* McGraw Hill: New York.

Harry H. Goode and Robert E. Machol, 1957. *Systems Engineering*, McGraw Hill: New Ysork.

Kenter, Jerome. 1984. *Management Infromation Systems,* Prentice Hall of India: New Delhi.

Lucas Jr. H.C. 1982. *Information Systems Conecept for Management,* McGraw Hill: New York.

Murdic, R.G.. R.E. Ross and R. Claggett, 1990. *Information Systems for Modern Management,* Prentice Hall of India: New Delhi.

Srivastava, S.S. *Management Information Systems and Computers,* Atma Ram and Sons: New Delhi.

Schroderbeck, P. 1971. *Management Systems,* Wiley: New York.

UNIT 5

SYSTEM DEVELOPMENT LIFE CYCLE

Objectives

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

- understand the mechanism involved in the system development life cycle,
- differentiate between various stages of system analysis and design,
- appreciate the efforts involved in and criticality of each stage.

Structure

5.1 INTRODUCTION

Regardless of where the data or information processing system has been implemented, what functional area it addresses, what level of management it caters to and who has designed, developed and implemented it, the growth of an information system passes through various identifiable stages and all these stages put together are referred to as the System Development Life Cycle.

The system size, complexity and coverage do not affect these stages. Any system designed for processing of information revolves around a life cycle that begins with the recognition of the problem and ends up with development and implementatin of the system.

To appreciate the stages involved in design and development of an information system and the efforts required to build up these systems, it is a must that managers should be familiar with the distinct stages of this cycle. The present study unit discusses these steps and related issues.

5.2 MODELS OF INFORMATION SYSTEMS

The information systems are considered to be evolved through three different levels of systems. These are:

a) **Conceptual System:** Every information processing system is evolved by way of a concept when somebody imagines that the organisation should have such and such a system to accomplish such and such an objective. A system so conceived may or may not be attained in reality. A conceptual model is no more than an idea.

b) **Logical System:** When the conceived system model is further worked out to design new ways to accomplish the objective set out in the conceptual system, it becomes the logical system design. A logical system design necessarily includes understanding of the flow of information, logic of processing and input-output relationships. The Data Flow Diagrams Flow Charts etc. are the basic components of the logical models.

c) **Physical Systems :** When the logical models are developed to actually deliver the desired results, it is referred to as a physical system model. The physical system model can be tested and implemented. It consists of the programs, data files and documentation.

5.3 SYSTEM DEVELOPMENT LIFE CYCLE

System development is an iterative process and it cosists of the following identifiable stages:

a) Problem Definition

b) Feasibility Study

c) System Analysis

d) System Design

e) System Development

f) Implementation

g) Post- implementation Maintenance & Review

In practice, these steps may or may not be clearly defined in a given system, and there is a possibility of an overlap of these stages. It is quite likely that while the system analyst is working on a particular stage, he is also considering possible solutions related to the next phase. There is always a possibility of coming back from an advanced stage to revise or review the decisions taken in the earlier phases.

Errors are costly in system analysis and design. But these become more and more costly as you keep going from an earlier stage to an advanced stage. It could be seen from Figure 5.1. The cost of fixing an error detected n the earlier stages is lesser as compared to the same detected at a later date. The simple reason for this is that an erarly detection of error will necessitate revision of fewer decisions whereas a late detection of an error will require revision of all the steps taken so far. So utmost care is nesesary on part of the system designers, while going through various stages.

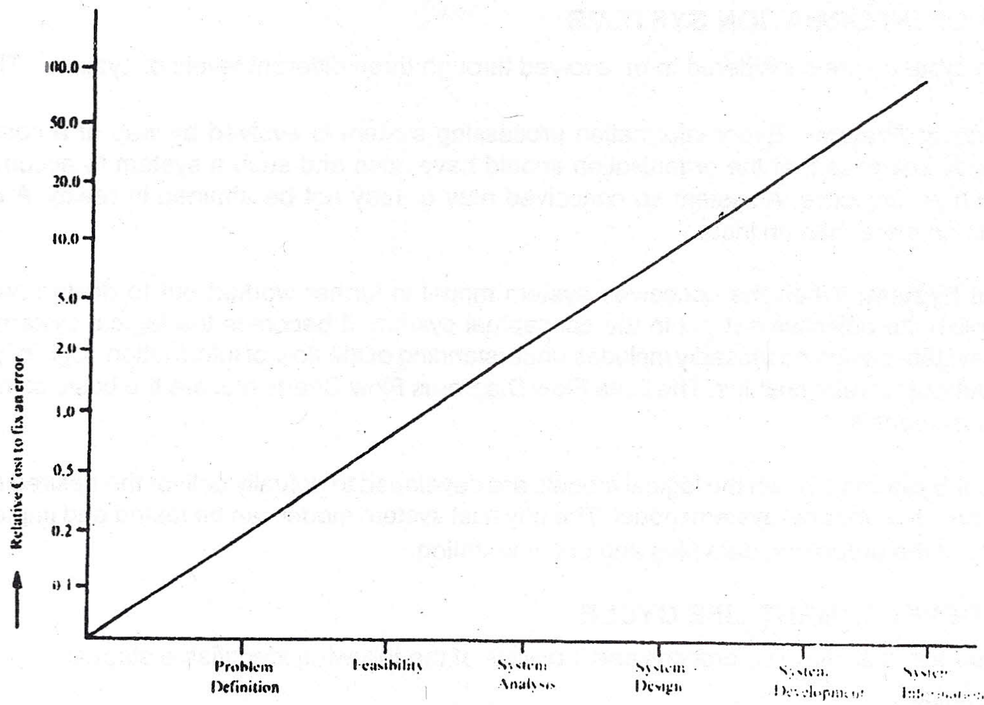

Fig. 5.1 Stages and cost of fixing an error

Every stage of the system development life cycle is marked by an identifiable end- result as well as sub-activities. These stages and the various activities involved are given in Table 1.

Tabel 1

Stage	End Result
Problem definition	Statement of Scope and Objectives. Performance Criteria.
Feasibility Study	Economic/Technical/Political/Feasibility Report. Financial Viability and Modification of System Scope & Objectives, if any,
System Analysis	Logical Model of the system consisting of details such as data flow diagrams,data dictionary, etc.
System Design	Alternative solutions along with revised cost-benefit analysis, hardware specifications, manpower requirements, plan for implementation, user sign- off, test plans, formal system test procedures, security, audit and operating procedures.
System Development	Actual programming as per the user sign- off, compilation and testing of the programmes.
System Implementation	Training of the user, staff, system documentation, implementation.
Post- implementation maintenance & Review	Refined and Tuned system along with revised documentation, satisfied users.

5.4 PROBLEM DEFINITION

Orgnisations face problems during their operations and come across opportunities which could be converted into profitable solutions. Whenever there is an opportunity and/or problem in the existing system or when a system is being developed for the first time the organisation considers designing a new system for information processing.

The organisation may face a problem or get an opportunity due to:

- a new product/plant/branch/market/process
- a failure of an existing system
- inefficiency of an existing system
- programming errors in the existing system

and therefore, a thorough analysis of the situation is required.

For identifying problems and/or opportunities, we scan:

- the performance of the system
- the information being supplied and its form
- the economy of processing
- the control on the information processing
- the efficiency of the existing system
- the security of the data, software, equipment, personnel etc.

After identifying the problem, it is defined and a general direction for solving this problem is also determined. The project boundaries are also defined. The management also establishes the terms of reference as well as the resources to be provided for the project.

Final output of this stage is **Terms of Reference.**

5. 5 FEASIBILITY STUDY

After the user has identified the need for a new system, his requirments are determined and the terms of reference are established. The proposed system has to be viewed from the practical utility and acceptability dimension. A few questions which are usually asked during this stage are:

a) Is the proposed system worth developing?

b) Will the proposed system contribute by way of improved efficiency, productivity or organisational effectiveness?

c) Will the system improve information availability and be cost-effective?

d) What will be the system development costs and will these be justifiable?

e) How will the user departments take this system and what will be the overall impact of this system on the organisation?

The key considerations involved in the feasibility analysis are:

- Economic
- Technical
- Behavioural

The economic feasibility will only consider the cost/benefit analysis of the proposed project. The benefits are always expected to be overweighing the costs.

The technical feasibility always focuses on the existing computer hardware and software. This also includes the need for more hardware or software and the possibility of procuring/installing such facility.

The behavioural feasibility includes a study of the organisational behaviour. An estimate of how strong the user reaction will be to the new system, will have to be made at this stage.

The final output of this step is a **Feasibility Report** having discussions on Financial Feasibility, Economic Viability, Technical Feasibility and Social Acceptability of the proposed system.

5.6 SYSTEM ANALYSIS

The system analysis includes review of the existing procedures and information flow. Decision making and individual information needs at various levels in different functional areas are also reviewed. The system analysis phase primarily focuses on isolation of deficiencies from the existing system.

The fundamental activities involved in the system analysis are:

- definition of the overall system
- separation of the system into smaller and manageable parts
- understanding the nature, function and interrelationship of various subsystems.

The analysis of the information systems could be done with the help of various tools of system analysis. Some of the tools which are available with the system analysts are:

Review of Documentation: Documentation on the existing system could be reviewed and analysed to study the objectives, reports, procedures being followed and equipment being used. The only limitation with this technique is that the documentation on any existing system is never complete and up-to-date.

Observation of the Situation: The system under study can always be observed by getting involved in the system. The system analyst can work in the system or can be a mere observer. The exercise is time consuming and costly. Also it has an inherent limitation of the fact that the analyst may never be able it observe the intricacies of the system.

Conducting Interviews: The system analyst can conduct interviews with the user managers and ask questions related to their job responsibilities. The interviews could be formal or informal ones and may span over a period of time. Teh limitation of this tool is that the user manager may not be able to explain the problem in detail.

Questionnaire Administration : A printed structured or unstructured questionnaire may be administered to find out the information needs of individual managers. The questionnaire survey does help in saving time as compared to interviews as well as gets more committed data. But it is impossible to design an exhaustive questionnaire to cover various aspects of the system under study.

The analysts use a combination of all the tools to analyse an existing system. The analysis phase is a time consuming phase and yet a very crucial phase. The final output of this phase is a functional specification report of the existing system.

5.7. SYSTEM DESIGN

If the system analysts phase defines the way things are, the system development phase defines the way things should be for the same problem.

The system development phase includes mapping of the business requirements of the managers on to the proposed system. The conceptual design of the model which has been developed in the problem definition stage is enlarged to understand the actual flow of data and the logical model is developed. The logical model is worked out to finally develop and test the physical system in the system development phase.

The system design should be as hardware and software environment independent as possible. The system development team should always keep in mind the cost-effectiveness. This phase includes development of the following:

- Output Definitions
- Input Definitions
- Data Element Dictionary
- Programme Specifications
- System Specifications

During the system development, the analysts also undertake the codification and compressing of the data to:

- use lesser magnetic storage space
- commit lesser mistakes while entering data
- maintain uniformity of data
- incur lesser cost in entering, updating, processing and storage of data.

Output Definitions : Are there detailed reports, screen and file layouts which will be outputted by the programs throughout the system? The system analyst is required to consult the user in finalising the system outputs.

Input Definitions : The data coming into the system has to come through some input formats and these formats are defined by the design of input documents.

Data Element Dictionary : A Document which contains bonafide details of each and every data item used in the system is called a data dictionary. The data dictionary contains the following details regarding the data items:

Name
Description
Source
Usage
Maintenance
Storage
Organisation

Programme Specifications : The actual logic up for individual programmes is defined in the Programme specifications by way of decision tables,decision trees and program flow charts. The program flow charts could be drawn for individual programmes or parts of the programmes . These tools are necessarily used for storing the logic of processing in individual programmes for future reference. The logic could also be stored by using English language which is also referred to as pseudo code.

System Specifications: The system specifications include description of the relationships of various modules of the system among each other and relationships between different programmes within a subsystem. Though the system specifications do not give the details of logic being followed, it gives the flow of processing among the programmes, files and reports. Apart from using descriptive English, the system developers also use System Flow Charts for depicting system specifications.

The end result of this phase is a design specification report which includes the existing system, the proposed system, system flow charts, modular design of the system, print layout charts, data file designs etc.

5.8 SYSTEM DEVELOPMENT

Following the modular design of the proposed system, the system analysts assign specific responsibilities to the programmers who develop and test the programmes. The development and testing of the systems take place in a phased manner:

* Development and testing of the individual programmes
* Development and testing of the individual programmes as a part of the system modules
* Development and testing of the system modules as a part of the major subsystems
* Development and testing of the major subsystems as a part of the proposed system.

The development of the system includes writing of the actual programmes to handle data. Excellent programming skills and experience are required for this phase of the system development life cycle. The basic activities involved in this phase are:

- Checking of the programme specifications received from the system development stage and expanding these specifications
- Breaking the system modules into smaller programmes and allocating these programmes to the members of the system development team
- Producing the programme code in the chosen computer programming language
- Defining the interfaces between various programmes and designing tests for checking their interfaces
- Ensuring the data availability for individual and integrated testing
- Checking the quality of the code and its adherence to the established standards
- Prepare the documentation for each one of the programmes
- Receiving the user data for acceptance testing
- Getting the user sign - off after the acceptance testing

For development of the proposed system, it its important that all possible support should be provided to the development team. This support includes availability of:

- Office Space
- Relevant Data
- Secretarial Assistance
- Access to key functionaries throughout the system development effort.

The final output of this phase is a fully developed and tested software system along with complete documentation and testing results.

5.9 SYSTEM IMPLEMENTATION

Once the system has been declared fully developed and tested by the development team, it is ready for implementation with the user department. The involvement of the user is necessary throughout the project duration, but the user involvement is critical during this phase.

The implementation includes the following activities:

- Planning for implementation
- Preparing the schedule for implementation
- Procurement of hardware
- Installation of software
- Operation and testing of software on hardware
- Recruitment of operating personnel
- Motivation and training of the selected personnel and users
- Conversion of data files from old system
- Final changeover
- Operation and production

Once the system has been implemented, the systems group provides outside support to the user group and trains the user group to handle production and operations of the system.

5.10 POST - IMPLEMENTATION MAINTENANCE & REVIEW

Though the system is thoroughly tested before the implementation, yet the system is never foolproof and errors always continue to exist. Therefore, there is a need to have a systems person to look after the system and maintain it even during the operation and production. The system maintenance could be because of any of the following reasons:

- Minor changes in the processing logic
- Errors detected during the processing
- Revision of the formats of the reports
- Revision of the formats for data inputs

Also the management is keen to know the quality of the system developed and the standards which have been followed. There is usually review team which evaluates the implemented systems and suggests changes, if required. It also leads to integrated and standardised system development.

5.11 PROJECT TEAM CONSTITUTION

For undertaking a study and design of a commercial information processing system, a project team is constituted. The members of this team are drawn from various functional areas and professional backgrounds. This team is usually of 7-11 member size. Each member is assigned specific responsibility with scheduled deadlines for each job. The involvement and representation of the user departments and affected parties is ensured while constituting such project teams. Normally organisations face a dilemma about choosing a project leader. The choice is between the user group or the systems group. Depending upon the availability, experience and type of project. The leader is chosen. It is in the interest of the proposed system that all the members of the project team should have sufficient time at their disposal and take keen interest in the progress of the project.

5.12 EFFORT DISTRIBUTION IN SYSTEM DEVELOPMENT LIFE CYCLE

The distribution of the organisational efforts over various phases of the system development life cycle can be seen from Figure 5.2. It can be seen that over the life cycle. almost half the efforts are devoted to maintenance after implementation and half the efforts in the system development itself are devoted to the testing and debugging activities. This once again underlines the need for a thorough testing and debugging of the information system before it is implemented.

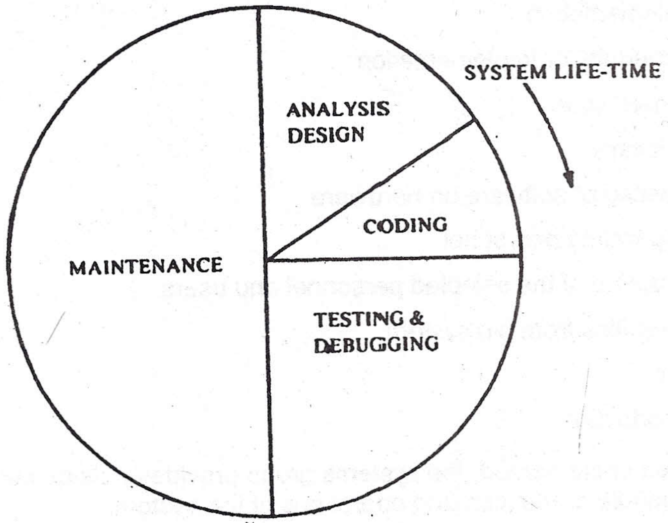

Figure 5.2 : Distribution of Effort

5.13 SUMMARY

Every system either developed as an improvement over the existing system or developed for the first time has to undergo various indentifiable stages. The unit has discussed these stages as problem definition, feasibility study, system analysis, system design, system development, implementation and maintenance. The birth of a system takes place when the conceptual model is developed by way of expressing a need. This need is converted into a logic for fulfilling of this need. It ultimately gets converted into data files, programmes and documentation at the stage of physical model. The total development cycle needs more than one full - time individual. Generally a project team consists of member from user group as well as systems group.

5.14 SELF - ASSESSMENT EXERCISES

1) What are the various outputs of each stage of the system development life cycle?

2) "Analysis is the what of the system whereas design is the how of the system." Comment.

3) What are the various stages of a system development life cycle and how are the efforts distributed over these phases?

4) What are the various stages system analysis tools and why do we need more than one tool at a time?

5) What do you understand by conceptual, logical and physical models of a system?

6) Discuss the various steps involved in programming

5.15 FURTHER READINGS

Awad, Elias M.`.,1990. *Systems Analysis and Design,* (2nd Edition). Richard D. Irwin Inc.

Daniels, Alan and Don Yeates, 1986. *Basic Systems Analysis* (2nd Edition), Pitman Publishing Limited: London.

Gane, Chris and Trish Sarson, 1979. *Structured System Analysis: Tools and Techniques,* Improved System Technologies Inc.

Gore, Marvin R. and John Stubbe, 1979. *Computers and Data Processing*, McGraw Hill Inc.: New York.

UNIT 6

DESIGNING ON-LINE AND DISTRIBUTED ENVIRONMENTS- DESIGN CONSIDERATION

Objectives

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

- understand system design features related to on-line systems
- know about the various computer system concepts related to on-line design.

Structure

6.1 INTRODUCTION TO ON-LINE OR REAL - TIME ENVIRONMENT

Data processing on computers, in its conventional form, consisted mainly of batch-processing - sequential or indexed-sequential, much after the event for which the processing was taking place. However, with sophisticated need for computers, the need for on-line or real-time processing came up. On-line or real-time processing is the processing of data on computers to produce the requisite results in very short time to enable an evént to take place. Some of the activities which take place in real-time processing with computers are:

i) **Computers - aided Manufacturing :** Where processes like thermal power generation are controlled by computers

ii) **Computers and Space :** Where the launching and journey of rockets/satellites in space is controlled by computers

iii) **Computers in Medicine :** Where vital activities of the body, like electrocardiogram, are controlled by computers

Activity A

From your experience give five more examples of real-time systems other than those mentioned above.

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6.2 ON-LINE SYSTEM ANALYSIS AND DESIGN CONSIDERATIONS

In an earlier unit you have been introduced to system analysis and design. Let us see here what are the factors that influence on-line system analysis and design.

Before we take up the above mentioned task, let us define the term **system**. A system is a group of interrelated subsystems interacting with each other and the environment to achieve desired objective.

The following figure shows the steps involved in system development, be it on-line or off-line.

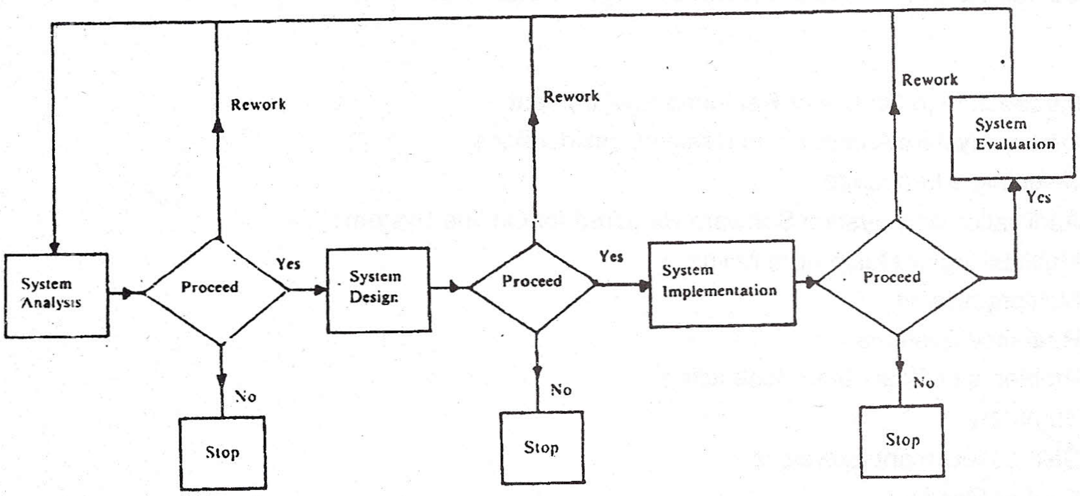

Figure 6.1 : System Development Life-Cycle

Making even minor changes without considering what has been done previously can cause errors or have unanticipated effects elsewhere.

While designing a system it should also be remembered that the final decision making regarding the end output of the system is the user's prerogative. The impetus or need for system development should come from the user community. Treating a computer as a solution-in-search-of-a-problem, instead of a tool to solve an already-identified problem can only lead to mistakes.

Even on-line system design consists of **preliminary investigation** and **feasibility study.** Detailed investigation consisting of:

- fact-finding
- data analysis and evaluation
- estimating costs and benefits, and
- preparation of a system proposal

follows.

By maintaining objectivity in fact-finding, the analyst can separate habitual or traditional acts from acts resulting from actual requirements and thus ultimately evolve a suitable system design in the data analysis and evaluation phase.

Data analysis and evaluation consists of recording, organising and evaluating collected facts. Information, system personnel begin to extract significant factors that help them identify the user's system requirements from this wealth of data. Increasingly, analysts are using computer-assisted software engineering (CASE) tools to organise and analyse data. The term CASE has been coined to refer to the automation of tools. methods and procedures used in system development. The products that accomplish the automation are computer programs, referred to collectively as CASE tools, They are grouped within two broad categories:

- **Front-end CASE tools** assist in the analysis of user requirements, description of data elements, description of operations (e.g., page sizes and numbers of copies for report printing). a high-level system design (output, input and file formats, high-level internal program structures and so on).

- **Back-end CASE tools** used to convert specifications into machine - executable codes, assist in debugging and testing, and/or restructuring existing databases and programs.

Some analysts organise their findings on flow diagrams (DFDs)

Once a system proposal has been approved by the user, a team of analysts and programmers set about coding and developing programs for the system.

Designers can use any of the several CASE tools to create mock-ups, called prototypes, for user review as early as possible.

Various methods used to design the system can be summarised as:

i) **Top-down design** : When doing top-down design we look first at the major function to be accomplished by the system and then fill in the details.

ii) Tree-diagrams or structure charts.

iii) Decision tables, etc.

Although, the techniques described above are similar to those that might be used for off-line systems, the major points to be kept in mind while designing on-line or real-time systems are as follows:

i) response time of the system should be very efficient to cater to the fast response times required in real-time systems;

ii) scope of failure of the system due to power failure or bugs in the system should be minimised, otherwise it may lead to fatal system break-downs;

iii) a certain degree of self-correction and review methods should be inbuilt in the system; and

iv) on-line system design should take into consideration the capabilities of the computer system- like the number of tasks/ programs it can handle at a time, number of terminals which can be attached to it, etc.

After the system analysis and design phase, we come to the system implementation phase. However, it must be borne in mind that no amount of good coding can repair the damage done by poor design or program coding. While there is no universally accepted definition of what constitutes a high quality system/program, most users agree that the following characteristics are important:

i) **Correctness:** Extent to which a program/system satisfies its specifications and meets the user's needs;

ii) **Reliability :** Extent to which a program/system performs its intended function without error;

iii) **Robustness :** Extent to which programs/system accommodates and handles unacceptable input and/or user operational errors. This factor is especially important for on-line systems;

iv) **Usability :** Effort required to operate, prepare input for, and understand output of a program;

v) **Testability:** Effort required to test a program to insure it performs its intended function;

vii) **Maintainability :** Effort required to locate and fix an error in a program/system. This is also an important factor in a program/system operating in an on-line environment;

vii) **Extensibility :** Effort required to modify a program/system to change or enhance its function. Again, an important factor in on-line systems.

viii) **Efficiency :** Amount of computing resources required to use a program/system.This is also an important factor in real-time system design since space required for data and programs should be large enough to cater to the system requirement;

ix) **Portability :** Effort required to transfer a program from one hardware and/or software environment to another one;

x) **Reusability :** Extent to which a program/system can be used in other related applications; and

xii) **Turn- around time :** Time required from feeding of input to receiving the output. This is important in on-line systems.

Activity B

What are the design considerations in on-line systems which are especially important for it or different from conventional systems and in what way? Give examples.

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The following methods can be adopted for system implementation:

a) Cut-over to new system and leaving the old system abruptly. This suffers from the drawback that if the old system is better or the new computerised system has drawbacks, then the new system implementation becomes very difficult. Bringing back the old manual/semi-manual system is also difficult. Hence this system of implementations not advised for on-line systems.

b) Phasing out the old system and bringing in the new computerised system in stages. This is better than the cut-over system, yet in most cases it is difficult to implement in on-line systems. In some cases, like railway or airline reservations, it may be useful.

c) Parallel run of the old system and the new computerised method till such time as the new system has established. This is better than the first two methods for on-line systems, as it gives time to new on-line system to stabilise.

d) Installation of a new on-line system. This requires repeated and meticulous testing for on-line systems before it can be adopted. This is true in cases like rockets/satellites launching and control.

6.3 SELECTING A LANGUAGE

How does one choose from among the myriad of programming languages the language that is most apporpriate for a particular system development effort?

Let us back up a bit. The first phase of the system development cycle is system analysis. The second phase is system design. In most cases, after the user requirements are understood, alternantive solutions can be identified. Today, most if not all user organisations are confronted by resource constraints. The programming talent, time and money needed for in-house system development are likely to be in short supply. Therefore , if application software packages that meet or nearly meet user requirements are available, they should be considered. Perhaps a "nearly-meets-requirements" package can be customized to do the job.There is no merit in writing a new program if an acceptable one already exists. However, if detailed program design, coding and checkout are to be done, then the selection and use of one or more programming languages is required.

Usually, one assembler program, or a system software program written in a language like "C", is provided for each particular family of computers. Programs can be written for the computers in the assembler language that the assembler program is designed to translate. Theoretically, any number of high-level-language processors can be written for any computer. It follows that any computer can be controlled by programs initially coded in any of several high-level programming languages, depending on the language processors available.

In deciding which programming language to use, some specific questions should be asked. Which programming languages are available? What knowledge does the head of the programming from assigned programmers or user- programmers have of those languages? What types of problems are the various languages designed for? These and other language selection considerations are summarized in Figure 6.2 below:

- LANGUAGE AVAILABILITY
- LANGUAGE KNOWLEDGE OF SYSTEM TEAM
- SUITABILITY OF THE LANGUAGE TO THE PARTICULAR PROBLEM OR APPLICATION
- EASE OF LEARNING THE LANGUAGE
- UNDERSTANDABILITY AND DOCUMENTATION EASE
- EASE OF MAINTENANCE
- LANGUAGE STANDARDIZATION AND PROGRAM PORTABILITY
- SPEED OF SOURCE-PROGRAM TRANSLATION BY THE LANGUAGE PROCESSOR AND LANGUAGE-PROCESSOR STORAGE REQUIREMENTS
- EFFICIENCY OF RESULTANT OBJECT PROGRAMS IN TERMS OF NUMBER OF INSTRUCTIONS, EXECUTION SPEED AND STORAGE REQUIREMENTS. THIS IS ESPECIALLY IMPORTANT FOR ON-LINE APPLICATIONS

Figure 6.2 : Factors to be considered for chossing a language that is most approperiate for a system development effort.

The relative importance of the selection criteria varies depending on the situation.

As we have seen, FORTRAN is well suited for problems that involve mathematical computations. COBOL was designed with business applications in mind. BASIC was designed to provide immediate, straight forward answers to simple problems. For many end-user real-time applications, a fourth generation language may be the appropriate choice.

The assembler language of a computer can be used to express all the operations the computer is capable of performing. If fast execution and/or minimal use of storage by the resultant object program are of primary importance, use of assembler language may be advisable. Some fourth generation languages' tools allow assembler-language routines to be embedded in fourth generation language applications to perform time-critical functions. This is especially important for on-line systems.

6.4 APPLICATION AND SYSTEM SOFTWARE REQUIRED FOR ON-LINE SYSTEMS

As you may be aware, software is of two types (i) application software, and (ii) system software.

To recall, system software is that part of the software that performs the tasks of controlling the input, output CPU functions and other instruction-related portions that are performed by the hardware of the computer system. Application software are the programs written by programmers to achieve the end-objective of the user community of the computers. System software acts as a 'middleman' between the application software and hardware of the system.

The conventional batch-processing techniques worked well where large volumes of input data were required for processing with significant time interval between one lot of input data and its required output and the next lot of input data sent for processing. For example, the processing of weekly time cards for all employees. They did not work well for small amounts of input generated randomly or for individual problem solving. Computer manufacturers addressed these needs by developing on-line direct-access systems.

In an online direct-access application, the computer communicates directly with both the source and the destination of the data it processes. The data can be sent to and received from local I/O devices or to and from I/O devices at remote locations by way of communication channels. Input transactions can be processed as they are received. Master files can be read to produce up-to-date output information in the form of status reports, invoices and so on. This approach is called **transaction processing**. Because queries about master-file data are received in random order, the files are generally stored on direct- access storage devices.

The first on-line direct-access systems were typified by the early airline reservations system.

These early on-line direct-access system met many user needs, but they were far from perfect. Because the systems had to respond quickly to many individual transactions, it was neither possible nor desirable to query or update master files. Instead, the master files had to be updated continuously. Otherwise, for example, a ticket agent at one location might sell airline space already sold by an agent at another location.

Further more, different types of transactions, say inquiries, sales and cancellations, required different programs to process them. These programs had to be kept in secondary storage and brought into primary storage when needed. Much time was spent in locating and gaining access to data and programs, rather than in processing transactions.

To add to the problem, transactions occurred irregularly. During peak periods, hundreds of thousand of transactions had to be processed within minutes. At other times, the systems were relatively idle. It become apparent that to use EDP system resources as efficiently and effectively as possible, new techniques had to be developed.

6.5 MULTITASKING OR MULTIPROGRAMMING

Fortunately, during this same time period, system software and hardware developments were occurring elsewhere. In 1963, the Burroughs Corporation released its Master Control Program, or MCP, for use with Burroughs B 5000 computers systems. MCP assumed greater control over system resources than its predecessors had. Input and output devices were activated by MCP rather than by application programs. This centralised control was possible because hardware interrupt conditions signalled to MCP when control of the EDP system should be passed to a special-purpose routine for I/O processing.

MCP could also assign memory areas to programs, determine the optimum sequence and mix of jobs, determine program priorities and system requirements, and provide for rescheduling if new jobs were introduced or job priorities changed. More than one user application program could be resident in primary storage at a time. Since the processor could execute instructions from different programs was not possible. The processor could, however, execute only one instruction at a time, simultaneous execution of instructions from the first program, then instructions from another program, than instructions from one program again, and so on. This type of processing is called **concurrent processing.** Program logic within MCP determined which system software routine or application program had control of the B 5000 prcessor at any given time. Today, a system that provides this capabilities is said to support **multitasking** or **multiprogramming.**

Concurrent execution of programs is desirable because I/O operations are much slow than internal processing operations. Fortunately, the design of modern computer systems permits overlapping of I/O and processing operations.

Under one approach, the actions of I/O devices are permitted to occur only at fixed points in a program and only in a sequence established by the program. Such a system is said to support **synchronous operations.**

As an example, assume a user wants to key in data from a VDU. Let's suppose a particular bit in storage is set to 1. The setting of the bit does not cause a read operation to occurimmediately, however. At fixed intervals , the processor is directed to rest that bit position. It also tests the bit positions reserved for other I/0 devices on the system. This technique is called **polling**. When the VDU's turn comes and its bit is found to be set, the input operation is allowed to occur. Since internal processing operations occur very rapidly, the user may think the data keyed in is read immediately. That is not the case. All activities within the system are rigidly controlled by the hardware and/or by stored programs.

Other EDP systems perform **asynchronous operations**. Such systems are designed to permit the automatic interruption of processing whenever the need for I/O activity arises. The input or output device signals the processor by means of an **interrupt** when it is ready to read or to write. The interrupt means, in effect : "My particular job is done. As soon as convenient, use the data I have given you (if it was an input operation) or give me any additional information you have (if it was an output operation). The signal may be the setting of a bit as above, but in this case, the bit has an immediate effect. As soon as the processor finishes whatever instruction it is executing, it accepts the data as input or transmits the information as output.

Ideally, the configuration and speeds of the various I/O devices included in a computer should be such that the processor can work at full capacity whenever the user workload dictates. Again, because of the slowr speeds of I/O devices, this means that the over-all system efficiency depends heavily on the extent to which input, internal processing and output operations can be overlapped, or allowed to occur at the same time.

Even so, if only one program is resident in primary storage and executing, chances are the processor is idle much of the time.

In 1964, IBM introduced its major third-generation operating system. OS/360, for use with IBM System/360 computers. A System/360 user could select the version of OS/360 that included a control program called **Multiprogramming with a Fixed Number of Tasks (MFT)**. Each task was simply and independent unit of work, such as a program or subroutine, that needed system resources. As its name implies, OS/MFT could operate on a fixed number of tasks concurrently. Actually, it could read jobs from as many as three job input streams, handle upto 15 job steps, and record upto 36 streams of output concurrently.

A system/360 user with extensive data-processing requirements could select another alternative: a version of OS/360 that included a control program called **Multiprogramming with a Variable Number of Tasks (MVT)**. As its name implies, OS/MVT could control a variable number of tasks concurrently. It could change the number, size and location of reserved storage areas to meet the data-processing requirements at any given time. Like OS/MFT. OS/MVT could handle as many as 15 job steps concurrently. Moreover, once a job step was initiated by OS/MVT, that job step could, in turn, initiate the processing of other tasks. There was not a 1-to-1 relationship between job steps and tasks (as existed under OS/MFT).

OS/MVT was used on the very largest mainframes of the late 1960s. These big mainframes sometimes had as much as 1 mega-byte of primary storage. A big application program was one that needed 256 kilo-bytes.

The Burroughs B 1700, announced in 1972, was the first small computer with an operating system that supported multitasking. Today, there are micro-computer systems with equivalent or greater capabilities. MS-DOS is a single-user, single-tasking operating system. OS/2 is single-user, multitasking operating system. It can interact with only one user, but that user may initiate the concurrent execution of two or more programs. UNIX is a multiuser, multitasking operating system. It can communicate at what appears to be the same time with two or more interactive users and can perform concurrent proccessing.

For real-time systems, multiuser, multitasking operating systems would be ideal.

Virtual storage capabilities allow a system to be used as though more primary storage exists than is actually present. A greater number of programs can be running at a time than would be possible otherwise.

Activity C

UNIX has been mentioned as one of the multiuser, multitasking operating systems. Can you name three more multiuser, multitasking operating systems.

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6.6 MULTIPROCESSING

Let us pause a moment to clarify some concepts and to relate some things we have learned. Like multi-programming and multitasking, the terms multi-programming and multiprocessing are sometimes used interchangeably, but they do not mean the same thing. Multitasking involves concurrent execution of instructions from two or more programs sharing one processor and controlled by one major operating-system control program. In multiprocessing, instructions are executed **simultaneously** (at the same time, in parallel) on two or more processors; the processors can execute different instructions from the same program or from different programs at a given time.

In today's most basic multiprocessing systems, one main processor handles all major processing functions. Other co-processors handle "housekeeping" chores such as opening and closing files, input validation and editing, and file maintenance or perform complex mathematical functions. The more sophisticated multiprocessing systems involve several main processors. There is no single "computer", but rather a **"computer system"** that consists of several processors linked together for purposes of communication and co-operation during processing.

Multiprocessing is not limited to mainframe environments. For example, the IBM PS/2 Model 70 computers introducted in late 1988 have a 32-bit Intel 80386 main processor and, optionally, an Intel 80387 math co-processor. Apples Macintosh SE/30, announced in January 1989, have a 32-bit Motorola 68030 main processor and a Motorola 68882 floating-point (math) co-processor.

Many of the problems now being addresed with computer help involve lots of data and lots of very fast computation and feedback-for example, monitoring and/or controlling the many variables that must be taken into account when journeys into space are initiated. With multiple processors, parallel work on different problems or on the same problem is possible.

Activity D

Differentiate between multitasking, multiprogramming and multiprocessing and try to give examples.

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6.7 REAL-TIME SYSTEMS

A system that can also provide output fast enough to satisfy any user requirement can be further classified as a **real-time system.** Such a system makes output available quickly enough to control (not simply react to) real-life activity.

The concept of real-time is closely related to immediacy. It is seen as **response time,** which we now define somewhat formally to be the interval of time between completion of input and start of output from an EDP system.

In actual operation, real-time is a matter of degree, depending upon the application at hand. The customer service representative of an insurance firm may be willing to wait from 3 to 10 seconds for details about the coverage of a policyholder. In a military defense system, responses within microseconds may be required. Variations in response time are due to differences in the system work-load, internal processing requirements, frequency and type of access to computer files and/or databases, and so on. Both the hardware and the software must be capable of fast performance. In addition, the system must be tunded by support personnel to fit the requirements imposed on it. For example, system characteristics such as the number and size of I/O areas, or **buffers**, may be set at system startup time.

Although basic business applications such as order writing, inventory control and payroll can be implemented as real-time system, they are not likely to be. Increasing the costs of software, hardware development and ongoing support is more likely to be justified for specialised applications in industries such as transportation, manufacturing, banking and distribution. Computer controlled robotic systems on assembly lines, automated teller machines at banks and point-of-sale terminals at retail department stores abroad are components of real-time systems. In hospitals, patient's vital signs are monitored at bedside by real-time system.

Time sharing is a technique that allows several users of an on-line real-time system to use that system on what appears to be a simultaneous basis. The speed at which the system components - both hardware and software - operate allows the system to switch from one active user to another, doing all or part of each job until all work is completed. The speed may be so great that each user believes that he or she is the only one using the system. The purpose for which one person uses the system may be totally unrelated to that of others. The system resources are shared by all.

There are three kinds of time-sharing systems in use today:

- General purpose systems. which support several programming languages and allow users to create and run their own programs;
- Systems in which a wide variety of programs are available for execution but cannot be modified by users;
- Systems in which all programs are related to one major application, and users merely provide input and request output.

In parctice a time-sharing system may be a combination of these, with the major application having first priority. The distinguishing characteristic among the three systems is the degree of user indepence provided.

From the point of view of Databases, Structured Query Language (SQL), allows real-time interactive users to access data by entering SQL statements; and programmers include SQL statements in application programs for the same purpose.

In a real-time environment, networks involve a communications or front- end processor which serves as a communication control unit in a system that must support many users and/or heavy traffic on the data-communication network.

In a data-communication system, any I/O device at the end of a communication channel is called a terminal. More specifically, since the device is located at a point other than where the main computer is, it is called a **remote terminal.**

In real-time systems, speed of transmission is important.

6.8 PROBLEMS OF REAL - TIME SCHEDULING

When procedures are designed for the processing of real-time systems their operations are usually arranged so that all contigency handling has been preplanned and is therefore built in. In this way, any requirements for the treatment of exceptional cases or other error handling have been analysed in advance, and the corrective measures to be taken in the case of their occurrence have already been plannned and constructed. This style of operation may be termed 'off-line', for convenience; and this framework and approach may be considered as a contrast to those which employ adaptation strategies on the run - such procedures may similarly be styled as 'on-line'. The latter is self-evident in 'expert systems' and systems posssessing artificial intelligence.

'Off-line' maintenance of real-time systems is evident, for instance like in a local reservation system for railways where the system can be interrupted for some time and maintenance carried out. On the other hand, an expert system following a satellites journey in space may need 'on-line' maintenance.

Activity E

Mention three more examples each of 'off-line' and 'on-line' real-time systems with a brief description of its function.

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6.9 SUMMARY

Effective application of computers is heavily dependent on software. Both system programs and application programs are required.

More sophisticated computers and operating systems that could handle job-to-job transitions were developed as time passed. Job-control statements were used to tell the computer what to do next in batch or stacked-job processing. On-line direct-access systems were developed to process input transactions in random order, as they were received, and to assist individual users in problem solving.

In a multitasking system, more than one program at a time resides in primary storage. The processor executes instructions from one program, then instructions from another program, and so on. Keeping the processor busy in this fashion helps to maximise the amount of useful work that can be accomplished.

In a multiprocessing system, instructions from the same program or from different programs are executed simultaneously on two or more processors. Today's personal computer systems as well as large system configurations may have multiprocessing capabilities. A real-time system provides output fast enough to satisfy any user requirements. It can be used to control real-life activity. It can be used to control real-life activity. Time - sharing allows several users to interact with a system on what appers to be a simultaneous basis. The system resources are shared amongst them.

In a virtual-machine environment, each user is able to use a total computer system -both hardware and softwae - that does not actually exist, but seems to. Many unrelated virtual machines running different jobs can be active on the system at a time.

6.10 SELF-ASSESSMENT EXERCISES

1) Explain in detail, with examples, what are the characteristics which go into the making of a high-quality system/program.

2) What are the various methods which can be selected for system implementation? Try to include in your answer the on-line system implementation suitability/unsuitability of each of the methods you describe.

3) What are the features of a language which should be considered for its selection in the design of a system? Explain your answer with special reference to on-line systems.

4) Explain what is system software and its significance in on-line system design.

5) Explain how problems in real-time scheduling are handled.

6) Explain and distinguish the following concepts with reference to their use in real-time systems.

   i) multiprocessing

   ii) time sharing

7) Explain the concepts of 'synchronous' and 'asynchronous' system software.

6.11 FURTHER READINGS

Szlanko, J. (Ed.)1986. *Real-time Programming: Proceedings of the 14th IFAC/IFIP Workshop,* Lake Balaton, Humgary, 26-28 May 1986; International Federation of Automatic Control of Pergammon Press.

Bohl, Marilyn, 1990. *Essentials of Information Processing*; Second Edition, Macmillan Publishing Company; New York and Collier Macmillan Publishers: London.

Core,Marvin R. and John W. Stubbe, 1987. *Computers and Information Systems;* Second Edition, McGraw-Hill International: New York.

UNIT 7

IMPLEMENTATION AND CONTROL OF PROJECTS

Objectives

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

* appreciate different approaches to implementation
* understand the various steps involved in successful implementation of projects
* appreciate the problems of security and control of MIS systems.

Structure

7.1 INTRODUCTION

The activity of MIS Project implementation can start only after a complete and detailed MIS design has been formulated and is available for implementation, for only a detailed design will specify as to what is to be implemented. In its absence one does' t know what to do.

It is also assumed that the design which is available for implementation has been reviewed and tested as to its viability as one of the end-activities in the detailed design stage. This minimises the possibilities of delayed detection of system logic errors and avoids or reduces the need of redesign/change efforts during implementation. Frequent occurrence of such errors adds to cost as well as frustration of implementing team.

7.2 PROJECT IMPLEMENTATION OPTIONS

After review, testing and evaluation of the completed design, the top management authorises the implementation. One or a combination of several approaches to implementation can be considered and chosen. The approaches are:

when the old system does not exist

1) **Install a system in an organisation which is just coming up**. Therefore, the existence and replacement of old system does not arise. In this case more problems of system logic error, debugging and redesign and change in the given detailed design are expected and should form part of implementation effort.

When old system is in existence

2) **Cut off the old system and install the new system**. Because installation is a time-consuming activity which may take days or months depending on the size and complexities of the organisation and the enormity and complexity of the system. Therefore, there is a time lag when the old system is cut off and the new system is not fully operational. During this period no system is in operation. Obviously this

method would be applicable for very small companies or small systems which can be installed in a day or two.

3) **Cut over by segments.** Small parts or subsystems of the new system replace the old system one by one or in groups. So the assumption is that identical or more or less similar parts exist in both the systems. That would lead to the conclusion that the 'new' system is not,really new, at best it may be an upgradation of the old one. Another implication is that the parts are independent or interaction among them is restricted. .

4) **Operate in parallel and cut over.** The new system is installed without scrapping the old system. For some time both the systems operate simultaneously, the results of the new system are compared with the old system for accuracy and reliability until the new system starts satisfactorily operating and the old system is dropped. The major advantage is that it helps in almost completely checking out the new system through comparison with the old system. But it involves complete duplication of work and as such is comparatively expensive. It is essential where implications of error in the new system can be very costly or highly embarrassing for the long term reputation of the company.

7.3 STEPS IN IMPLEMENTATION

The steps in implementation, which are listed later on, are equally applicable, with minor variations, to any of the above listed options. It is assumed that the design specifications provide general as well as specific details regarding all requirements of the system such as: procedure, forms, database, equipment, personnel facilities etc. The major steps are based on these specifications. It may be noted that the steps are not sequentially exclusive, they usually overlap.

The steps are:

* The Plan
* Space and Layout
* Manpower and Organisation of MIS
* Training for Operators and Users
* Hardware Equipment Installations
* Programme Development,Design of Forms and Files
* Testing and Changeover.

7.3.1 The Plan

This is a pre-implementation activity where identification of all activities required in implementation is done. Their sequence and relation to each other is ascertained. Time and cost estimates for each of the identified acticity is obtained.

For very small projects, plan and the sequence of implementation of activities may be undertaken informally or in text form. But the use of Gantt Charts or network diagrams - CPM or PERT is very valuable in providing visually a clear picture of the total plan. It is helpful later on for control function over actual stages of implementation. An example of network diagram is given below in Figure 7.1

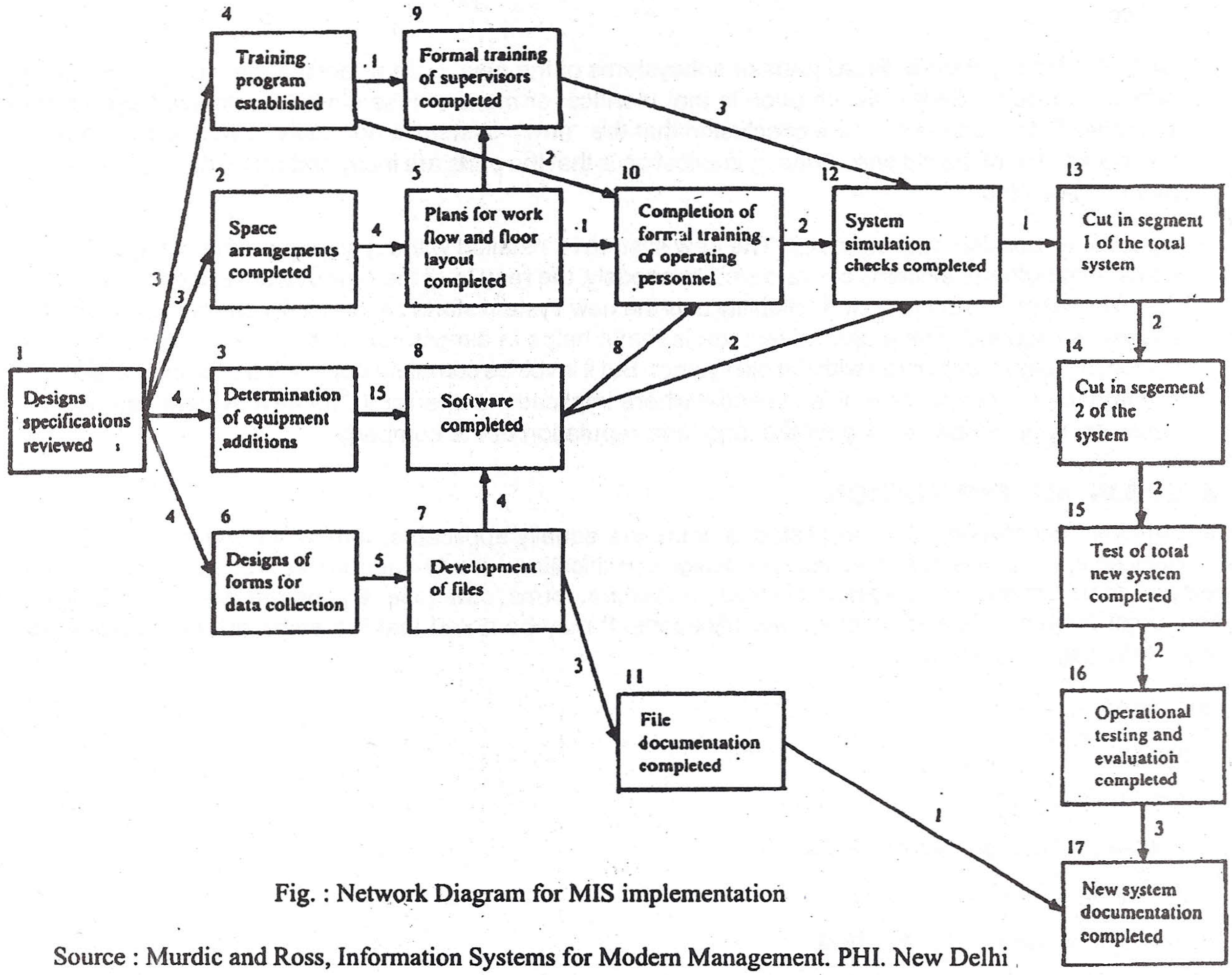

Fig. : Network Diagram for MIS implementation

Source : Murdic and Ross, Information Systems for Modern Management. PHI. New Delhi

7.3.2 Space and Layout

When a new system is to be installed in a completely new company where old system does not exist, floor space and layout is required for housing the people and the facilities. Even in those cases where the old system is to be replaced by a new system, revisions in the existing floor space and layout may be required. In certain cases, these may be major revisions.

The MIS project implementation manager is expected to prepare estimates of floor space requirements and also rough layouts. These would be based on the knowledge and expertise of the project manager and the required specifications available in the detailed system design. In consultation with and approval of the top management, the acquiring or generating/building of specific space is done.

The layout takes into consideration location of facilities in relation to each other e.g. computers, terminals, etc. location of people through partitioning or grouping together or -where required - allocating separate offices and cabins. Movement of people and equipment, storage, air-conditioning, utilities, safety and security factors also affect the layout and location.

7.3.3 Manpower and Organisation of MIS

In the first instance, a project manager who should later on take charge of the whole MIS department should be appointed as its head or somebody from accounts, finance or computer can be deputed as a stop-gap arrangement with full implementation responsibility. This position should be available right after the design work so that implementation plan is taken up by the project manager.

The line manager, line functional and operating personnel must be actively associated with the implementation. They should feel that it is their system. At development and design stage also active involvement through all stages of these personnel (system user) advocated. The systems specialists are assigned to the various phases/parts of implementation and to assist the line people (the users).

The contract/subcontract/assignment may be given to internal or external groups as the work progresses e.g. the work of buliding, painting, electric/air conditioning installation etc.

The other MIS personnel such as systems, managers, analysts, programming people, operating people, data entry people, secretarial and other staff may continue to be engaged as and when needed depending upon the progress of work. A personnel requriement chart showing the number of persons in terms of skill and qualifications should be prepared. It should also show whether they are internally available or recruited from outside, and the date when they would be needed according to implementation plan. But their recruitment and selection is to be plannned before-hand. Whenever old system is being replaced, the old employees must be adjusted at appropriate jobs through restructuring, upgrading etc. If necessary, they may be provided with additional training in the meanwhile.

7.3.4 Training for Operators and Users

The training is required at two ends, the MIS department people (all levels) and the users at different levels engaged in different functional areas.

The training for MIS department people must be arranged with respect to procedures and operations of inputs, formats, processings, outputs, frequencies, destinations, the terminals and equipment operating etc. The training is a must whether an entirely new system is being implemented or an old one is being replaced. All operating and supervisory people, through training, must become completely familiar with their job fuctions and the system of which they are a part. This can be achieved through a judicious mix of theoretical input (discussion and familiarisation with system procedure) and practical training on the equipment in actual use. They must get a chance again when the system is at the last stages of implementation to develop complete familiarity with the installed system and their respective job functions.

Proper user training is an important factor in promoting the acceptance of the new system and making it a success. The training may be for a specific language, or package or general user understanding of the system. The users must know what the system can do for them (in relation to their job functions) on routine as well as on special request basis. How can they use the system? How and when can they make the request? The users should be able to appreciate as to what is available and what can be made available. If some formats are introduced, they should be made familiar with it. When terminals are made available to the users, they must be fully trained to make use of it. The users should understand the changed procedures, the changed codes,pass words etc. If there are changes in the hardware or software, the users should be familiar with it to the extent it is related to them or their job functions.

The usres can be classified differently such as developer versus non-developer, novice versus expert, frequent user versus occasional and primary versus secondary user. These classifications are not necessarily exclusive; or often they are likely to overlap. User training programmes must cater to specific needs of all types of users, The utility of a system is enhanced if users genuinely feel that the system is helpful to them and make active use of the system.

7.3.5 Hardware Equipment Installations

The acquisition of computer related hardware is a complex and specialised subject. Apart from identificatin of specific equipment from a wide range of prices, capabilities and vendors, the question of buying or leasing is also related to it.

The related equipment requirements and estimates are available from detailed design. The purchase orders should have been placed earlier depending upon the estimated supplier time lag. By the time the equipments are received, site preparation work, room layout, air conditioning, electric connections, communications, link lines etc. should be complete or near completion so that not much time is wasted in installation and making the equipment operational. Testing of equipment and training of operating people on new equipment should start as early as possible. At appropriate times, the orders for tapes,disks, paper, filing cabinets etc. should also be placed.

7.3.6 Program Development, Design of Forms and Files

There are two options available for meeting the software requirements - i) obtain software packages or ii) develop software internally. Usually a judicious mix of the two is the best way out. Small companies may purchase most of the software, but usually, some modifications are necessary to fit it to the company's specific requirements. It can also be custom made by many specialised software development agencies.

For large companies, or for organisations with very specialised and complicated requirements, a majority of the requirements may be met through in-house development of the programs.

Forms required for inputs, intermediate stages and for outputs are necessary to ensure that the 'right' information is supplied in a manner that simplifies computer storage, retrieval, processing as well as user utilisation. Even though certain specifications on forms are available in the detailed design, this is the first opoortunity to try out in practice. Necessary changes and modifications, if any, should be made. Standardise forms are a great help to both the end-users as well as system operating personnel. Even when a user is working directly on a terminal, the screen format should reflect the document layout where ever feasible for input, processing, as well as output.

The identification of files and specifications such as file name, maximum number of characters required to record each data element for each file, frequency of access, retention characteristics, updating frequencies, formats etc. are developed at detailed design stage. The conversion of these specificatons into computer programs is the function of computer experts. At the implementation stage this conversion takes place and initial testing is conducted from actual data obtained and recorded. This may be termed as creation and testing of the physical file. Testing is done for range, volume, data validation and file operation procedures including input, retrieval and updating etc.

Master file is the one which contains data used in routine processing. The structure of information is more specific in these files. These are comparatively permanent. In contrast there are transaction files, which are created for specific transaction purposes only and are temporary. There could be some other files which may be used for capturing and storing data about the environment. The structure of informatin in these files may not be as specific.

The porcedures are developed for access to files, input, update and delete frequencies for file and data protection, for input data validation. Indexes retrieval procedures are also developed.

7.3.7 Testing and Changeover

Testing is very important part of the implementation phase. Even though testing is basically a part of each phase, it is critically important at this stage because, here the testing is done under actual operating coditions with real data. It can take up 15 to 50 per cent of the total system development effort depending upon size and complexity.

Usually a hierarchy of testing is advocated at different levels, starting from individual programs to subsystems and finally to the system as a whole.

At the component level - individual components file input forms, programs, output forms, work procedures etc. may be tested using representative or limiting/unusual data for accuracy, range of input and processing, operating conditions reliability etc.

At individual application level - again using the actual data from the present data bank for its functioning logic, input-output etc. each individual application at operation level is to be tested.

At subsystem level - the testing is directed to verification of multiple input, output, complex logic interaction and interfaces of various lower level subsystems which form part of this subsystem.

At any of these testing levels difficulties or errors may be experienced which in turn may require changes in forms designs, logic, sequence, workflow, output formats, procedures, interaction of subprograms etc.

Cutover is an event signifying the actual replacement of the old system by the new system. The old system is completely dropped and the new system is fully operational.

Despite repeated testing at each of the phases and careful testing at the last stage of the implementation phase, ther are still likely to be minor as well as some major problems with the new system when it is fully operational and facing the real world challenge. The appearance of errors is inevitable as the system operates in varying combinations of volume, transactions and conditions which could not have been foreseen. The process of overcoming these difficulties in computer terminology is called 'debugging'. This process of debugging continues for several days to several months depending upon the size and complexity of the system.

When the system becomes operational, it has to be maintained at an efficient level with respect to equipment, processing, ooutput , inputs etc. There have been various estimates and it can be safely concluded that for an average operating system, the maintenance effort is around fifty per cent of the total operating effort. The calss of problems, that are definitely errors and need to be corrected in time, fall in the category of maintenance. Apart from manitenance, the requests for modifications and improvement will also continue to be received over the life of the system.

7.4 PRECAUTIONS IN IMPLEMENTATION

Even though the implementation process has been discussed in fairly great detail, some important aspects are further discussed wihch if overlooked would have been the cause of failure of a large number of MIS projects.

1) **The question of equipment :** The question of equipment should be viewed in terms of organisational information need rather than being limited or created because of equipment.

2) **The Software :** The software and the processing logic should be error-free. A small error at any of the input or process or logic stages can result in very serious blunders. A thorough and repeated planning and review at each stage is a must.

3) **Testing :** Wherever testing is recommended or desired as part of design or implementaton, it must be done meticulously according to standards given. This is one activity where 'Cutting Corners' or carelessness can be very castastrophic.

4) **Controlling :** Many small jobs taken together make a project. The identification of tasks was undertaken in the implementation phase itself. Successful completion of each of these tasks in respect of time, cost and efficiency must be carefully monitored.

5) **User Participation :** One of the most prominent causes of failures of MIS had been non-acceptance by the users. User participation must be intensively encouraged and sought at all phases and more so at the culmination stage of the total development process i.e. implementation.

7.5 SECURITY AND CONTROL

Data and information stored and maintained as part of total MIS activity is a very valuable asset of the company. The physical equipment also is costly and valuable. The problem of security is two pronged-security of physical assets and security of intangible assets i.e. data. There could be three types of security problems: (i) Frauds (ii) Sabotage(iii) Accidents and Disasters.

These security problems can be overcome through:

i) **Control on physical access to equipment:** This can be achieved through usual security procedures i.e. Buliding security, proper locking system, proper entry, restrictions, guards, alarms etc. The problem is slightly more difficult when distributed data processing or networks are in operation. That would mean keeping safeguard control on all the terminals.

ii) **Access to data :** Data availability to unauthorised persons irrespective of the fact whether physical access to equipment is valid or not should be prevented. As such specific identification codes or pass words are used for specific terminals, for specific files and specific working hours.

iii) **Splitting the work:** The critical work packages, like programming efforts, where possibilities of fraud exist, must be split between more than one person.

iv) **Semi- disconnected distributed system :** Provisions in a distributed system should Include procedures for switching/shifting processing to alternate location in case one local facility is not functioning. The capability to continue processing at all sites except the non-functioning one is called 'fail-soft' protection.

v) **Back-up and Recovery :** This is sometimes called 'disaster management'. All systems are required to recover from errors and failures, fire, floods, accidents, natural disasters or deliberate damage to equipment, software and data. Apart from other precautions such as safe locations, fire and smoke detectors, alarms, automatic power off, back-up power supply, insurance etc, following provisions may be incorporated:

- Back up copies of important software and data be stored at alternate sites off the premises.
- Back-up recovery plan.
- Alternative arrangement for stop-gap utilisation of equipment facilities. It could also be done through mutual inter-department or inter-corporation facilities dependence in case of need.
- Back up supply of forms and other supplies.

7.6 SELF- ASSESSMENT EXERCISES

1) How much importance should be accorded to implementation phase as part of the total MIS development activity? Explain.
2) Briefly discuss the various implementation strategies. Under what circumstances are they suitable?
3) Describe the major steps in implementation of MIS design. Are they overlapping or exclusive? Explain.
4) Discuss appropriate measures for security of data.
5) Explain the methods in Back-up and Recovery/Disaster Management. Why is it so important?
6) Discuss the precautions necessary during implementation phase and also explain why?
7) Study the security procedures which are in operation in MIS or Computer Centre of the organisation in which you are working or you are familiar with.

7.7 FURTHER READINGS

Davis, G.B. and M.H. Olson, 1985. *Management Information Systems: Conceptual Foundations, Structure and Development,* **McGraw Hill:** New York.

Murdic, R.G., R.E. Ross and R. Claggett, 1990. *Information Systems for Modern Management,* Prentic Hall of India: New Delhi.

Kanter, Jerome, 1984. *Management Information Systems,* Prentice Hall of India: New Delhi.

Lucas Jr. H.C., 1982. *Information System Concepts for Management,* McGraw Hill: New York.

Srivastava, S.S. *Management Information System and Computers,* Atma Ram and Sons: New Delhi.

Bhatnagar, S.C. and K.V. Ramani, 1989. *Computers and Information Management - Primer for Practising Managers*, Prentice Hall of India : New Delhi..

BLOCK 3

COMPUTER NETWORKS & DATA COMMUNICATIONS

This block comprises of three units.

Unit 8 on Trends in Information Technology - Hardware, Software, helps us to understand the evolution of Information Technology with respect to Hardware and Software. The part played by expert systems in Information Technology evolution and the kind of human expertise required for hardware and software systems used in Information Technology is also discussed.

Unit 9 on Data Communication Concepts explains the various aspects of data communication as applied to computers.

The tenth and last unit in this block on Computer Networks gives an idea of the components of computer networks and the applications to which computer networks can be put.

UNIT 8

TRENDS IN INFORMATION TECHNOLOGY - HARDWARE, SOFTWARE

Objectives

After going through this unit you should be able to

- understand the evolution of Information Technology with respect to Hardware and Software
- know about the role of expert systems in the evolution of Information Technology
- learn about the kinds of 'peopleware' required for the hardware and software systerms used in 'Information Technology'.

Structure

8.1 INTRODUCTION

With computers occupying the centre stage in the modern world's information systems area, it would be interesting to trace the history of computers.

However, before going into its history, it would be fruitful to examine the components which go into the building up of computer services since to some extent the history of the components can be traced separately, Still, it should be noted that advancements in hardware and software went along hand in hand as time passed. Computers can broadly be sub-divided as shown in figure 8.1.

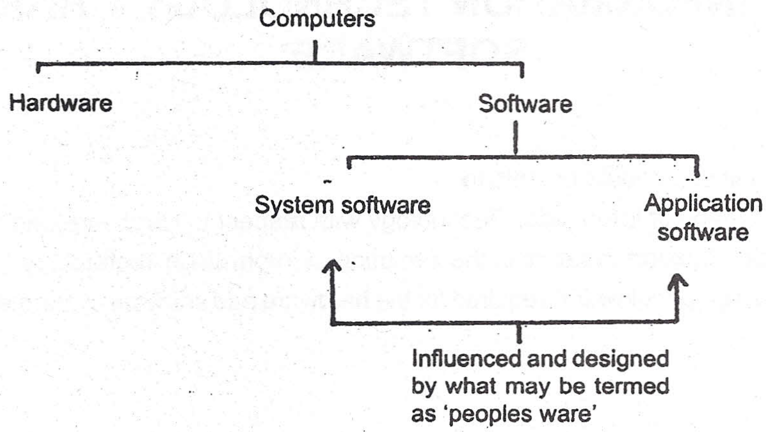

Figure 8.1.: Parts of a Computer

The computer industry is today the fastest growing in the world. The rapid growth accompanied by more and more sophisticated technology has resulted in hardware becoming progressively more powerful and compact and at the same time much cheaper. These falling hardware prices have practically reversed the hardware to software cost ratios.

The changing economic balance between hardware and software has resulted in formalisation of the software development process. What used to depend solely upon the skill and art of the software developer, now is aided by structured methodologies and automated prodictivity tools. Software development which was more of an art has now become an engineering discipline.

The advent of technology and reducing hardware prices has resulted in a widespread proliferation of computers. There has been a considerable amount of development in the area of Software Development tools and Data Management utilities. Very good relational database management products are available today on a wide range of hardware platforms. Most of the relational database management products are supplied with fourth Generation Language products for software development. This has changed the environment of software development substantially. Hardware also has undergone a sea change from the first generation valve-based computers to the fourth generation's very large scale integrated circuits.

8.2 INFORMATION SYSTEM DEVELOPMENT

Since we are examining the development of computers with respect to Information System, let us examine the stages of Information System Development. These can briefly be summarised as under:

1) **Requirement Analysis:** Study of the existing system and determination of requirements of User Preparation of System Study Report.
2) **Systems Design (Logical Design):** Conceptualisation of the New System based on System Study Report prepared in step 1 above. Preparation of detailed specification of algorithms to be used in the programs. Preparation of detailed Database Design. Specification of interfaces between all programs to make a system. The hardware platform, operating system, file system (conventional or database) and programming languages available are important considerations in the above design.
3) **Development of Prototype**
4) **System Design (Physical Design):** Partitioning of the system into programs. Preparation of detailed specification of algorithms to be used in the programs. Preparation of detailed Database Design. Specifications of interfaces between all programs to make a system. The hardware platform, operating system, file system (conventional of database) and programming languages available afe important considerations in the above design.

5) Preparation of test data for individual programs as well as for system link testing.

From the above we can see that the stage which is affected most by changing hardware and software platforms is the Physical Design phase of System Design.

8.3 HISTORICAL DEVELOPMENT OF APPROACHES TO ALGORITHMS FOR INFORMATION SYSTEMS

We will now develop the conventional approach to algorithm for information systems vis-a-vis hardware availability.

First and Second Generation Computing Environment

Hardware	-	Single user machines with limited memory
Data Storage and Retrieval	-	1. Magnetic tapes 2.Low capacity disks
Input device	-	Card Reader
Output	-	Line Printers
System Software	-	No Operating System
Language	-	Machine Language in First Generation computers and Assembly Language in Second Generation Computers.

The above environment was one of batch processing and primarily involved the use of sequential file system on tapes.

As a result of these restrictions the following approach was used in file design:

i) All the required fields of data whether maintained in another file or not should be available.
ii) In case of Master-detail kind of data relationship both types of records to be maintained in one file itself.
iii) About 10% of the record size to be kept blank in the record as provision for future addition of fields.
iv) Sequence of the file should be well defined. Each file must have an order of sequence.

Guidelines for program algorithm design were as follows:

i) Check order of sequence of all input files.
ii) Use standard two file matching algorithm for Master-transaction file processing.
iii) Maintain counts of 'input files' records read and 'output files' record created and tally.
iv) Use Data area of memory for overlaying, housekeeping routines etc., in case of long code.
v) Create temporary files for use in next program.
vi) Maintain sequences of all output files.

Since the language of programming was 'machine language' in first generation computers and 'Assembly language' in second generation computers, it is implied that code for all tasks had to be explicitly written. However, there was a facility of Macros which was used for file handling and other commonly used repetitive functions in 'second generation' computers only.

Third Generation Computing Environment

Hardware	-	Multi-programming machines with a little more memory.
Data Storage	-	1. Magnetic tapes primarily as backup and retrieval medium. 2. Magnetic disks with larger capacities.
Input devices	-	1. Card Reader 2. Operator's Console 3. Tape Drive
Output devices	-	Line Printers
System Software	-	Operating system and several utilities
Languages	-	High level languages like FORTRAN, COBOL, ALGOL, PL/1 etc.

File System		1. Sequential, ISAM, Direct file systems. 2. Database Management Systems (Hierarchical and Network Models).

Approach to files design was as follows:

i) Use of ISAM files structure for Master files which require random access.

ii) Use of the Noramalization principles for design of file contents.

iii) More emphasis on disk space conservation.

iv) Removal of redundancy wherever possible.

Approach to Program specifications Design was as follows:

i) Use of random accessing facility provided by indexed sequential and Direct Access file structures and Database Management Systems.

ii) Use of multiple files as input in one program.

iii) Use of parameter files and Code Master files to make the System more flexible.

iv) Use of structured programming techniques.

v) Processing logic specified for a record or a set of related records.

vi) Processing logic to be detailed for each activity expected to be performed by the program.

Fourth Generation Mainframes and Minis

Hardware	-	Multiprocessor, multiuser system with expandable memory
System Software	-	Operating system assisted by message control system, network management system and utilities
Input devices	-	1) Terminals 2) Tapes 3) Scanners
Output devices	-	1) Terminals 2) Printers 3) Disk 4) Tape
Data Storage and Retrieval	-	1) Tapes only as back up medium 2) Disks (large capacity)
Application	-	High level languages like FORTRAN, COBOL, ALGOL, PL/1 etc.
Productivity tools	-	Program generators, Application generators tools.
Data Management	-	1) Conventional file system (ISAM, sequential, System Direct files) 2) Database Management Systems (Mainly hierarchical and Network Models) Relational Database Management systems available for the last few years

Approach to File Design was as follows:

i) Use of ISAM files structure for Master files which require random access.

ii) Use of the Normalization principles for design of file contents

iii) More emphasis on disk space conservation

iv) Removal of redundancy wherever possible.

Approach to Program Specifications Design was as follows:

Previously the batch processing environment was predominantly used. Now-a-days systems normally consist of parts which are on-line, batch and real-time. Any system will have either one of the above environments depending on the user's requirements.

Program specifications will vary depending upon the processing environment, but otherwise the approach will remain more or less, the same as that outlined earlier under 'Approach to Program Specification Design' under 'IIIrd Generation Computing Environment'.

Activity A

Detail the differences in the first, second, third and fourth generation computing environments with examples.

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8.4 MICROPROCESSOR BASED SYSTEMS

With the advent of microprocessors more and more CPU power and memory is available at a much lower price. This phenomenon has increased the number of machines in the market. With this the importance of End-user computing was realised. Several user-friendly, easy to learn software tools are available and are widely used.

In India the computing environment is dominated by the Unix-based microprocessor based systems. On these systems many Relational Database Management Systems with fourth generation language are available. Fourth Generation Language, like COGEN, are languages whose single statement generates a series of higher-level language statements, like COBOL in the case of COGEN. The trend is therefore to develop systems using random batabase management systems for data management and fourth generation language for program development. This environment helps in increasing software development productivity.

8.5 NOVEL FEATURES OF RDBMS/4 GL ENVIRONMENT

Some salient features of Random Database Management System/Fourth Generation Language Environment are as follows:

1) Powerful and versatile Query language in SQL (de facto industry standard) is available.
2) Table level operations of Join, Select and Project are available.
3) These are event/action oriented languages.
4) Several routine tasks don't have to be specifically programmed, as they are automatically taken care of.
5) Excellent Report generation facilities are available.
6) Excellent forms/screen handling facilities are available.
7) Integrity and validity of data is ensured by building the controls into the Database Design itself.

We also find that previously hardware used to be standard for all applications in first generation computers, whereas, with the sophistication of technology, hardware sizing study needs to be done now, depending on the application and system software used.

8.6 EVOLUTION OF SOFTWARE SYSTEMS

Software has evolved from single transactions to batch sequential processing to batch indexed sequential processing to batch random to real-time systems.

Figure 8.2 gives the trend of software development in detail.

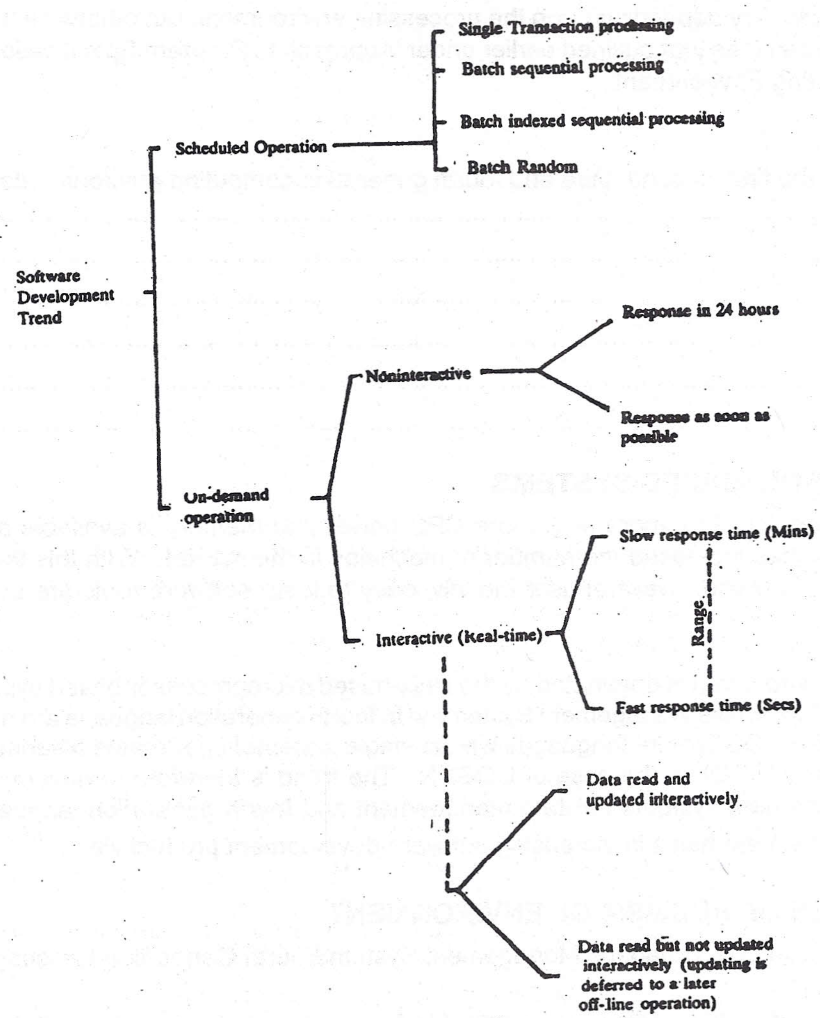

Figure 8.2: Development of Software Systems

Another significant feature in software development is the addition of secondary key inquiry of records to primary key inquiry of records and then to databases needing a search of higher kinds of inquiries as shown in figure 8.3.

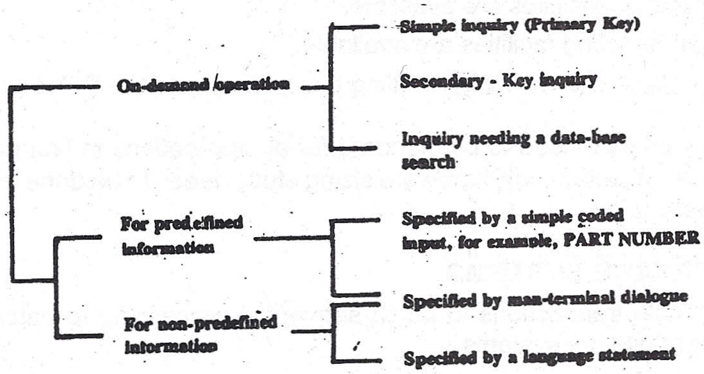

Figure 8.3: Categories of Database Usage

Activity B

Examples from your experience of the various kinds of software mentioned in the two diagrams in this sub - section on "Evolution of Software Systems"

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8.7 EXPERT SYSTEMS

Expert systems, the latest tools are provided by the fifth generation computer technology, not only to aid the manager in the process of decision - making, but also to suggest alternative solutions and to guide him in taking decisions. These tools till now are yet to catch up in our industry and busines and they will be the future tools to the manager in the process of decision - making.

Expert systems are very closely related to the decision - maker, not only in decision - making, but also in giving expert advice and guidance to the decision - maker by capturing the "domain specific knowledge".

A right decision can be taken at the time - only when right information is available to the right man, in the right form, at the right time. Right decisions can be taken in the light of information; without informmtion, decision - making is very difficilt. The information provides the basis for decision - making.

Decision - making is the process of selecting a course of action from among the alternatives available. Up-to-date knowledge about the environment is very important for right decision - making. The decision - maker must be able to analyse, evaluate and reason with this knowledge in appropriate ways.

An effctive decision has two improtant components viz., timeliness and correctness. A decision will lead to a successful result only when the decision is right. Still it will have its impact only when it is taken and applied at the right time. Hence we can define knowledge as the power or skill in a human being which guides we can define knowledge as the power or skill in a human being which guides him in taking 'timely decisions '. The basic ingredients in decision - making are data and information guided by specialised knowledge. Data is a set of compiled facts. These can be arranged in a logical manner to convey meaning, which is information Processing this information requires knowledge; comprising judgement, experience and reasoning, to reach a decision; to take an example. sales invoice information is 'data', which on compiling and processing gives sales 'information', that is, sales reports and forecasts. The 'knowledge' of the sales manager is utilised in generation of sales plan evaluation and resource allocation. Expert systems are the tools which capture this domain specific knowledge and suggest, aid and guide in the decision - making process.

8.8. EXPERT SYSTEMS IN DECISION - MAKING

Expert systems are computer programs which make recommendations and draw conclusions from rules of thumb and from relationships derived out of human experience. Expert systems are proving useful in practically every area. From quick and easy retrieval of context sensitive information to indepth analysis of an investors stock portfolio, expert systems are becoming an important tool in helping managers to make decisions. They can be successfully applied to almost any situation where rules of thumb or heuristics are used to make decisions. We can make use of expert systems in every area in industry from configuration of complex equiment to subassemblies, cost and time estimation, the interpretation of large amounts of data, data analysis, engineering design and diagnostics. Diagnostics of machinery - forms the largest simple application class of expert systems. Financial decision - making represents the fastest growing, and one of the largest growing expert system applications. Closely related are insurance, underwriting and routine office procedures that are complex, requiring some expertise. Manufacturing planning and scheduling is another rapidly growing application. One of the most surprising applications is sales. The spectrum of applications is astonishingly wide and are extremely complex.

Expert systems are useful at all management levels. Planning and prediction are the major activities at the top level. The planning activities are : expansion, investment planning, raising fresh capital, make or buy analysis and dividend decisions. The predicting activities are : projection of growth, and forecasting future income. For example, we can have expert systems in determining raising of new capital. It involves considerations of several factors such as current economic environment, the position of the stock and bond market, and the existing capital structure of the firm. Econometric procedures can be applied to predict the trend in these factors. The results can then be combined with the capital structure of the firm, the anticipated costs of capital, cash outflows and other factor. Similarly we can use expert systems for make or buy decisions.

These decisions involve the setting up or shutting down of a production unit /line against the alternative of purchasing the item. Expert systems can help make a decision for the short run by estimating various costs associated with each alternative. Control, disign, monitoring, prediction and training are the major activities at the middle management level. Establishing control systems, budgeting, cash flow analysis, framing customer credit policies, forecasting income, expenses, and growth rates instructing junior professionals in analysis techniques are activities at middle level. Expert systems can be developed in the areas of framing customer credit policies involving forecasting of sales revenue from a liberal or stringent credit policy. Diagnosis, Interpretation and monitoring are the activities at the lower levels. Diagnosis involves inventory management warehousing and loan and credit analysis. Interpretation is the analysis of cost and manipulation of financial data. Monitoring involves retrieving and control activities of things like accounts payable and receivable. Expert systems can be developed in areas where human skill and knowledge are required. The possible applications are virtually endless, including both small and large expert systems in areas such as:

- Establishing sales quotas
- Conducting trainee orientation
- Recommending acquisition strategies
- General project proposals
- Job shop scheduling
- Facilities maintenance
- Selection of forecasting models
- Determining credit limits, and
- Selecting transport routes.

Activity C

Mention five other uses of expert systems in the business field.

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8.9. BENEFITS OF EXPERT SYSTEMS

Expert systems improve the quality and consistency of decision - making. They improve the efficiency of the decision - making process. They can also be used as "knowledge spreading tools" for training the staff. There is a vast scope to develop expert systems to support different levels of staff in all areas. With the appearance of tools specifically designed for developing business expert systems,managers and business computing professionals can no longer regard the topic of expert systems as an intellectual curiosity or the domain of a selected few. Any repository of problem solving expertise that exists in an organisation is a candidate for expert system development - be it secretarial expertise or knowledge about solving strategic management problems. Expert system technology has already advanced to the point at which it offers innovative and most effective solutions to a wide range of industrial problems. Over the next decade further improvements in methodologies, new hardware architectures and more powerful software will result in expert systems being introduced into almost all areas where expertise is routinely applied. Expert systems are still in their fledgling stage. The next decade or two should see tremendous growth in advancement and utilisation of expert systems.

8.10. DATA MODELLING CONCEPTS EVOLUTION

Over the years, the emphasis in the programming methodology has shifted away from the design of procedures towards the organisation of data. This paradigm is often known as"data hiding" principle. The focus is onthe partition of programs into modules so that data is hidden in modules. In PASCAL,variables defined in the main program may be used by any procedure defined in it. The only mechanism to hide a name from the rest of the program is to define the variable in the procedure. This results in procedure nestings. In C, a module is defined by grouping together the related functions and data definitions in a single source file. The programmer has control on the names to be seen by the rest of the program by declaring them as 'static' or 'external'. A name can be seen by the rest of the program unless it has been declared static. Modula -2 supports this technique by making it a fundamental language construct with well defined module declarations and explicit control of scope of names.

Programming with modules leads to the centralization of instances of a type under the control of a type manager module. A type created through a moduel mechanism is different from bulit - in types. Languages such as Ada handle this problem by allowing user defined types known as abstract Data Types (ADTs), that behave much like a built - in type. The basic support for programming with ADTs consists of facilities for defining a set of operations (procedures or functions) for a type and restricting the access to variables of these types to this set of operations only.

An ADT, once defined, does not adapt to new uses except by modifying its definition. Programming with general ADTs makes no distinction between the general properties (attributes and operations) of a type and properties specific to a type. For example, it is not possible to establish that instances of the type CLOSED - POLYGON have some properties which are common to instances of the types TRIANGLE and SQUARE. A language with constructs that allow this distinction to be expressed and used, supports object - oriented programming. The focus is on the design of classes and a full set of operations for each class, and a mechanism that allows inheritance through class hierarchies.

In the object - oriented approach the essential idea is that data and procedures are represented in a structure called object. In traditional programming systems, data and procedures are separate entities. The programmer is responsible for applying active procedures to passive data structures. In contrast, in object - oriented systems, instead of passing data to procedures, the objects are asked to perform operations on themselves. In traditional languages, routine to perform any function is directly invoked by the program or another routine. In object - oriented languages functions/procedures are invoked indirectly.

Proceeding further, a database is a collection of stored data together with their description and interrelationships. A database is supposed to represent the semantics of an application as completely and accurately as possible. A data model provides a framework of concepts used to express the semantics of application. In classical data models (hierarchical, network of relational) or one of their derivatives, there is a considerable gap between the semantics of an application and the semantics of an application as represented within the database. This is because the semantics of an application may be modelled as a set of entities and relationships among them at various levels of abstraction. In classical systems this abstraction is not possible. This is primarily due to the fact that only atomic data can be stored in these systems. This is where object - oriented database systems come in, as they support the concept of data abstraction. Moreover, these systems are based on data models that allow one to represent a real - world entity, however complex its structure may be, by a single object in the database. However the object may be composed of other objects. This is accomplished by building the domain (called data type in programming languages such as PASCAL and C) of an attribute of a class (or relation) to another class (or relation). For example , an attribute "division" of a class UNIVERSITY may be bound to the class EMPLOYEE. Thus, object - oriented systems support modelling of complex entities and relationships directly.

8.11. ROLE OF COMPUTER NETWORKS

The role of computer nerworks in information systems has gained increasing importance with the fast pace of improvements taking place in technology today.

Computer networks in simple language are computer systems and devices interconnected with each other by means of electronic cables or satellited.

They enable pooling of information for use by a wide class of people distributed over a wide geographical area, by means which provide faster access to information.

Combination of artificial intelligence with computer networks has led to enhanced information exchange, storage and retrieval possibilities.

8.12. BUILDING UP OF PEOPLE

Information processing and computer processing are people-intensive.People are the most important and basic resource in this sphere. There is worldwide shortage of Information Technology people with the needed skills; knowledge and experience. Over the coming years, this shortage will grow. Some of the reasons for this shortage have to be recognised and analysed carefully.

The software industry is growing at the rate of 15% per annum and this rate is increasing.The increase in the growth of software demand can be ascribed to the following factors:

i) Software systems are becoming large and complex. For instance. USA's manned space programme in 1962 accounted for 1.5 million lines of code. Whilst in 1985, it was 80 million lines of code. Software systems require :

- Adherence to time schedules
- Working within cost estimates

- Conformity with quality and reliability standards
- Maintainability and maintenance
- *Adaptability to modifications and extensions*
- Operational efficiency in user environment
- Sensitivity to life - cycle costs and not only to initial developmental costs.

  All these requirements increase the complexity and work required.

ii) Software estimation is still an art and there is usually an under estimation of projects. Over - runs have become the rule, and projects are much behind schedule.

iii) For the first time it is being realised that hardware and software have a useful life in the field of information technology. While the life span of software is more than that of hardware, it is not indefinite. Many of the existing software systems have become obsolete. Newer systems are required to meet the increased complexity of operations and to make use of advancing hardware technology.

iv) There are huge backlogs of software development with almost all kinds of organisations all over the world. Some organisations are forced with backlogs of more than four years.

v) Skills required in software development today are less of programming and more of analysis. Computers can now do most of the programming through program generators, application generators,.fourth generation languages, Sequential Query Language and database languages. Programming skills by themselves are no longer sufficient.

While there is growing realisation of the importance of Information Systems; business, industry and the government are finding that there is an acute shortage of trained professionals. There is considerable leeway to be made in building up people of the right calibre who would bring about the information revolution.

Development of the manpower for accelerating the progress towards the Information Age calls for effective steps in selection, recruitment, training, continuing education and career development of software and hardware people. Only if we take such comprehensive steps aimed at choosing and building up the right people and providing them opportunities of growth and professional advancement, will we be able to harness the full potential of information systems.

8.13. SUMMARY

The managers of today's complex and diversified businesses must have up-to-date knowledge of company operations in order to serve their customers and control their business activities. This need calls for rapid collection, processing and distribution of large amounts of business data. Efficient, dependable data - collection and data distribution capabilities are particularly important in cases where geographically separated facilities are controlled from one central facility, or where operations at one facility have a direct bearing on operations at another.

With the increasred recognition of the potential of electronic data processing, more and more business applications have been computerised. Because data collection or distribution by mail, courier or carrier is slow and subject to both traffic and weather conditions, other types of data transmission are needed. Initially, attention was directed to telephone and telegraph facilities. The latter provided printed copies of whaterver was transmitted. However, electronic data processing has now established itself in the Information Systems filed.

We conclude by summarising that the vast range of data- processing/data- communication capabilities that are currently available from computer service companies, has enhanced the significance of information systems.

8.14. KEY WORDS

Attribute : A field containing information about an entity.

Domain : The collection of data items (fields) of the same type, in a relation (flat file)

Entity : This refers to the smallest element of data in computer language.

Semantics : This refers to the logical portion of a program or computer system design.

8.15. SELF-ASSESSMENT EXERCISES

1) What are expert systems and how do they help in decision- making ? Can you give examples to illustrate the same.

2) What kinds of decisions can be appropriately programmed on expert systems ? Give examples.

3) Trace the evolution of data modellng concepts with examples which are different from the ones given in the preceding text?

4) Write a short note on 'peopleware' in information technology.

8.16. FURTHER READINGS

CSI Communications (No. ISSN 0970-647 X), Nov. 1990

Bohl, Marilyn, 1990. Essentials of Information Processing, MacMillan Publishing Company; New York.

UNIT 9

DATA COMMUNICATION CONCEPTS

Objectives

The objectives of this unit are to :

- understand the concept of data communication as applied to computers
- inform about the hardware and software required for data communication in computers.

Structure

9.1 Introduction
9.2 Basics of Data Communication
9.3 Fundamental Communication Concepts
9.4 Hardware Requirements
9.5 Data Communication Software
9.6 Data Transmission Error and Recovery
9.7 Data Communication Protocols
9.8 Summary
9.9 Key Words
9.10 Self- assessment Exercises
9.11 Further Readings

9.1. INTRODUCTION

Personal computers are forcing the world into the information age, which is characterised by computers and the networks that connect them. The need for such connectivity is emphasised by the fact that information is required for initiating, executing and monitoring of a project. In today's world, every activity needs to be optimised to get the maximum cost-effectiveness.

This scenario is similar to the early part of this century where automobiles forced the development of highways for free accessibility and communicability,. Similarly, widespread use of computers (ranging from PCs to Mainframes) are forcing us to build up the information highways, namely the networks, to facilitate access, common utilities and common services. Fundamental to these goals is data communication.

By data communication we mean the transportation of information from one point to another through a communication media. Data communication facilitates efficient use of large computers, improves the day-to-day monitoring of projects and provides a variety of services like Electronic Mail, Credit Card Checking, Videotex, etc. These services on networks are called value-added services. This is becoming a new commercial business proposition.

9.2. BASICS OF DATA COMMUNIICATIONS

The main components of data communication are data source, data sink and communication media (Figure 9.1). The source is the originator of information, while sink is the receiver of information. The media is the path through which the information is transported to the sink from the source. This media could be a telephone wire, a micorwave system or a satellite circuit of a fibre optic line. Usually, the media is provided by one or more common communication carriers. In india, the common communication carrier is the Department of Telecommunications. The carrier agency lays down the rules and regulations on how to use communication media and also specifies the type of equipment that canbe connected to the carrier. The source usually is a computer of a computer terminal. The computer equipment is connected to the communication media through a piece of equipment calied Modem. This piece of equipment converts the digital signal to the analog signal and passes it on to the communication media through which they are propagated towards the sink. The sink is similarly connected to the communication media through a Modem and receives the propagated signals.

Figure 9.1

The source and sink could both be computers; or one could be a CRT terminal and the other a computer, or one could be a terminal and the other may be a printer, or any other computer resource. The source and sink can be connected in a variety of ways.

9.3. FUNDAMENTAL COMMUNICATION CONCEPTS

Types of Electronic Signals

The electronic signals actually represent reality. For example, the temperature or pressure can be represented as "equivalent" electronic signals. Such representations are of two basic types. These are Analog and Digital.

Analog Signals

Analog signals are continuous in nature. Figure 9.2 shows an analog signal called sinusoidal signal. Analog signals are ideally suited to represent the natural phenomena which are continuous. There is no discontinuity in nature! It is not possible to say that the pressure can only be measured as 100,200.... 10,000 psi.

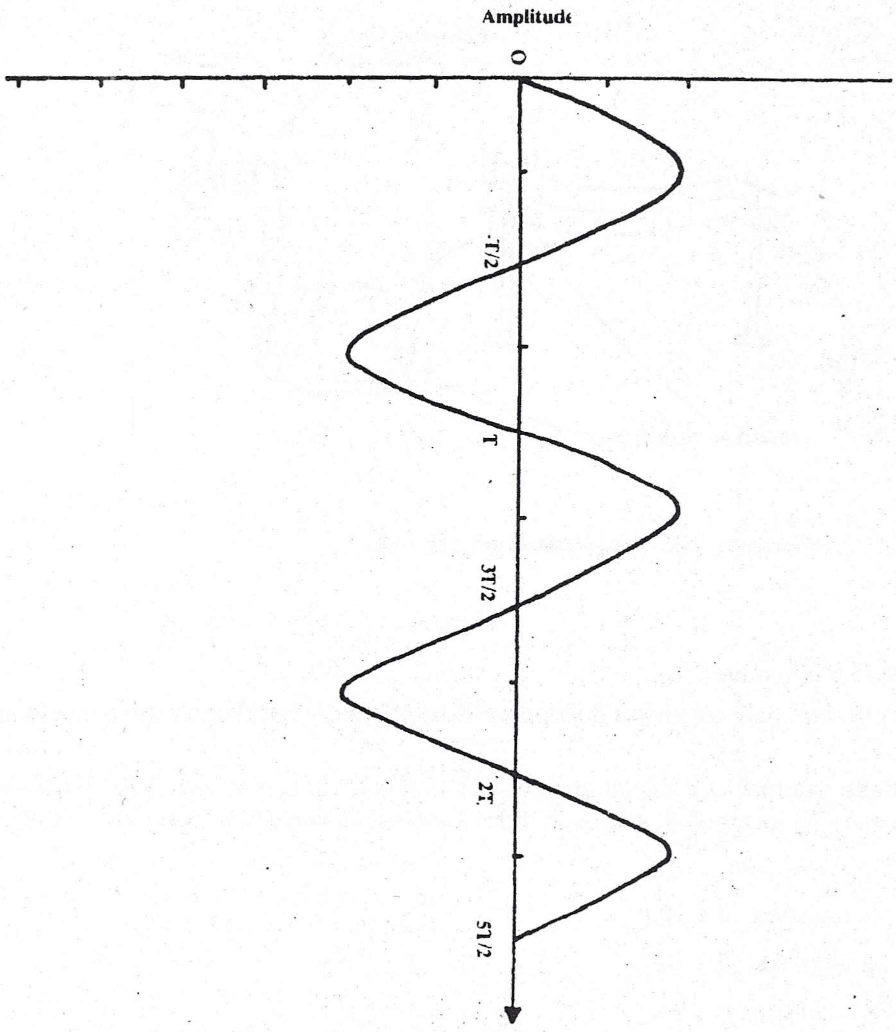


Figure 9.2: Sinusoidal Signal

You can always have 100.3 or 100.39 or 100.39421789. This is what we mean by continuous signals. There is no break anywhere. Let us consider another example, say, speech. When you speak using the telephone, the microphone in the handset near your mouth converts your speech or voice into analog electronic signals. It is this analog signal that gets transmitted through the public switched Telephone Network to the called party. At the other end the analog electronic signal is converted back to speech signals by using a speaker which is part of the telephone handset near the ear. This is depicted in Figure 9.3. This is an example of analog signal transmission.

Digital Signals : Digital Signals are the basis of modern computer. In the digital system, there are only two states to the signal - Present and Not Present. TRUE and FALSE, 1 or 0. Any other quantity has to be represented in terms of these. What we use in everyday life is the decimal number system, that is the numbers (or should we say digits) run from 0 to 9. The digits that we deal with are only 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. Any number that we want to represent in this decimal numbers system, can be composed of these ten digigs. A number is made up of individual digits (egg., 803 consists of the digits 8, 0 and 3). The value of each digit in a number is determined by three considerations:

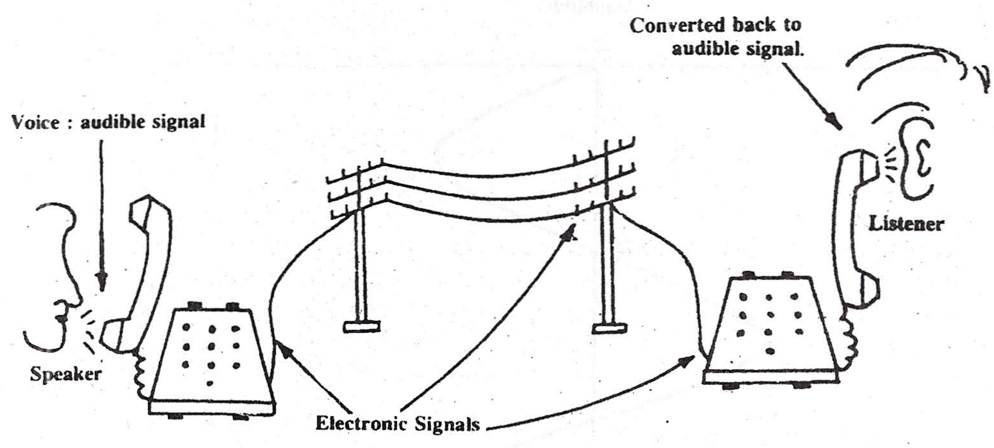


Figure 9.3: Voice Transmission-Block Schematic

a) the digit itself
b) the position of the digit in the number
c) the base of the number system (where base is defined as the number of digits which can occur in any one position).

In the decimal system the base is equal to 10 since any position can contain one to ten digits (0123456789). The system therefore has a carrying factor of 10 and each digit indicates a value which depends on the position it occupies:

In 6,421 the digit 6 signifies 6 x 1000

In 4,621 the digit 6 signifies 6 x 100

In 4,261 the digit 6 signifies 6 x 10

In 4,216 the digit 6 signifies 6

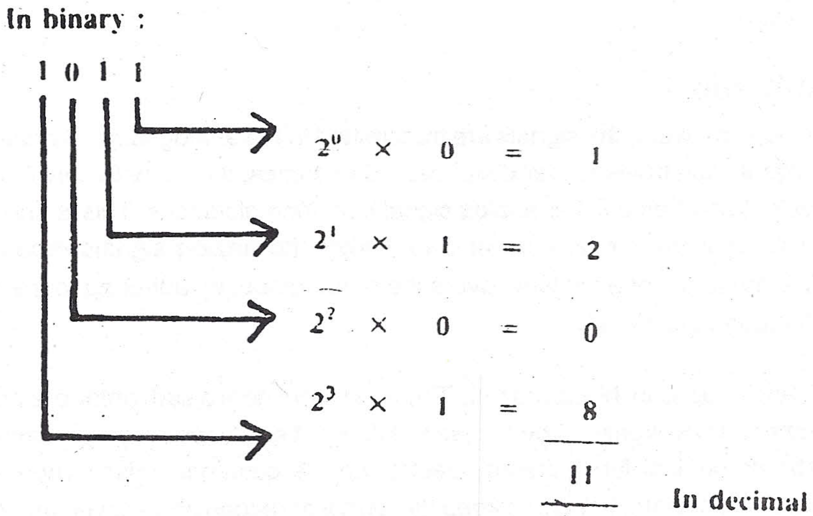
On the contrary, in the case of digital signals, there are only two levels. That is the ability to represent a ZERO or a ONE. Any other number has to be represented only as a combination of these. Here 0 and 1 are called binary digits or bits. We use the binary number system for this purpose. In binary, the base is equal to 2 and the two digits are 0 and 1. This system is ideal for coding purposes for the computer because of the two-State nature i.e., ON or OFF of the electrical components that are used.

Remember we only have two digits, 0 and 1, and therefore the binary equivalent of the decimal number 2 has to be stated as 10 (a 0 with a 1 carry, read as 'one, zero').

Binary	Decimal Equivalent
0	0
1	1
10	2
11	3
100	4
101	5

110	6
111	7
1000	8
1001	9
1010	10
1011	11 and so on.

This system has carry factor of 2 and each bit has a value which depends on the position it occupies:



In our 36-bit word, numeric data can be represented by upto 35 bits with the 33th bit always reserved to indicate whether the number is positive or negative.

Numbering the bit positions from the right, we can assign each bit a value based on two times the value of the previous bit. The number 1,208,747 is represented in the computer by the unique pattern of 1's and 0's as shown below. It is the total value of those bits (reading from right to left marked with a 1 that gives us the number in decimal figures, i.e.,

Bit number from right	value		
1	1	=	2^0 x 1
2	2	=	2 x 1
4	8	=	2^3 x 1
6	32	=	2^5 x 1
8	128	=	2^7 x 1
9	256	=	2^8 x 1
13	4096	=	2^{12} x 1
14	8192	=	2^{13} x 1
15	16384	=	2^{14} x 1
18	131072	=	2^{17} x 1
21	1048576	=	2^{20} x 1
	1208747		

Types of Transmission

In the previous section we tried to explain the types of electronic digital signals. Also, we noted that the computers use only digital signals. But when we consider an application like office automation, both types of signals may be present because the signals may originate from several independent sources, e.g., computers, Fax machine, Video conferencing machines etc. It, is often necessary to pass the information at application level from one system to another. The information becomes electronic signals when it passes through a communication medium. Most often, the systems that act as source and destination could be far apart, even thousands of miles apart. A little insignt into the transmission of analog signals and digital signals will put these in proper perspective.

Analog Transmission

In the popular telophone network, the signals are transmitted in the analog form. By nature, without ant special effort, the analog signals can travel longer distances. Sometimes, it is easy to convert a digital signal, 0 or 1, to an analog equivalent and transmit the analog signal over long distances. This is known as *modulation*. The receiving end can recover the digital form of 0 to 1 from the analog signals received. This is known as *demodulation*. Since the telephone system covers the entire globe, by adhering to the analog signal, we can transmit signals all around the globe.

There are some disadvantages in this approach. The most prominent disadvantage is noise. Noise in electrical parlance is yet another analog signal. When noise interferes, it easily mixes with the analog signal that is being transmitted, disturbs its original form, thereby destroying the contents. Also, when the signal travels long distances, it may lose its strength; hence, to keep the signal at recognisable level, amplifiers (or boosters) are required. These device not only increase (or boost) the signal but also increase the noise content. Hence, recognition of the signal at the receiving end is an involved affair.

Digital Transmission

On the contrary, the digital transmission is less error prone. But, without a booster, it cannot travel long distances like analog counterparts. Incidentally the digital signal cannot be simply amplified. It has to be absorbed and regenerated at regular intervals. Because it is absorbed and regenerated, the noise signals are completely eliminated. Therefore, the digital transmission is always preferred because of its high quality as compared to analog transmission. But then all the real world or natural signals are analog. Voice and video are excellent examples of analog signals. To make use of high quality associated with the digital transmission for analog signals, the analog signals have to be converted into their digital equivalents. As we all know, intuitively, no translation can be 100% perfect. But there are several techniques developed over a period of time for converting signals from one form into another with fairly high fidelity.

Bits and Baud

Bit is the basic unit of information. Bits are combined to farm characters. In contrast, Baud is a measure of signalling speed. In fact baud should not be used to experss the capacity of a line. However, these two are used synonymously. It (baud) refers to the number of times the line condition changes in each second. If the line condition represents the presence or absence of one bit, then the signalling speed in baud is the same as the line's capacity in bits per second. Baud describes the rate of change of the signal on the line, that is, how many times (per second) the signal changes its pattern.

In figure 9.5, the sending device assembles the bits into groups of two and then modifies the oscillating wave form (i.e. changes the signal state) to one of the four amplitudes to represent any combination of 2 bits (00,01,10,11).

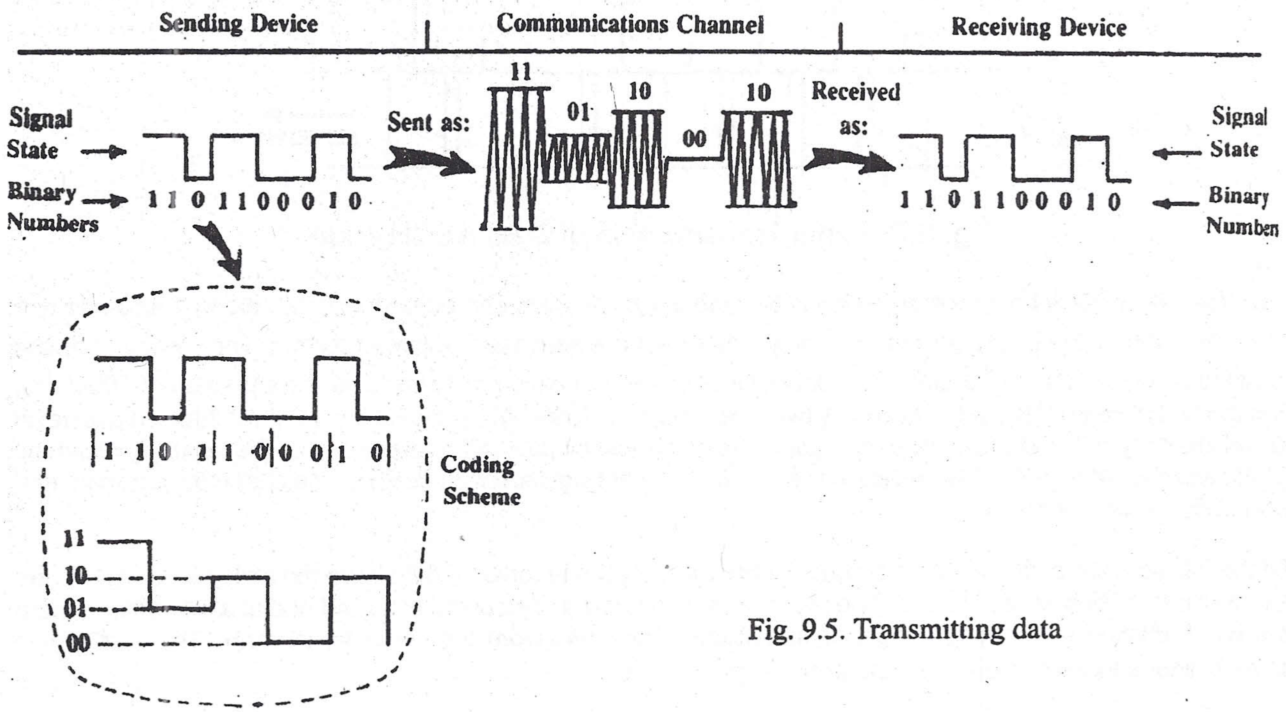


Fig. 9.5. Transmitting data

Source : Black D. Uyless Data Communications and Distributed Networks (Second Edition). 1987. A Reston Book. Prentice. Hall Inc. Englewood Cliffs. New Jersey).

Mode of Transmission

The computer system transmits data to its devices in two modes-serial and parallel.

Serial Transmission Mode

The transmission of a stream of data bit by bit over the communication line is called serial transmission. This is illustrated in Figure 9.6. In this, initially, the sender trasmits the first bit. Then after some time (machine cycle) the second bit is transmitted and then the third and so on till all the bits are transmitted. The receiver receives the data exactly in the same format bit by bit.

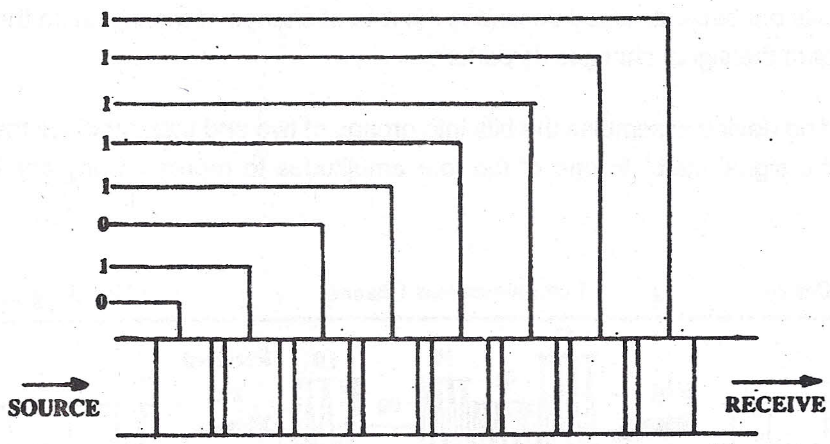


Fig. 9.6. Serial Transmission of 8-Bit ASCH code

The objective of serial data transmission is to send the bytes from one point to another along a single line or channel. That is, the bits representing a given character are sent serially, one at a time. The medium has the ability to carry only one digital signal i.e., only a bit at a time. For example, to transmit the charater A (01000001), first the digital level '1' is sent followed by five digital level '0', followed by digital level '1' and then a digital level '0'. Incidentally, in the charater representation, the right most bit position is referred to as the least significant bit (LSB) and the left most bit position is referred to as the most significant bit (MSB). The chatacter is transmitted with LSB first and MSB last.

As the bits sent are digital electronic signals, consequently the receiver should have the ability to recognise the serial stream of bits as characters. The receiver must be able to detect the start and end of a character. There are two techniques for recognising and separating characters from the serial bit stream. They are called asynchronous transmission and synchronous transmission.

Parallel Transmission Mode

In this transmission mode, all the bits of information are transmitted in a single cycle. For example, in the 8-bit ASCII code, all the 8 bits are transmitted over the communication media in one single cycle. This is illustrated in Figure 9.7.

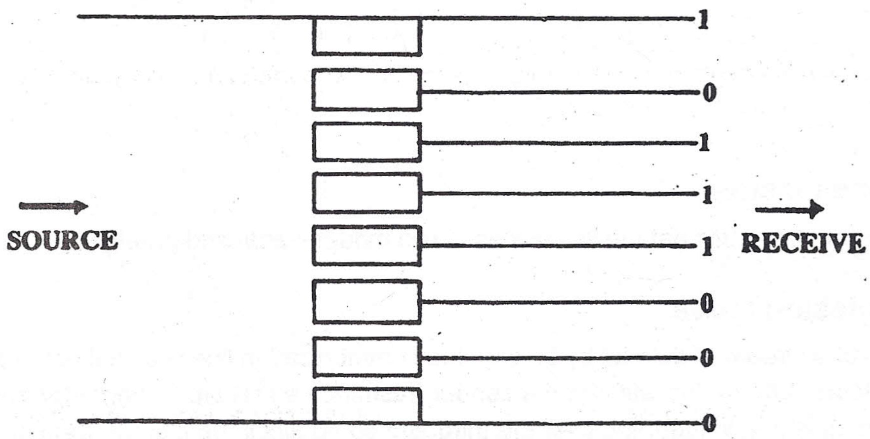


Figure 9.7 : Paralel Transmission of 8-Bit ASCII Code

It is clear that if there are 8 bits the serial mode transmission would require 8 machine cycles while the parallel mode transmission would require only one cycle.

In parallel transmission, as the name implies, the bits of a chartacter are sent in parallel (simultaneously) using as many signal carrying lines as there are bits. For example, to transfer an eight bit character from one subsystem to another, eight separate signal carrying lines are required. As you can see, the entire character can be transferred in one bit time. That is an eight- fold increase in transmission speed as compared to serial transmission.

But such an increase is not without its share of problems and limitations. First of all the sender and receiver have to agree on the exchange of one or more characters. this necessitates a protocol or prior understanding between them. Protocol is a communication control methodology which defines the content and the sequence of exchange of units of information (bits,bytes or groups of bytes called packets) between any two systems. This can be implemented either through hardware or software. At high speeds of tranfer using parallel transmission, protocols will be in the form of hardware signal exchanges. Therefore, systems capable of such high speed transfer will be complex and are expensive to build. They are used typically for exchanges between subsystems of a computer system. The high speed also limits the distance and hence parallel transfers are confined to shorter distance of the order of a few feet. The parallel mode is used to achieve high transmission speeds between the devices and the CPU.

Serial transmission is achieved in three ways. These are asynchronous, synchronous and iso-synchronous.

Asynchronous Transmission

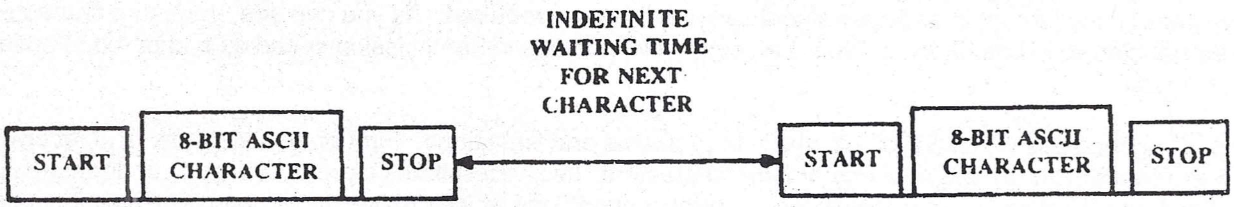
Asynchronous is the most commonly used transmission mode. In asynchronous transmission of characters, each character to be transmitted is preceded by a start bit and terminated by one or two stop bits. Because of this, the asynchronous transmission is sometimes referred to as "start /stop" transmission. The function of the start bit is to tell the receiver where the new character starts and the function of the stop bit is to tell the receiver that the character has ended, so that the next start bit will be perceived as the start of a new character. The receiver can know the end of the character by counting the number of bits.

Asynchronous character framing is designed for a situation where the charactes are transmitted intermittently. Ths is typical wher a person is sitting at the keyboard of a terminal that is connected to a computer. Whenever a key is pressed, the binary code corresponding to that character is generated and sent to the computer system immediately.

Typical applications of asynchronous transmission are computer to terminal communication, communication with slow printers, and sometimes even between computer to computer. The main disadvantages of this approach are the overhead transmission is generallly slow (at 1200 bits per second) using a telephone line. With dedicated point-to-point lines one can go up to a speed of 9600 bits per sencond or even 19200 bits per second. For example, 1200 bits per second means that the communication channel has a capacity to transfer 1200 bits of information in one second.

Always, the two devices (terminal and computer for example), have to agree upon the number of bits in a character and the bit time. The ASCII character set, which uses 7 bits, is the most widely used. The bit time is set by deciding how many bits per second to transmit. The bit time refers to the duration for which the digital signal remains either at "0" leverl or at "1" level.

Let us refer to Figure 9.8. Which depicts the waveform of the signal where the character whose ASCII represenation is 1100111 is transmitted. Here it is assumed that the LSB will be transmitted first and the MSB at the end followed by a bit called parity bit. Here we assume odd parity. That is, there will be an odd number of 1 s in the character. There are 7 character bits + 1 odd parity bit + 1 start bit 2 stop bits = a total of 11 bits for every 7 bit characcter, 4 bits overhead for 7 bits of data. The idle state of the line is "high state" or "1 state". A drop suddenly for a one-bit period means that start bit is on the line. This is followed by the 7 bits belonging to the character in the order 1,1,1,0,0,1 and 1. Then the parity bit is sent. Since in this case the character already has odd number (s) of 1 bits, the parity bit sent is actually '0'. Then the 2 stop bits ar sent.



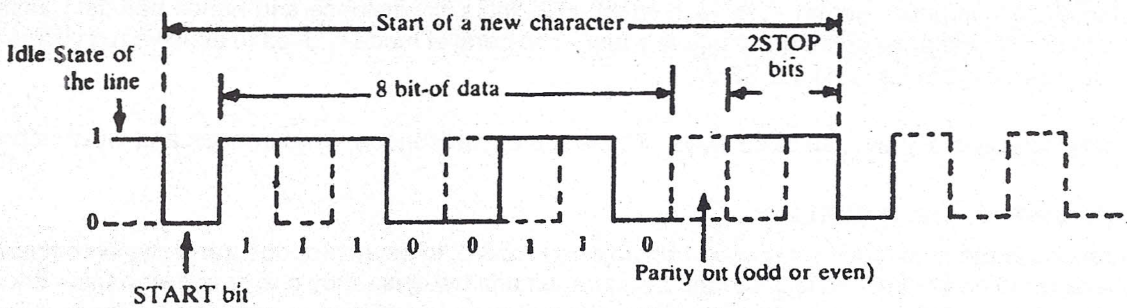


Figure 9 .8 : Asynchronous Transmission

Asynchronous or start/stop transmission is relatively simple to implement. But it results in inefficient use of channel capacity because ten bits are transmitted to convey the characters consisting of only 7 bits - approximately 20% to 30% overhead. This is mainly because each character is a separate entity by itself in the start/stop case.

Synchronous Transmission

synchronous transmission is used to achieve high speed of data-transmission. In this the sender transmits a block of characters together in one single transmission.

The synchronisation between the transmission device (sender) and the receiver device is achieved by transmission of a pre-determined group of bits known as synchronous bits (figure 9.9). These synchronous bits inform the receiver that the data is following and he can determine the time frame between each of the bits. The receiving device based on the synchronous bits starts receiving the bits and starts interpreting them bit by bit into character form as per code and transmits the characters to the computer. In the case of 8-bit ASCII, it counts 8 bits interprets the character and then transmits it to the computer. There are at least three SYN characters, followed by number of data characters and then finally the checksum character:

Asynchronous vs Synchronous Transmission

As can be seen, asynchronous transmission is less efficient compared to synchronous transmission as, for every character, there is a start bit and stop bit in the former system. However, in asynchronous transmission, if an error occurs during transmission, only one character is destroyed. On the other hand, the same error in synchronous transmission may destroy the whole block (set) of characters.

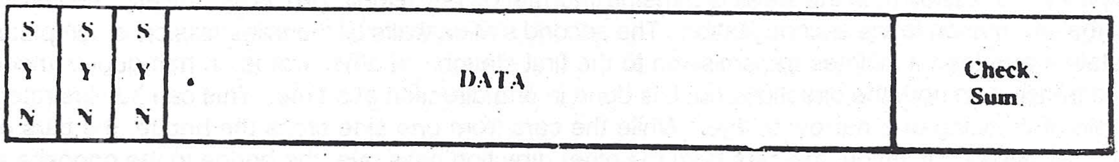


Figure 9.9 : Synchronous Transmission

The equipment required for receiving synchronous transmission will obvioulsy be more expensive than that used for asynchronous transmission.

Both the asynchronous and synchrounous transmission methods are widely used in terminals. While terminals of microcomputers and minicomputers support asynchronous connection to terminals, the mainframes still support synchronous communication between the computer and the terminals. One reason in favour of asynchronous approach is the simplicity and significantly low cost of realisation. On the other hand, synchronous communication terminals and interfaces are complex by an order or magnitude and are significantly more expensive to implement. But synchronous mode terminals are favoured in situations where fast query/ response times are desirable. One must also take cognizance of the fact that the **population of devices** using the asynchronous method has increased dramatically due to the spectacular growth of personal computers. The PCs almost exclusively use asynchronous transmission for communication lines and for printer interfaces. It is really a matter of balancing between response time, communication channel cos's and the cost of implementation.

Iso-chronous

Iso-chronous is a technique which makes use of both synchronous and asynchronous modes. In this, each character starts with a star-bit and ends with a stop-bit. In addition, the time interval between the transmission of two characters will always be an integer multiple of the length of time required to transmit one character. That is, all periods of non-transmission consist of one or more character time intervals. This common timing allows higher precision than asynchronous transmission between the end devices. Iso-chronous transmission is generally used to achieve higher rate of transmission compared to asynchronous transmission and also to retain the advantages of asynchronous transmission.

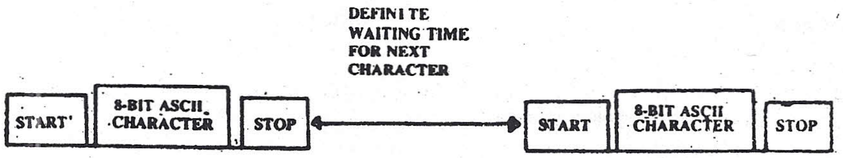


Figure 9.10 : Isosynchronous Mode

A circuit is a path for transmission of electrical signals between two or more points. The terms channel, line, circuit, link or a path are synonymously used.

There are three types of transmissions. These are simplex, half-duplex and full-duplex.

In a simplex transmission, signals are transmitted in one direction only from one point to another. The roles of the transmitter and the receiver are well defined. An example of this is remote control of VCR or a Television. Here, the remote control unit sends a signal to the television or VCR to perform a particular function. Here the role of the remote control is to direct the action at the television or the VCR. Another example is a one way road.

In half-duplex transmission both the stations transmit information but in their own turns. Initially, the first station transmits the information to the second station. The second station waits till the transmission is complete from the first station and then it initiates transmission to the first station. In other words, in half-duplex mode it is possible to transmit in both the directions but it is done in one direction at a time. This can be illustrated with the example of crossing of a narrow bridge. While the cars from one side cross the bridge, the cars on the other side wait. After completion, the cars from the other direction pass over the bridge to the opposite side.

In full-duplex transmission both the sides can transmit information simultaneously. A two-way road is a simple example of full duplex transmission. The concepts mentioned above are illustrated in Figure 9.11.

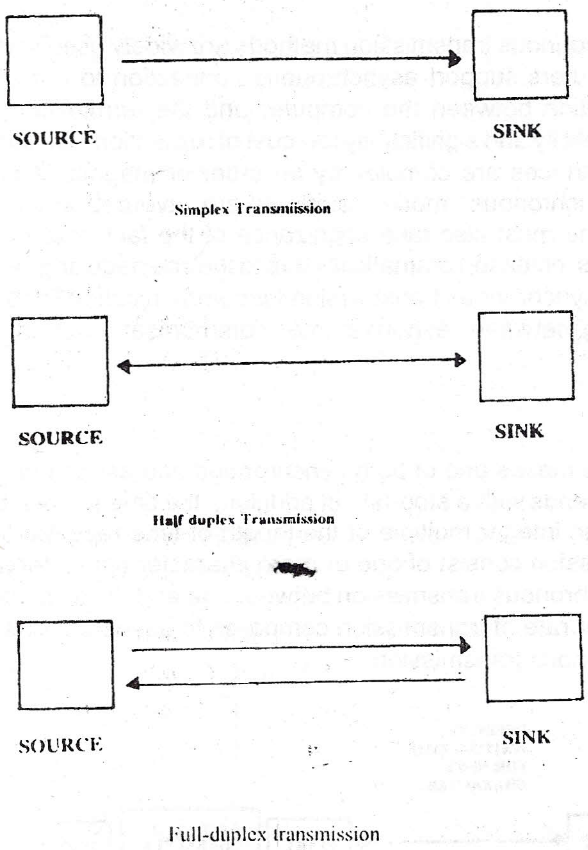


Fig. 9.11 Modes of Transmission

Half-dujplex operation is possible on both two-wire and four-wire circuits. In a two-wire circuit, only one wire is used for transmission. The second one is for grounding. However, on two-wire, the user must deal with turn around time, i.e., 'the time required to change the direction. During that time there is no transmission. In full-duplex there is no turn around time. It generally requires four-wires. However, some sophisticated modems can handle full duplex transmission on two-wire circuits.

9.4. HARDWARE REQUIREMENTS

Till now we have been discussing the transmission of data on the communication lines. In this section we will be discussing the interface between the computer lines. In this section we will be discussing the interface between the computer and communication equipment, i.e., how to get onto the communication media. As has been spelt out earlier the communication media deals with the digital signals. Further, the commuication media is comparatively slower than the data processing equipment. These differences make it necessary to have an additional equipment which establishes the linkage between the data processing equipment and the communication media. It is something similar to providing an interface between the two of them to facilitate movement from a high level to a low level and from a low level to a high level. Similarly, the data communication hardware facilitates linkage between the communication media and the data processing equipment.

If you look at Figure 9.1 you will see that we have identified three elements, i.e., source, media and the sink. In this section, we will be talking about the equipment which interfaces between the EDP equipment and the media. There are three possible locations where these equipments can be located. The two obvious places are at the two terminal ends of the communication lines (Figure 9.12). In between the two terminal ends, a lot of equipment is also deployed to facilitate, maintain and monitor the communication link between the source and the sink. In this course, we will be exploring only the equipment located at the first two palces.

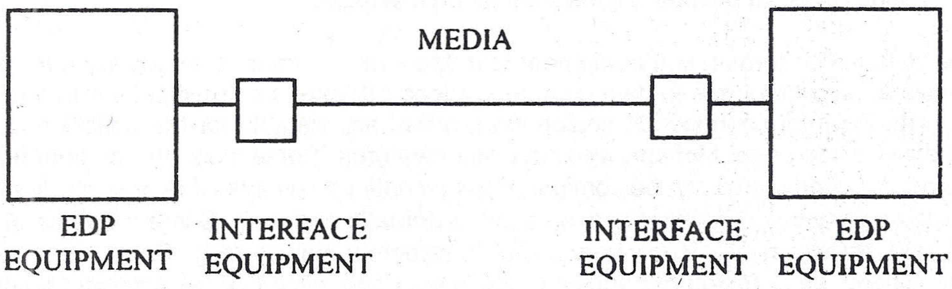


Fig. 9.12. Interface Equipment

The equipment at the end of the communication lines are generally called data circuit terminating equipment. Each of these equipments performs certain functions. Some of these equipments have very sophisticated functions.

Some of the major functions of the Data circuit terminating equipments are:

a) establishment of the physical connection between the two end points;

b) transmission and receipt of all digital information through the physical circuit;

c) conversion from digital to analog and analog to digital;

d) error detection and correction;

e) monitoring and diagnosing of equipment faults.

Lines for Data Transmission

So far, we have referred to communication channles as lines, without being precise as to their physical nature. In fact, the most commonly used medium for transmission, both nationally and internationally, is the telephone system. Links may be established by dialing on the Public Switched Telephone Network (PSTN) or by using private circuits leased from telecommunication administration or by using privately installed wires.

In none of these cases does a physical line exist in the sense of copper wires joining any two arbitrarily chosen points. Telephone channels for transmission other than the "local leads" are grouped together in carrier systems using coaxial cable, microwave, fiber - optic or even satellite links. The coper wires exist only at the ends called"local leads" and, ironically, these relatively short "tails" or "local loops" are the one which are subject to electrical interference. Such interference produces noise and consequent errors in data transmission using the telephone channels.

Naturally so, because the telephone network was designed for voice communication and not for data communication. The Telecommunications authority provides leased lines which are equalised or "conditioned", so that improved quality of data transmission is possible. but little can be done to improve the quality of channels established by dialing on the public switched telephone network. Moreover, the communication equipment at the exchange cannot tolerate the variability and correct the transmission errors. the communication lines are available either as "4-wire" or "2-wire" circuits. The former provides, in effect, two independent channles, one in each direction, while the latter provides one channel, usable in either direction. In practice, most lines are 2-wire only at the local loop.

The lines may be of two operational types :

* **Switched** (i.e., public Switched Telephone Network - PSTN) with world - wide availability and connectivity.

* **Leased**, specially engineered circuits between (usually) two points only. The signalling is not required and the line is conditioned to provide a consistent level of service.

The most common data circuit terminating equipment is a 'Modem'. Modem is an acronym for modulator / demodulator. It plays an important role in data communications. It takes binary signals from the computer/ terminals and converts them into contiguous analog signals that are suitable for transmission on the voice communication media and vice versa. Modems also have other features. Some modems can perform automatic dialing to remote stations. Some also can be configured to be continuously available or in ready state so that they can be accessed at any time. This feature is called "automatic answer". Some modems also allowed alternate data and voice transmission. This is very useful for remote troubleshootig. Some also have "reverse channel" capability, where by a limited full duplex transmission capability can be achieved using two-wire circuits.

Modems are calssified as low speed or high speed. Modems with speed less than 1800 bps are referred to as low speed and ones with more than 1800 bps as high speed. The cost of the modem accordingly varies with the functions and speed. For any two data terminal equipments to communicate with each other over a communication line / medium, the associated modems should also be able to communicate with each other. For this, the two modems should follow the same procedures and techniques. Recognising this, standards for modems have been prescribed. The CCITT an international organisation dealing with telecommunications has published a series of recommendations known as V-series for the modems. As long as the modem manufacturer conforms to the standards the modems of different manufacturers will be able to communicate with each other over the communication lines.

The modems can be interconnected by a variety of ways with the use of leased point to point circuits or dial up circuits. Some of the simple connections are given in Figure 9.13.

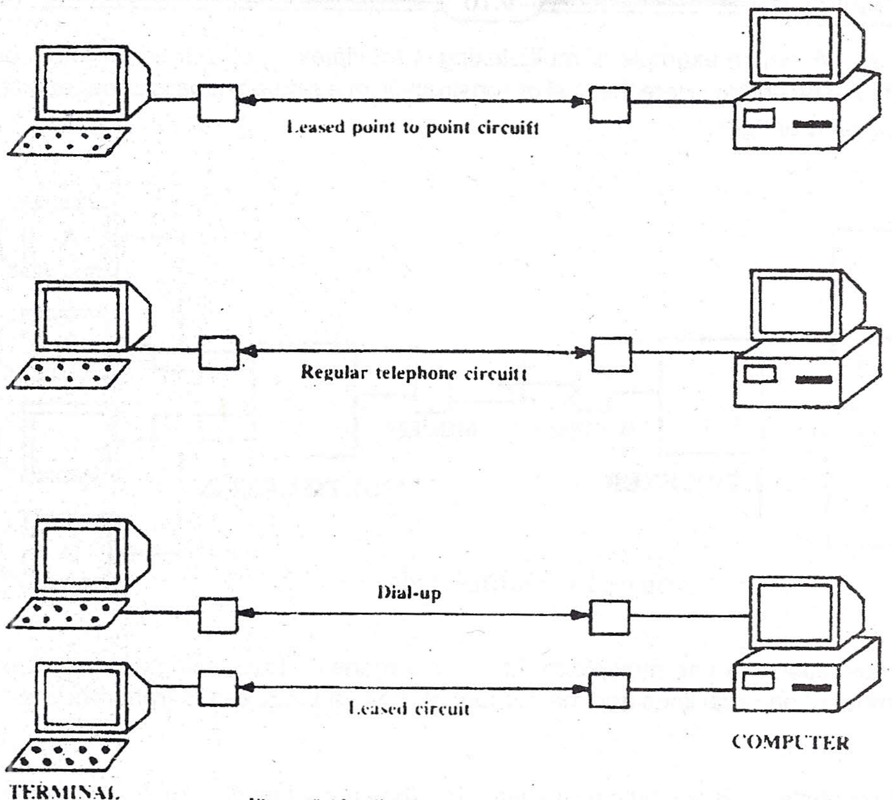


Figure 9.13 : Simple Modem Connections

Multiplexor

In the approach given above (Figure 9.13) each communication line with a modem would facilitate one data terminal equipment to communicate. The efficiency of utilisation of the line will very much depend upon the usage. There are many ways links can be used to interconnect data processing equipment for higher utilisation of line. One method might be to have a common communication line, for several terminals, with the computer. Each terminal communicates with the computer as long as the line is available. If a terminal wants to communication to the computer it must wait until the data line is free. This can be illustrated with the example of a telephone with two or more extensions. When one of the extensions is busy, the other extension cannot make a call. Only one terminal on the data-link can transmit at one time. The criteria for choosing a modem are speed, error rate, reliability, maintainability (like loop-back) turn around time and cost.

The other methods of line sharing use devices of various types to interconnect data terminal equipments with each other. Instead of connecting several terminals to the mainframe using a multi-point data-like, we can think of (as described in the above paragraph) a mechanism of combining all the links at one end and transmit them on a single line with the facility of recovering all of them at the other end. This method is called multiplexing and the equipment is called multiplexor.

The multiplexor's main job is to combine the data being transmitted over a number of low speed data links for transmission over a common long distance line. This would mean that the low speed lines will be able to achieve their speed over the communication lines media. Here we gain the cost of the lines against the cost of multiplexing equipment.

The end effect of the multiplexing is to combine several low speed transmissions into a single high speed transmission. Because of the economics, a single communication line is nearly always cheaper than an equal number of smaller lines. A simple example of multiplexing is multiplexing of four small roads over a river by constructing a single four lane bridge. Here the cost of construction of a single bridge is cheaper than construction of four separate single lane bridges.

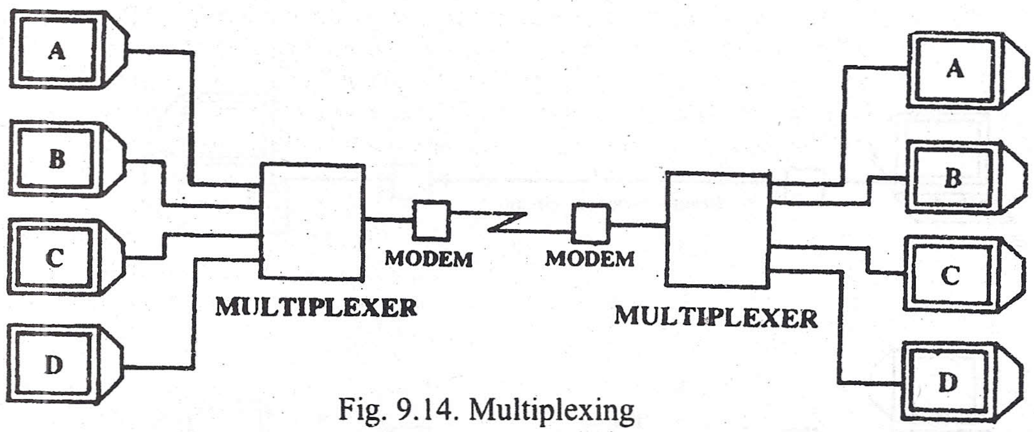


Fig. 9.14. Multiplexing

The most often quoted reason to use multiplexor is to save money. The savings are realized through the reducation in the number of physical lines and the number of modems required to transmit data from a number of terminals.

The multiplexors only multiplex and demultiplex the signals. They are relatively simple, rugged and transparent to the user.

Simple multiplexors techniques generally provide a "transparent" connection between terminals located remotely from the computer and the computer ports to which these terminals are individually attached. the word "transparent" means that the multiplexor system does not in any way interfere with the flow of data. Neither the computer nor the terminal knows that the multiplexor system is being used. Thus, neither terminal equipment nor the computer software need to be changed when a multiplexor system is installed. The use of multiplexors can result in substantial savings in telephone line rentals or in long - distance call charges.

It should be noted that multiplexors are normally required at both ends of the "shared" telephone line, so that a given number of channels multiplexed at one end may be demultiplexed back into the same number of channels at the other end, thus providing the transparent connection between each of the points on either side. In data communication, characters may be multiplexed in different ways. Three main methods are used : Frequency Division Multiplexing, Time Division Multiplexing and Statistical Multiplexing.

Frequency Division Multiplexing (FDM) is the oldest type of multiplexing. It takes advantage of the fact that the bandwidth of a voice-grade telephone line is significantly greater than that required by a low speed channel. Using different centre frequencies, several channels can share the same line. Typically, up to a maximum of 24 low speed channels can be derived from one voice grade line. However, due to its relative inefficiency and inflexibility, FDM is now rarely used for general purpose data multiplexing

Time Division Multiplexing (TDM) is a digital technique. **TDM** interleaves bits (called bit TDM) or characters (called character TDM), from low speed channels attached to it and then transmits the combined data stream serially using a high speed line. The multiplexer at the other end, demultiplexes the data stream, presenting one bit or character to the corresponding low-speed channel. If we observe the low - speed channels both at the transmitting and at the receiving end, they will be identical. Each low-speed channel is allocated a fixed time duration or time slot on the high speed line. Character interleaving is more widely used than bit interleaving primarily because of its efficiency when multiplexing asynchronous channels. Because a character multiplexer stores a complete character before transmitting it down the high speed line, it is possible to remove the start and stop bits during demultiplexing at the other end. Thus, it is only necessary to transmit eight bits for every ten bits (8 bit data plus one start plus one stop bit) received. The net result is that the high speed line is used more efficiently and channel capacity for a given speed of a high speed line is greater when character TDM is used as opposed to the bit TDM. However, the character storage required in character TDM results in longer delays than with bit TDM. As a result, bit TDM is usally preferred for the multiplexing of synchronous channels. Since there are no redundant start and stop bits in synchronous transmission, character TDM offers no advantages in efficiency. Modern Time Division Multiplexers accommodate a wide range of terminal speeds and codes. Typically, speeds from 50 to 9600 baud and any combination of ASCII, IBM and Baudot codes may be mixed.

It may be noted that the channel in a Time Division Multiplexer is allocated to a fixed time slot on the high speed line. A slot is allocated to a channel whether it is active or not, idle characters are inserted if a channel is not active. Therefore, even when a channel has sporadic or low use, the time slot must be allocated. This leads to inefficient use of the high speed line.

Another deficiency of conventional TDMs is that errors occurring on the high speed line cannot be corrected and will cause corruption of the characters received by one or more channels. This does not matter of the terminals connected to the multiplexer have their own built-in error correction features, but a large proportion of terminals in use are simple asynchronous devices without this capacity.

Lack of error correction effectively limits the application for which the conventional TDMs can be used. Also on all lines except the very best, the error rates experienced are unacceptable to the user. This is especially true if the high speed line is operated at 9600 bps or faster in order to squeeze the maximum number of channels into the line.

Statistical Time Division Multiplexer (STDM) overcomes the problems associated with the conventional TDM. The STDM operates on the principle that at any one instant only some of the channels will be transmitting data. The TDM "frame"is "collapsed" with no idle characters being inserted. Instead, addressing infomation is included to indicate for which channels data characters are present. Using STDM an improvement of 2 to 4 times can be achieved in a typical application. The STDM can be safely used at high speeds to provide very efficient use of the lines even in highly sensitive applications where data loss or corruption unacceptable.

Concentrators : The Concentrator, as the name implies, helps in concentrating a set of terminals at a site. Once the concentrator is used, individual communication lines between the terminals and the computers are no longer required. The concentrator works based on the following simple principle. It collects all the data to be passed in one direction (say from terminal to the computer), tags it to identify the source and then puts it out on one of the serial lines. Obviously, the concentrator should have its counterpart as an integral part of the computer. This part (may be in hardware and software but typically in firmware) will separate the data to its original form and feed it to the computer for further processing. At this point, the data looks similar to the one received from the local terminals which are connected via dedicated cables.

The exact differences between multiplexers and concentrators can be brought out as follows. While a multiplexer codifies several low speed lines into a single high speed line, the concentrator enables several lines to share a few lines.

In general concentrators can be used for connecting a groups of serial devices to a remote computer. That is, the terminal in Figure 9.15 can be replaced with any input/output device, viz., a printer or even a microcomputer itself. When only terminals are used with such an equipment, then, it is called terminal concentrator.

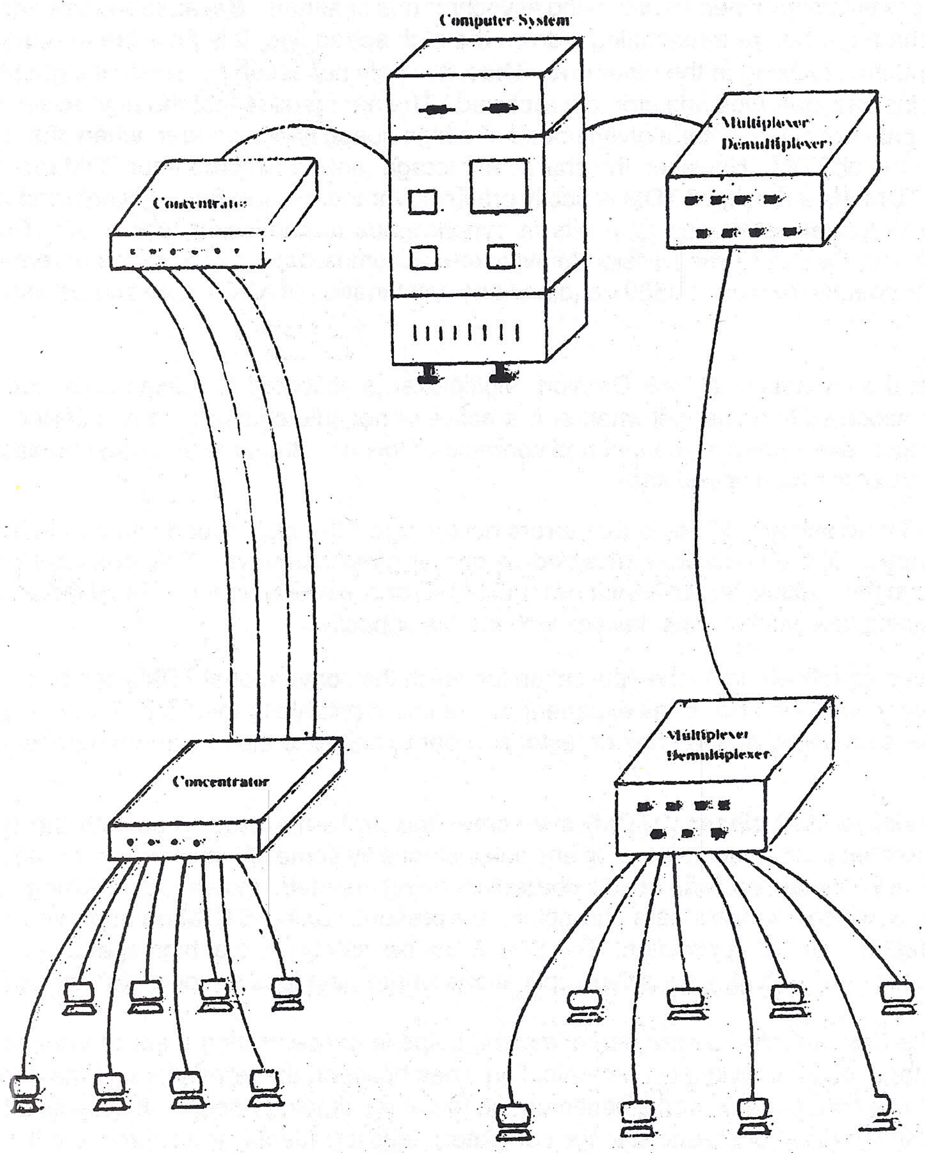
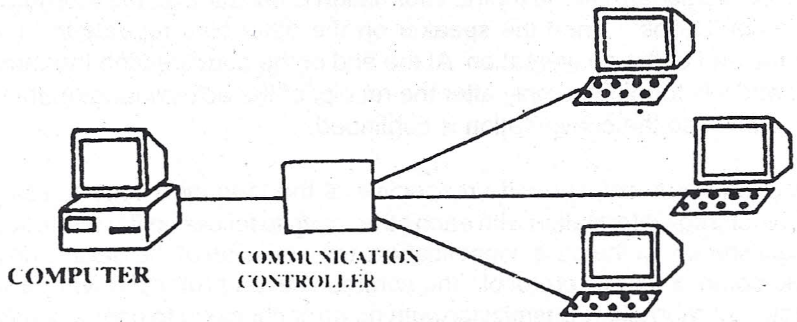


Fig. 9.15. Concentrator and Multiplexer

There are certain other devices which combine the functions of both multiplexers and the concentrators, they are called statistical multiplexers,

Communication Controllers

The most important device which controls the functions of data transmission is the communication controller. The main purpose of this equipment is not to optimise the use of transmission facilities but to optimise the usage of the host computer to which it is attached. As we have stated earlier the transmission takes place byte by byte or bit by bit. These bits are sent to the computers at the speed of the line, they are assembled to form the characters and also checked for the transmission errors. The communication controller is used to remove these functions from the host computer. These communication controllers are also called transmission control or line control computers. These controlling equipment feed information to the main computer (Figure 9.16). It thus maintains the discipline on the communication line and relieves the host computer from these jobs. The communication controller has its own instruction set that is different from the conventional computers.



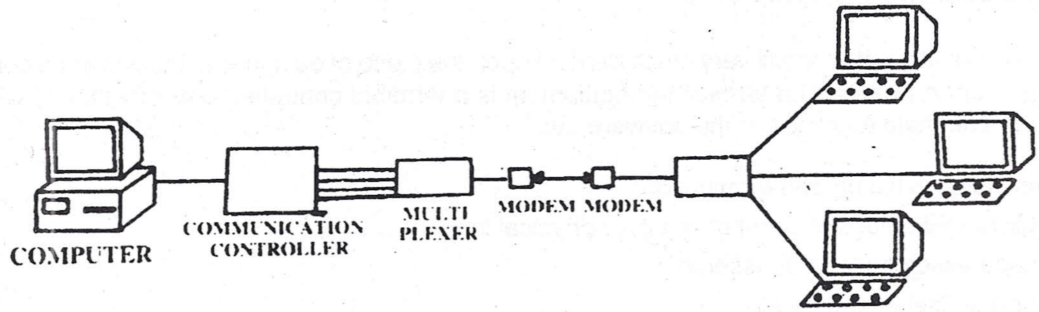


Fig. 9.16. Use of Communication Controller

To overcome the problems of interfacing, the hardware manufacturers have come up with standards for interfacing. The most commonly used interface is the RS-232 interface. This clearly defines the physical and logical standards for connecting devices, such as, connecting terminals, modems.

Personal computers

The personal computers have proliferated in all activities. This becomes one of the most common data terminal equipment which is used in many data communication systems.

The personal computers usually have two ports: one serial and other called parallel port. The parallel port is mostly used for connecting the line printer. The 25 pin DIN is the most common connector used for the line printer connection. However, the standardised interface is the centronics interface which uses a 36-pin connector.

The serial port is used most oftem in connecting the personal computer to the remote mainframe using modems. This interface is mostly known as RS-232-C. Most of these adaptors terminate in the standard 25-pin connector. A notable exception is the PC-AT (in some cases) P which has a 9-pin connector of 25-pin connector.

9.5. DATA COMMUNICATION SOFTWARE

In the preceding two sections we have discussed the communication media and the interface between the communication media and the computer equipment. In this section, we will be discussing the software that is required on the terminal equipment (computer) to bridge the gaps and interpret the bits/bytes that are transmitted via the communication media through the interface. This is illustrated by the following example:

When people use a telephone they follow a particular procedure or a protocol. First, the disired telephone number is dialled. Then the establishment of the physical link to the disired number is confirmed with telephone bell sound. The receiver acknowledges the call by saying 'Hello'. This is confirmed with a return 'Hello' from the speaker. Subsequently, the parties identify each other. Only after this identification process, the information is exchanged. During the conversation, whenever the information is not audible, the listeners request repetition of information by a series of 'Hellos'. Then the speaker on the other side repeats the information and this process is continued till the end of the conversation. At the end of the conversation the terminating process is initiated by saying 'bye'; and it is terminated only after the receipt of the acknowledgement from the other side by a reciprocating 'bye', otherwise the conversation is continued.

This procedure, the telephone protocol, is used irrespective of the language communication. Similarly, the computers which have to exchange information with each other have to follow similar procedures. This collection of rules for physical establishment of the calls, identification, transmission of the data, non acknowledgement and terminattion is called communication protocol. the communication protocol covers a wide spectrum and range from single character by character transmission with no error checking to complex rules about moving of large amount of data involving many devices.

The requirements of the software will very much depend upon the piece of equipment that would be connected. It would depend upon whether the terminating equipment is a terminal controller, concentrator, a switch or a host computer. The main functions of the software etc.

- transmission initiation and termination,
- establishment of logical connections over physical line,
- message assembly and deassembly,
- data transmission and receipt,
- code conversion,
- error detection,
- data editing,
- control character recognition,
- data delivery,
- data output,
- transmission monitoring and maintenance.

In addition to these the system also has to schedule and monitor the resources.

The software that fulfils these functions may completely reside on the central computer or part of it may be located on the front end communication computers, a concentrator or remote concentrators or in the intelligent terminals.

The desingner of data-communication software faces some unique problems. The most basic of these is time dimension. In a normal batch processing system the software may be designed so as not to accept any inputs until all the stipulations/conditions are met. Whereas, in a data-communication environment data/users arrives in time and sequence beyond the control of the desingner. It also has to face the errors that may be caused by the media or the equipment connected to it, for example, major breakdowns like line failures, of interruptions lasting as long as one or more message. Because of these and other reasons the communication software is different from other software.

For this reason while developing the communication software the principles of software design and development namely: modularity, hierarchy and generality-are comprehensively and completely followed.

The software of advanced computers is always developed in layers. Different layers perform different functions and provide services. This applies to any major software like operating system of database. Similar technique is also applied to data-communication software. These layers of software have to ensure that the data is physically transmitted and the user receives it with no errors. Whatever, necessary storage, error correction, monitoring and security that have to be provided will have to be embedded between various layers of communication software. For advanced computer separate computers are made to perform these tasks. By these processes the activities are made transparent to the user while accessing or delivering the services.

It is evident that computers of different vendors, having different operating systems, should have a common communication protocol to facilitate their communication with each other. Towards establishment of standards the International Standard Organisation (ISO) has defined a seven layer architecture called Reference Model of Open System International (OSI). This International standard 7498 provides the source of documentation with OSI reference model. This model is also now documented in the CCITT X.200 series. The ISO and CCITT versions of the model are essentailly the same. This model provides a basis for coordinating the development of a standard that would facilitate a flexible interconnection of systems using data-communication facilities.

The seven layers of the OSI are:
- physical layer,
- data link layer,
- network layer,
- transport layer,
- session layer,
- presentation layer and
- application layer.

Each of these layers performs certain specific tasks. The physical layer's objective is to support a wide variety of physical media for interconnection by using suitable control procedures. This is the lowest layer in architecture.

Data link layer: provides methods for error-free transmission over the physical layer. The layer is above the physical layer.

Network layer: performs the delivery of data through certain protocols such as routing. It provides a communication path between the two end- points.

Transport layer: forms the uppermost layer of data transport service. It isolates higher level entities from any concern of transport of data from one system to another. It makes the network transparent to the users.

Session layer: mainly performs the job of the controller and synchronises the dialogue session between the systems.

Presentation layer: also provides a general service not unique to a specific application. It mainly concerns a represenıation and manipulation of data. It provides service to the application layer.

Application layer: makes use of the service provided by the lower layers by providing interface to the user processes.

The four main principles in the layering are:

a) to define as few layers as possible while ensuring that each layer performs a specified task.

b) Each layer performs a small job but at the same time ensures that the number of interactions between the layers is minimised. Each layer is independent of the other to facilitate complete predesign and to facilitate maximum advantage of the architecture. Each layer will provide a service to the upper layer and derive service from the lower layer.

c) Each layer can be modified without affecting the other layers.

d) The interface between the layers should be clearly defined so that the other layer can be independently developerd. Each layer will communicate to its next lower and its next upper layers only.

Type of Protocol

The data-communication protocols are either bit-oriented or byte-oriented. Bit-orinted protocol transmit data in blocks of any length up to a specified number. In this, acknowledgement takes place after one or several blocks have been sent; depending upon the protocol, the normal size is 18 to 512 characters of bytes. In a byte-oriented protocol the data is transmitted in 8 bit blocks. The acknowledgement is effected after each transmission. By this we mean transmission on a block. The complexity of the communication protocol very depends upon the complexity of the network. In a simple host terminal exchange it is not necessary to identify and verify the communication as it has been established physically. However, it will be required when several terminals are made use of as a single line or a concentrator.

The most commonly used data communication protocols are synchronous (STIC) and by-synchronous (BSC), Higher Level Data Link Controller (HDLC), multipoint poll select, etc. Recently, efforts have been made to evolve a common communication protocol which would facilitate different vendor machines to communicate with each other. One of such protocols, which has wide accessibility, is the CCITTS x.25 recommendation.

9.6 DATA TRANSMISSION ERROR AND RECOVERY

Data, while it is being transmitted, may suffer some damage. This can be due to the characteristics of the transmission medium or due to external disturbances. In either case, the data bit 1 or 0 that is transmitted will be recieved as 0 or 1, as the case may be. Please note that for a given bit the error is either 0% or 100% and nothing in between! When a bit is received erroneously the character 'A' sent by the transmitter will not be received by the receiver as 'A' but as something else. If we consider a communication channel capable of transmitting 9600 bits per second or approximately 960 characters per second, then we need to estimate as to what percentage of these characters are transmitted correctly. This can be a measure of the quality of the communication channel. For example, to arrive at such a quantifier, one can transmit a million bits and see how many of them are received correctly. This will give the Bit Error Rate (BER) of the channel. One need not count patienly up to a million. There are standard test equipment available that transmit a large number of bits and measure the quality of the line. Similarly, blocks of data can be transmitted and the quality can be assessed by measuring the percentage of good blocks in the receiving side. These are called Block Error Rates (BLER) of a channel.

Since the channels are error prone, recovery mechanisms are a must. For example, even if a single bit is lost, the whole character consisting of eight bits is lost! One would like to capture at that level and request the transmitter to retransmit the lost character. For doing this a prior understanding between the sender and receiver is required. Such an understanding is called the "protocol". Protocol between two communicating systems essentialy determines who can talk what and when. In fact, the asynchronous character transmission is based on "start-stop" protocol, which helps in restricting the transmission loss to a character. Recovery from the loss of a character will require that the receiver is able to signal back to sender. This leads us naturally to the need for a higher level of protocol.

"Protocol" has two main purposes: (1) to ensure that the information is transmitted when and only when the communication channel is free and the appropriate terminal devices are ready to receive; and (2) to prevent corruption or loss of information during transmission.

The term "protocol" is used to describe the set of rules governing information flow in a communication system. What is required is a method of checking the transmission of data and, if an error occurs, of informing the transmitting node or computer so that the transmission of the same data may be repeated. The solution is to break up the transmission into blocks containing a convenient number of characters and to add to each block a check character or characters, computed from the data characters according to a predetermined algorithm. By recomputing the check character (s) at the receiving end, it can be determined, to a certain level of probability, whether an error has occurred.

The receiving terminal can then send a character to indicate either that the block was error free or that an error occurred and a retransmission is required. These two responses are sometimes designated as ACK for "acknoledgement" (i.e. all correct) and NAK for "negative acknowledgement" (i.e. an error has been detected). Such a simple protocol is illustrated in Figure 9.17 with the application called file transfer.

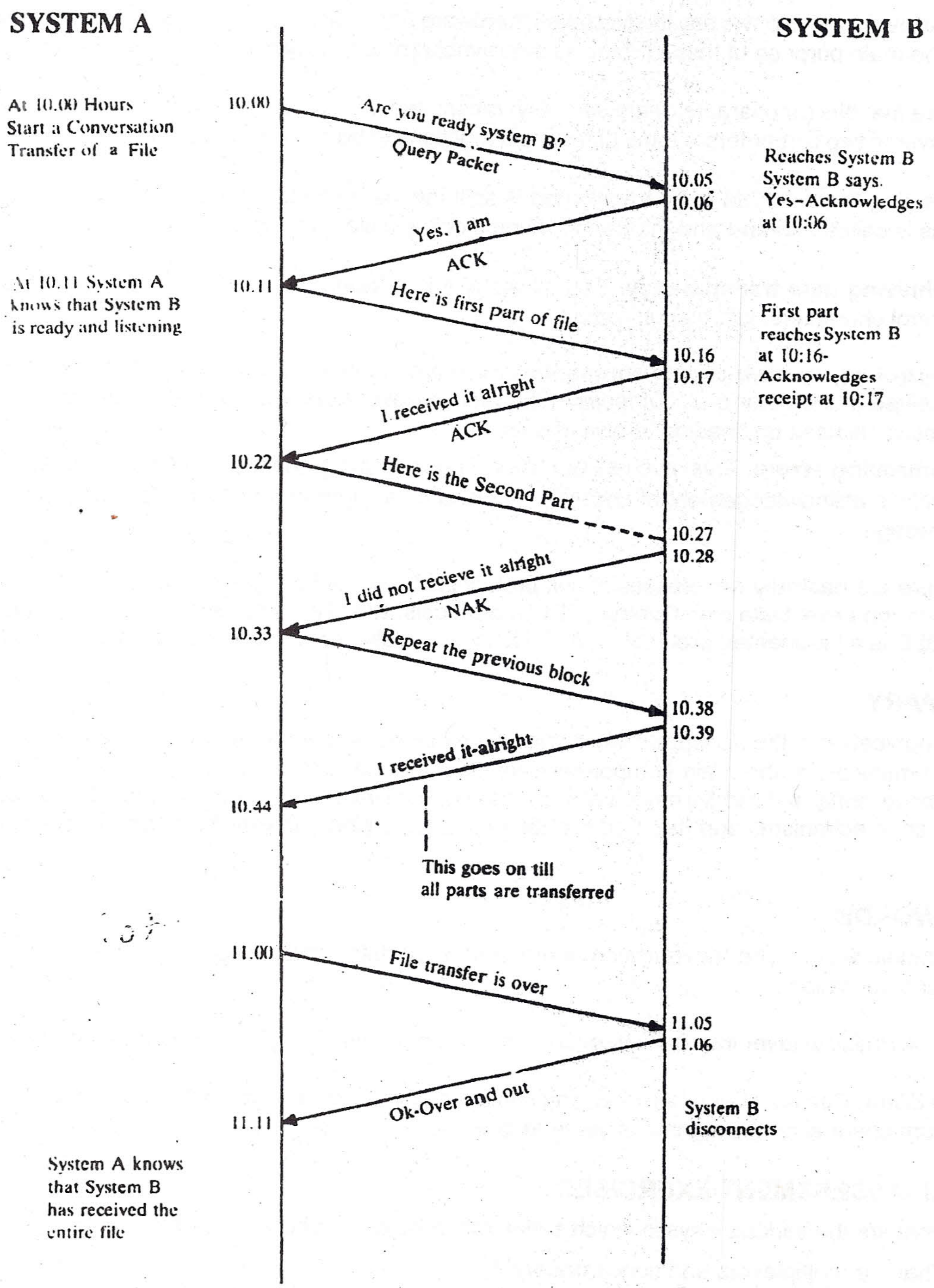


Figure 9. 17 An Illustration of a Sample Protocol

The protocol just described also guards to a high degree against loss of data: if the terminal receives nothing or becomes inoperatinve it will respond with neither ACK nor NAK: the computer can be programmed to take appropriate action in such a case. Such an error control system is also known as ARD (Automatic Repeat Request) system.

9.7. DATA COMMUNICATION PROTOCOLS

At the lowest level (or should we say the first level), hardware protocols, like asynchronous transmission protocol, operate. The main purpose of these protocols is to synchronise between transmission and reception.

To make sure that bits (or characters) are securely transmitted through the channel or line, we need a link level protocol between two computers. Some of the main functions to be performed by such a link level protocol are:

- Ensuring that the data to be transmitted is split into data blocks with beginning and ending markers. This is called **framing** and the transmission block is called a frame.
- **Achieving data transparency**. This allows a link to treat a bit pattern, including normally restricted control characters, just as pure data.
- **Controlling the flow of data across the link**. It is essentail not to transmit bits faster than they can be received at the other end. Otherwise, the receiver overflows and the data is overrun, or all buffering capacity is used up, leading to loss of data.
- **Controlling errors.** This involves detection of errors using some kind of redundancy check. It also involves acknowledgement of correctly received messages and requests for retransmission of faulty message.

There are basically two classes of link protocols. They are BInary SYNchronous protocols (BISYNC) and High Level Data Link Control (HDLC) protocols. BISYNC is based on character control, whereas HDLC is a bit-oriented protocol. In fact, HDLC is widely used in most link protocols of computers.

9.8 SUMMARY

Data Communication is the transportation of data from one point to another through a communication media. In data communication, the main components are data source, data sink and communication media. The concept of baud, serial and parallel modes of transmission, hardware equipment required for data communication, error recovery mechanisms and the requisite data communication software have also been dealt with in this unit..

9.9 KEY WORDS

Data Communications : The transmission and reception of data, often including such operations as coding, decoding and validation.

RS-232C : A Physical layer interface standard for the interconnection of equipment, established by EIA.

Two Wire (2Wire) Circuits : Circuits comprising two conductors insulated to each other. This circuit provides a go and return channel for the signals of same frequency.

9.10 SELF-ASSESSMENT EXERCISES

1) What are the various ways in which serial transmission can be achieved ? Explain each way in detail.
2) What are multiplexers and concentrators ?
3) What are the main functions of data communication software ?

9.11 FURTHER READINGS

Black Uyless D., *Data Communications and Distributed Networks* (Second Edition); A Reston Book, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Hunt, Roger and Shelley, John, *Computers and Common Sense* (Fourth Edition). Prentice- Hall, of India Private Limited, New Delih, 1989.

Indira Gandhi National Open University , School of Engineering and Technology; DCO-5: *Modern Office, Block - I : Communication in the Office,* Unit 2A.

UNIT 10

COMPUTER NETWORKS

Objectives

This unit will help you to understand :

* The hardware and software components of networks and the manner in which they function
* various kinds of network topologies
* standards established for multi- vendor networking
* applications of networks.

Structure

10.1 INTRODUCTION

The word 'computer' quite a few years back, conjured up images of very large grey metal boxes housed in air-conditioned glass rooms accessible only to those who had security clearances. These were once the exclusive domains of very large companies, universities and government offices. The advances in electronic technology have led to changes in the size as well as the cost of these machines. These changes have made it possible for even individual users to avail of this sophisticated technology. With the increase in the use of small computers distributed over a large network of individual users, the demand for interconnection in order to exchange information has dramatically increased. This is the basis behind the concept of 'net work'

What is Network ?

Throughout this unit we use term computer network to mean interconnection of autonomous (stand - alone) computers for information exchange. The connecting media could be a copper wire, optical fibre, micro - wave or satellite.

The physical location of a network could be a single or multi-storeyed building or a building complex covering an area as wide as the world itself.

The term, a 'local area network' (LAN) is used to describe a network covering an area ranging from a room to a small complex such as a university campus. The physical distance covered varies from 1 m. to 1 km. The term 'wide area network' (WAN) is used when the physical distance covered is more than 10 kms. WAN could be spread over a city, a district, or a country. It may also include the whole globe. Sometimes the term long haul network is also used to mean a wide area network.

Most of the time a network conjures up a picture of computer systems linked together to provide access to information. However, a network consists of much more than just computer systems. It includes transmission media such as cables, fibres, radio frequency equipment etc. It also includes devices which facilitate, maintain and control the flow of transmission of data between two or more computer systems. Example of such devices are modems, multiplexers and switching devices.

In particular LANs used in engineering environment consist of mainframes as well as engineering workstations. In a manufacturing environment they support a broad variety of applications including manufacturing, resource planning, real time process control, inventory control, maintenance management etc. Devices in this type of network include powerful mini-computers with monitoring and logic controllers. In this real time environment, errors as well as down time can cause unacceptable delays and cost overruns. Network performance and reliability are very critical.

The wide area networks consist of medium/large mainframes with a variety of peripheral devices. WAN also includes a variety of switching equipment and commuication software to facilitate easy access by users. In this environment user accesses the network through a variety of computer interfaces. The applications that can be performed on a network are unlimited.

10.2 DEFINITION OF A LOCAL AREA NETWORK

Local Area Network is a transmission system that allows a large number and variety of computing equipment to exchange information at high speeds, over limited distances. The computing equipment may range from large mainframe system to personal computers and peripherals.

Resource Sharing is perhaps the greatest advantage of local area networks. LAN allows a large number of intelligent devices to share resources, such as storage devices, program files and even data files. Whereas on a traditional network each machine will be directly wired into a switching device, on a LAN a single physical medium is usually shared.

Area Covered by the LANs are normally restricted to moderate size, such as an office building, a factory, or a campus. the limiting factors are usually the overall length of the cable used and any interdevice restrictions imposed. In practice, the distances involved range from a few meters to a few kilometers.

Low Cost per Connection is also an important characteristic of LANs. Many applications for LANs involve low-cost microprocessor systems, so that the connection of these systems to a LAN should also be inexpensive.

Loacal Area Networks are becoming more cost - effective as technology expands and new items, like fan-out units and networks interface units, become prevalent.

High Channel Speed is another quality of LANs. Most LANs transfer data at rates between 1-10 million bits per second. This is equivalent to 200 pages of the book you are presently reading. This is especially beneficial for applications with high resolution, movable colour graphics and for bulk data transfer between mainframe computers.

Furthermore, flexibility in growth, low error rates, reliability of operation and simple maintenance are all distinguishing features of LANs. When we discuss networking, we generally consider two situations : one, where the systems interconnected are in the same building or campus and the other where the systems are spread all over the country. In addition to these, there are two other interconnections that are already in vogue. One of them is the "bus" that connects the subsystems within a computer system and the other where the existing telephone network is used for networking. All the four methods have their own "niche" in the world of networking. Let us look at Figure 10.1 We find that "Computer Bus Networks" are very fast but covers very small distances only. The "telephone exchange based networks" have very slow speed operation but cover distances of the order of 10-1000 meters. But when we come to wide area networking, the speed of operation is marginally higher compared to the telephone exchange network but distances covered are extremely large of the order of one thousand kilometers. Local Area Networks, deftly combine the high speed of operation and provide a geographic spread of 1-10 kilometers, which is in time with the requirements of today.

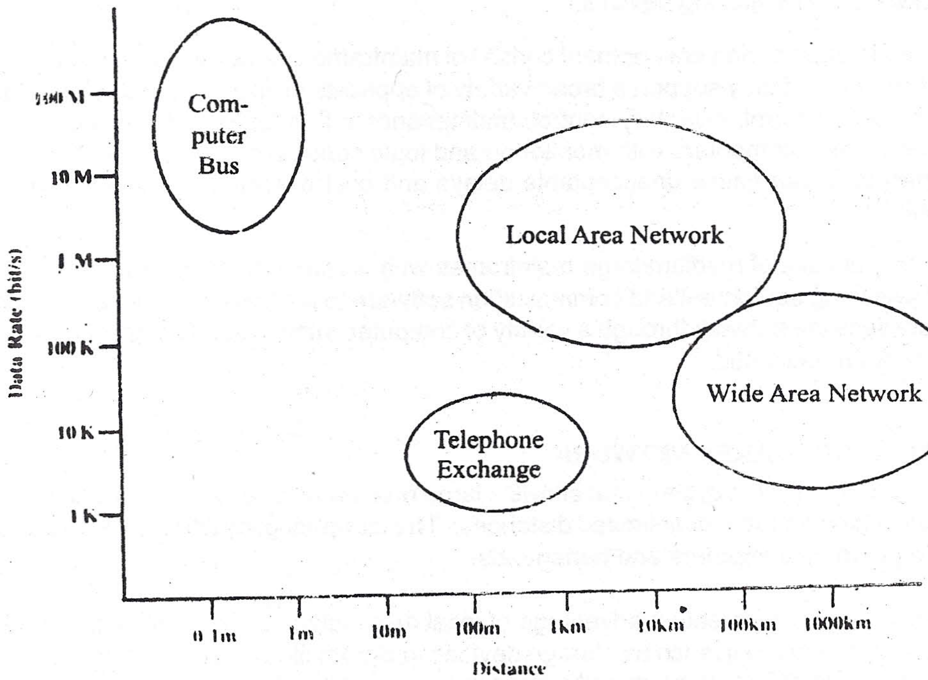


Fig. 10.1. LANs Relative controller network

The block schematic of a typical local area network is shown in Figure 10-2 . It consists of several workstations and servers. The workstations and servers. The workstations can be a personal computer or a workstation with multi-user and multi-tasking capability. A server on the network, as the name implies, provides a specific service for all workstations. The example shown in the figure are the File Server, Print Server, and Communication Server. They provide file storage and access facility, printing facility and external communication facility respectively to all the workstations connected to the local area network.

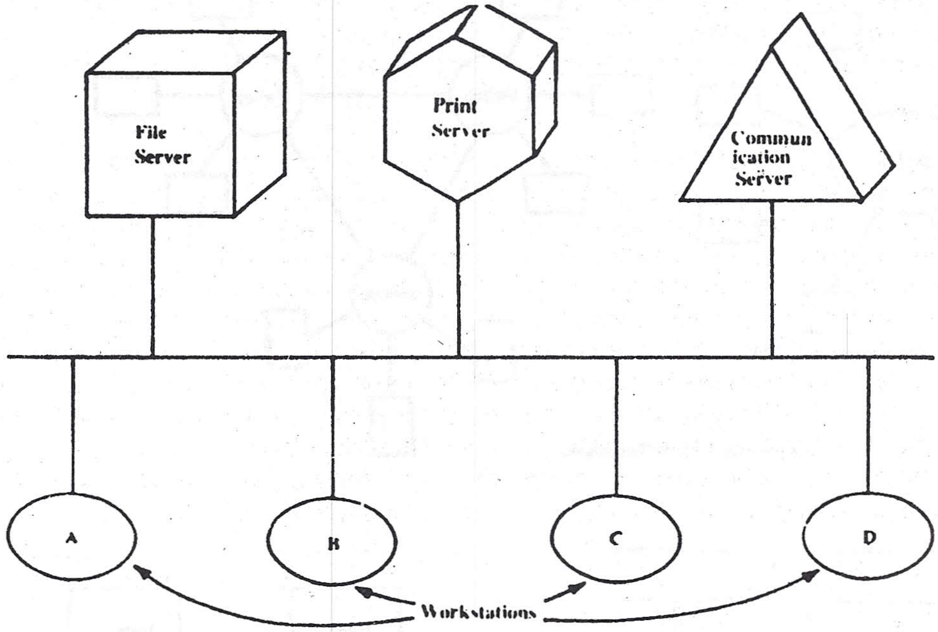


Fig. 10.2. A Typical Local Area Network.

10.3 CHARACTERISTICS OF LOCAL AREA NETWORKS

A LAN is best described by the following characteristics.

* LAN is wholly contained within a limited geographical area.
* LAN provides a high degree of interconnection between devices which are otherwise independent.
* LAN uses inexpensive transmission media and interface to devices.
* Every device has the potential to communicate with any other device on the LAN.
* LANs facilitate sharing of information ana Hardware.

The contemporary LANs differ in the ways in which the above mentioned characteristics are actually implemented in practice. The LANs can be compared by considering the following factors:

* The type of cabling used.
* The Topology.
* Method used to control access to the shared medium.
* The nature of the interface unit which connects a device to the network.
* The rate at which digital data can be transmitted across the common shared line.
* The application services that are provided on the LAN.
* The facilities that are available to configure and manage the LAN.

Some examples of LAN are Ethernet, IEEE 802.3, Token Ring and Token Bus.

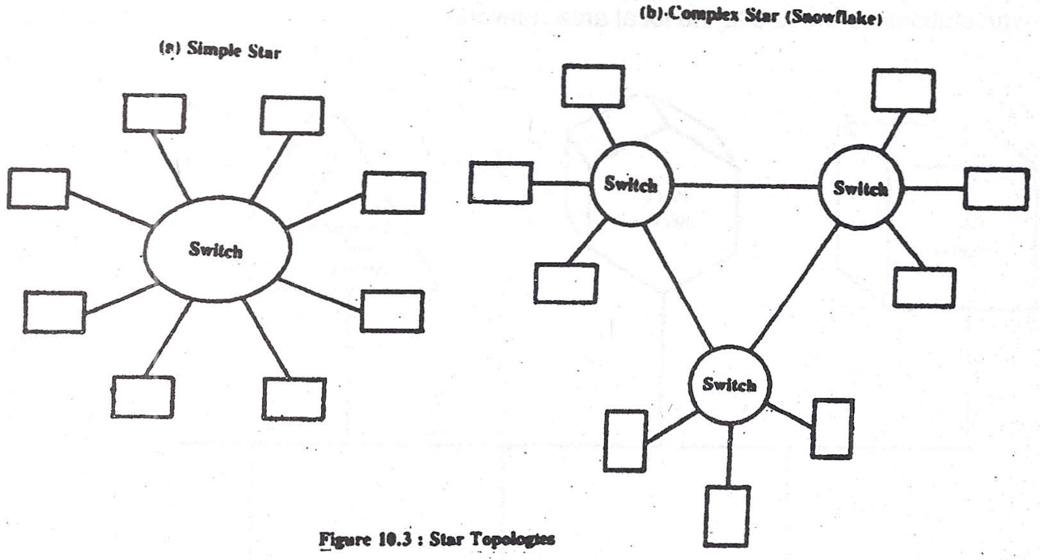


Figure 10.3 : Star Topologies

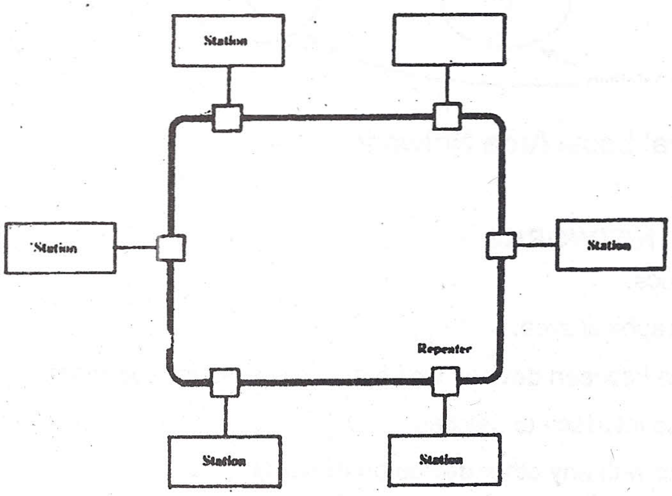


Figure 10.4 : Ring Topology

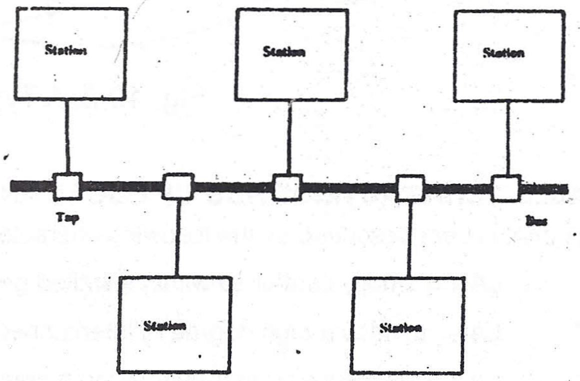


Figure 10.5 : Bus Topology

10.4 NETWORK TOPOLOGIES

Network topology is the basic outlay or design of a computer network. Think of topology as the architectural drawing of the network components, which is much like the architectural drawing of a home or building (some are simple, some are very complex). This design can be varied in accordance with the company's needs, but certain base elements to configure the topology of a network still apply. Any system on a network is called a node. Nodes are connected to each other by links. Links can be phone lines, private lines, satellite channels, etc. When you draw a road map of the communication links between nodes, you then have a network topolgy.

When we talk about links, we always refer to two basic types of links: physical and virtual. To give a very simple explanation.

If you can see and touch it, it is PHYSICAL

If you can see it but not touch it, it is VIRTUAL

Networks use virtual links to allow the sharing (multiplexing) of the physical line by multiple network programs or data transters. If a new physical line is to be installed for every new network program that was started up, it would be VERY expensive to provide communications capability to many locations. Therefore, virtual communications over physical lines are extremely valuable in providing cost-effective communication capabilities.

Depending on the processing needs of an organisation, different types of networks may be needed, sometimes even in the same organisation. There are several network models that describe most networks in existence today. Figure 10.6 describes these topologies.

Point-to-Point Topology

In pont-to-point topology nodes can communicate only with an adjacent node-one that is "next" to the system. It should be observed that just because two systems are not in the same room, that does not mean that they cannot be adjacent. In its basic form, a point-to-point network is two nodes directly connected. In its advanced forms, it could be 200 nodes connected to adjacent nodes and those nodes connected to other adjacent nodes, ad infinitum.

Multipoint or Multidrop Topology

A multipoint or multidrop network is one where nodes share lone line by sharing time on the line. Multipoint networks are very useful where high speed data transmission capabilities are NOT necessary and where cost of implementation is an important factor. Many manufacturing companies that use systems to automate their production, run their own wires throughout the production area. If the company had to run a separate set of wires to every machine, the cost could be prohibitively high. By using multipoint communications, however, the company can implement a functional network of prodution systems quickly and without major cost considerations Remember that multipoint does not lend itself well to high-speed data communications, nor where there is a great volume of communications. Also, the more the number of nodes on the trunk, the higher are the chances that some other node is communicating when the need to communicate arises. Thus, it will take longer to get the data to other systems.

Mesh Topology

Mesh networks are most commonly employed for long-distance transmission of data between nodes which act as message switches, circuit switches or packet switches. A fully connected mesh linking n nodes requires n(n-1)/2 links but it is unusual for all the possible connections to be provided. Throughout depends upon the media and the capacity of the switching nodes. Distance may be extended indefinitely and the number of stations may increase up to the limits imposed by the maximum throughput and the size of the address field in the message header. The multiple message paths' reduce vulnerability to link or node failure if stable re-routing facilities are built into the nodes. Messages delay may be high because long-distance transmission media have relatively low data rates and the throughput limitations of the nodes may result in queuing for retransmission in store-and-forward nodes. The cost of a mesh network may be optimised by eliminating redundant link capacity.

Communication in the Office

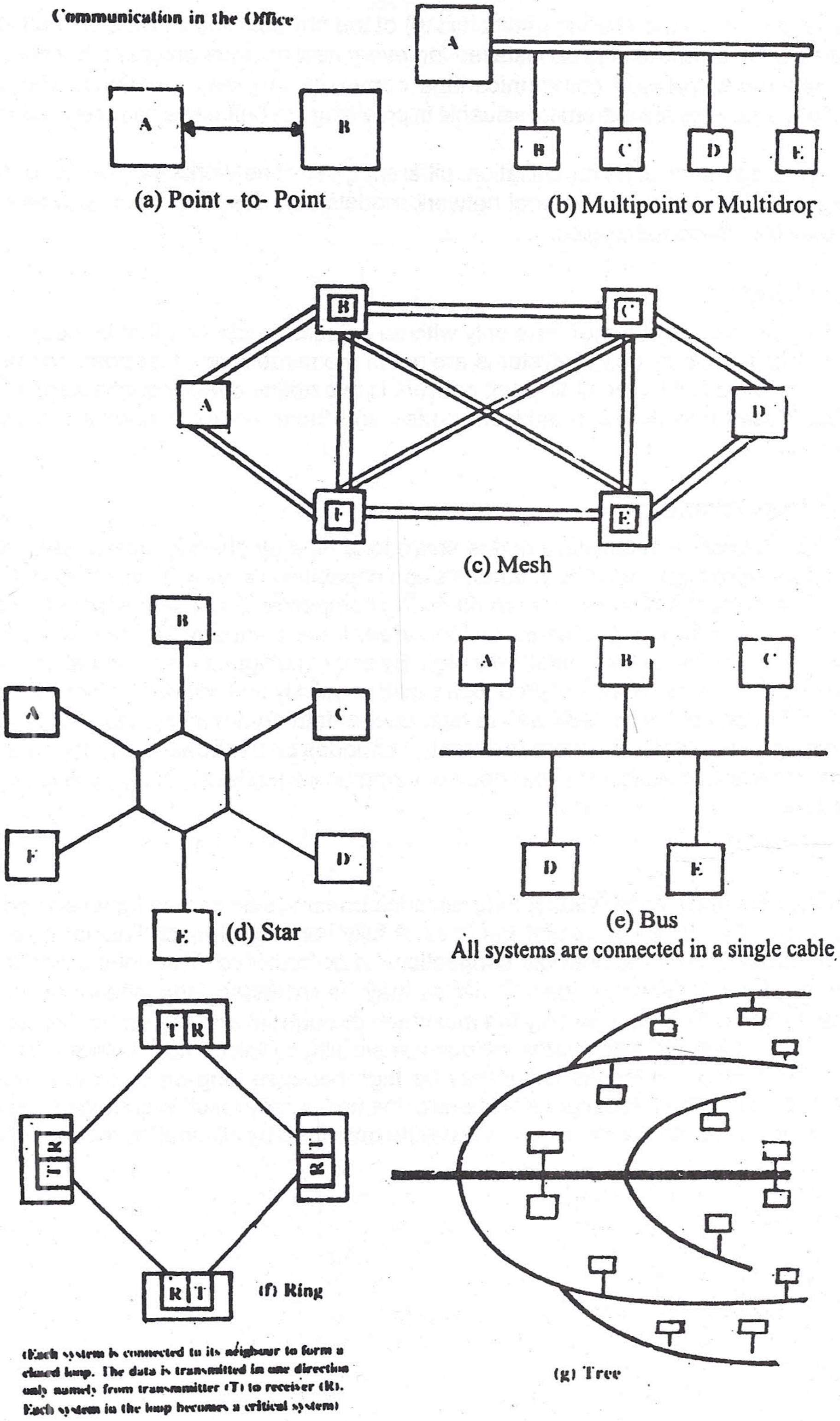


Fig. 10.6. Network Topologies

Star Topology

The star topology consists of a central node to which all other nodes are connected by individual dedicated parts. This topology is normally used in networks that use the electronic PABX. A familiar example of star topology is the distribution of terminals from a computer where a dedicated cable is laid for each terminal from the computer system.

In some cases, the building is wired in such a way that from a central node cables are drawn to wiring closets in each floor, From the wiring closets (the connection points), individual wires are taken to individual nodes. The star topology generally implies that there is central intelligence availble for controlling the operation of all the nodes.

Star networks are most commonly employed to connect remote and local terminals to mainframe computers and in private branch exchanges (PABXs). The throughput of computer-based star networks is constrained by the rate at which the central hub can accept messages and retransmit them if necessary. The distance covered by a star network is determined by the communication link. Each link must have the full length required to connect the hub to the station. The number of stations may be expanded only up to the limits of expansion permitted by the central hub. The central hub is a single point of failure which may cause the entire network to fail; single cable failures affect only single stations.Message delay may be high because of throughput limitations at the central hub which causes queuing. The initial cost of a star network is high because the central hub must be installed with a margin for expansion. Incremental cost for additional stations is low up to the expansion limits of the hub.

Bus Topology

Bus is the next popular topology for LANs. This consists of a single segment of a transmission medium (normally a coaxial cable of thick or thin variety) on to which various devices can be attached. This is analogous to the traditional CPU to the terminal connection in multidropped mode. The main advantage of this approach is the simple wiring and the ease with which the network can be extended to cover large distances. Also, the interface to the Bus is uniform. simple and can be repeated for any number or type of devices.

Bus networks are used extensively for baseband local area networks. multipoint terminal clusters and military data highways. The maximum length of the cable is often low because a high bandwidth is required to support many virtual channels. New stations may be added without reconfiguring the network until the throughput and message delay limits are reached. Message delay in token passing buses increases with the number of stations and in contention buses, delay increases with traffic volumes. Polled systems have a delay determined by the polling sequence. Cost per station is generally lower than star networks but higher than ring networks and buses do not involve a high initial investment.

Ring Topology

Another topology that is quite useful in the case of LANs is the Ring Topology. In this case, each node is connected only to the two neighbouring nodes. The medium is connected to the node by a repeater. Data is accepted from one of the neighbouring nodes and is transmitted to the immediate next node. The data travels in one direction only from node to node around the ring. Thus the opportunity to transmit data around the ring is passed on from node to node in a fixed order. It may so happen that some stations on the ring do not have anything to transmit and may transmit the opportumity to use the ring to the neighbouring node in a transparent fashtion. The data in fact, circulates around the ring and comes back to the centre all the time.

The ring topology is almost exclusively used by local area networks which use token passing or slotted ring access control. Throughput is determined by the media and the capability of the repeater. The total length of the ring and the distance between nodes is limited but the total span is generally greater than that of a linear bus. The maximum number of nodes is limited by the system design. Each additional node involves system disruption and reduces performance. A ring is vulnerable to a single break in any link of node repeater. Message delay increases as more nodes are added to the ring and is greater compared to a lightly loaded bus with contention access control. The cost per node is generally lower than other topologies offering similar performance and the amount of cable required is generally less than for a star topology.

Tree Topology

Tree topology is another form of bus topology. Unlike the bus topology, the segments in a tree extend similar to the branches of a tree with the trunk as the root. Tree topology is normally implemented using a coaxial cable. The main difference between the bus and tree topology is that while the former uses baseband transmission techniques the latter uses the broadband techniques. The data transmitted by a node always goes through the trunk on headend before reaching the destination.

Tree network may be formed from a number of linked linear buses but are most commonly employed by broadband local area networks which have as branching tree topology converging at a headend. Throughput of broadband tree systems is high and limited only by the bandwidth of the cable. The maximum distance covered is greater than linear buses because many branches may be linked using repeaters. Broadband systems may span several kilometers and have extremely large number of stations added without reconfiguring the network. The single point of vulnerability in a broadband tree is the headend equipment which is commonly duplicated. Cable or repeater failure elsewhere in the tree removes all station in the branches beyond the point of failure. Message delay in a broadband system is low when independent channels are provided by frequency division multiplexing. Cost is generally similar to that of linear bus systems.

Activity A

List the various topology alternatives available for designing a computer network.

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10.5 NETWORK STRUCTURES

Networks can be classified into switching and non-switching.

A switching network has three components. These are the computer systems' (Host), transmission media and the switching nodes (Figure 10.7).

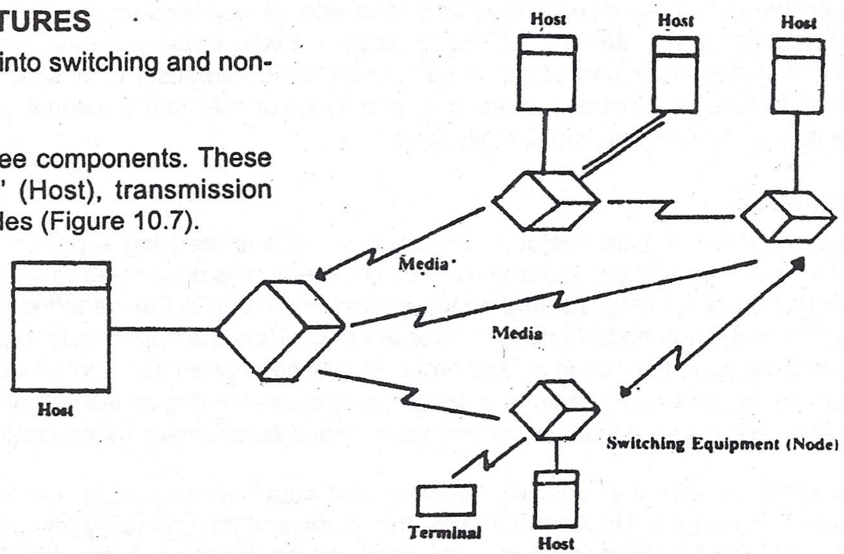


Figure 10.7 : A Switching Network

The computer systems are mainly used for processing and storing information. The transmission media are used to transport information beetween these computer systems. The switching nodes are specialised computers which are connected via the transmission media to hosts.

In the early stages of networks, Host computers were directly connected to each other via the transmission lines and were responsible for performing both the switching and processing functions. But with the growth of network usage valuable host resources were used for the switching functions. To improve response times, specialised computers have been evolved to perform the switching functions. These functions mainly involve setting up a link betweeri two hosts, and monitoring it, and disconnecting it when no longer needed.

Before proceeding further consider the following analogy.

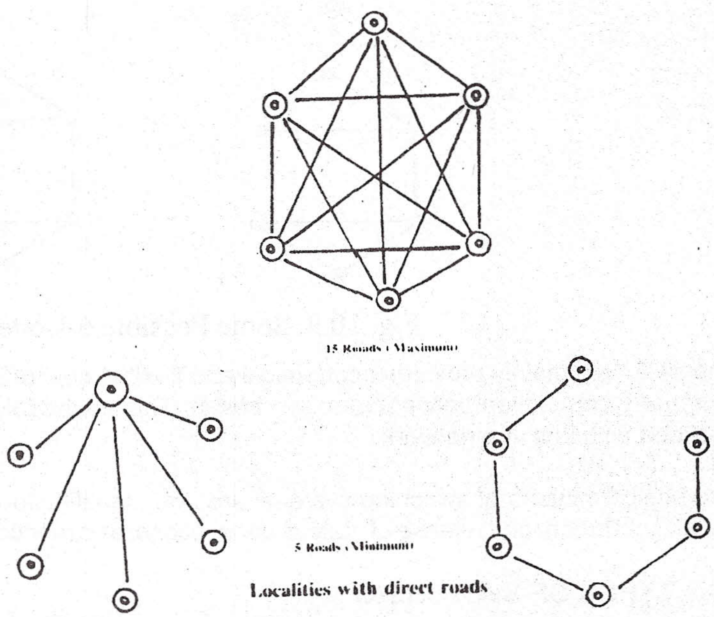
Let us take the telephone network at Delhi . It has several exchanges. Each telephone is connected to its local exchange. Any individual who wishes to make a call has to connect via one or more of the exchange till the local telephone of the called party is reached.

In our analogy there are three important components namely telephone sets, exchanges, and lines connecting exchanges. Here the telephone sets relate to the computer systems, the roads related to the transmission media and the exchanges play the role of switching nodes. The computer network handles calls from computers to transter data to each other, just as the telephone network allows people to send voice signals to each other systems.

10. 6 CONNECTIVITY THROUGH SWITCHED NETWORKS

Switching systems are connected to each other through point-to-point media. The media could be leased telephone lines. radio or satellite circuits.

In our analogy, if there are six localities and if each of these localities are to be connected directly with each other then we would require 15 roads (Figure 10.8). However if the traveller does not have any distance limitation or time limitation then the number of roads could be reduced considerably to as low as five roads. We can also have the scenario where each locality is connected through one or more interactions (Figure 10.8).



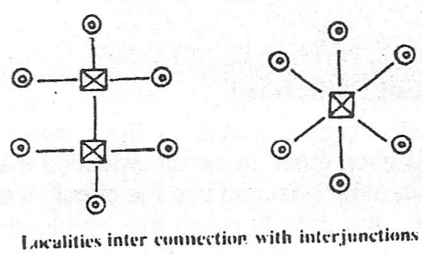


Fig. 10.8. Interconnection of localities.

If we assume in our network, N hosts then the maximum number of lines that would be required to have complete connectivity would be N (N-1)/2. The minimum number would be (N-1). Depending upon the applications and the requirements the number of point-to-point lines varies. There are a number of possible topologies which depict these. Some of these are shown in figure 10.9

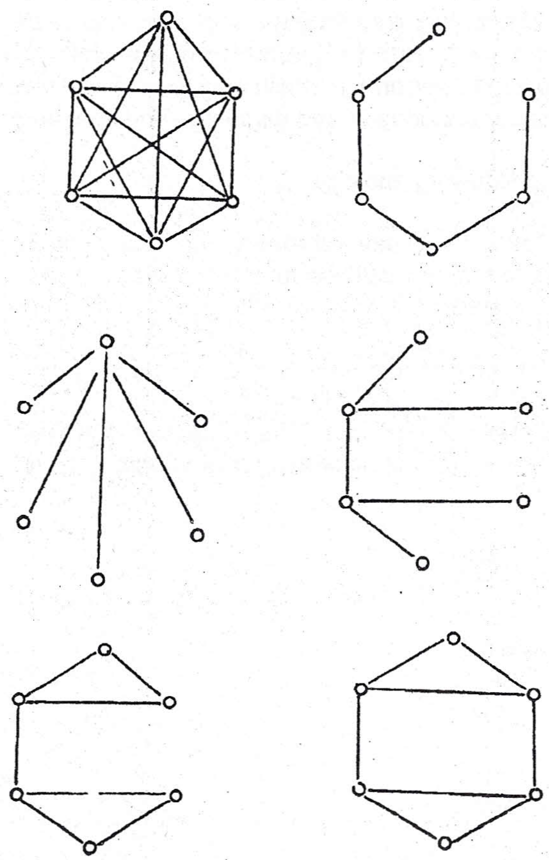


Fig. 10.9. Some Possible 6-Node Topologies

The switching mainly provides economical and flexible type of interconnection arrangements that would allow temporary connection between any two hosts . This methodology eliminates the need for direct connections between all hosts in a network.

The basic functions of switching systems are: the identification of a communication path between two hosts; the establishment and release of various connections; and monitoring the performance of the network equipment.

10.7 TYPES OF SWITCHING

There are two types of switching networks, Circuit (line) switching networks and store forward switching networks.

10.7.1 Circuit Switching

Circuit switching works in real time. The connection is established between two hosts and messages can be directly sent to each other. In circuit switching the physical path established remains connected till the end of the session. No other host can use the circuit. It may take a few seconds to establish the circuit but only a few milliseconds for the data to reach the destination. At any one time only the two communicating hosts can transmit information to each other. Result--slow speed. A simple analogy is the pre-setting of a route of railway tracks for a particular train. When the train has to change from mainline to sideline or any other line, the railwaymen change the track by physically (mechanically) operating a lever. It takes time to switch the track and is usually done in advance.

Circuit switch networks provide a connection pipe through which data pours without being stored any where within the network. The store and forward technique is fundamentally diifferent when it comes to providing a connection between two hosts. The public switched telephone network and telex networks are examples of circuit switching.

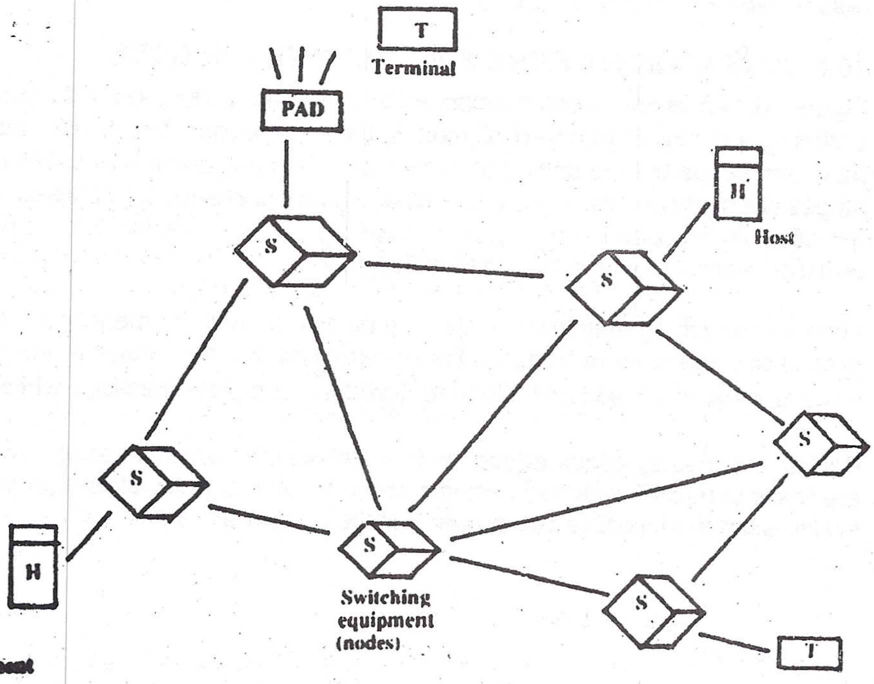
10.7.2 Store and Forward Communication Switching

In store and forward communication switching, the switching nodes store the incoming messages and route the message to the next switch as per the address on the message. The user would not usually know what physical path the message took to reach its destination. Store and forward switching can give better line utilization compared to circuit switching. As the data transmission is bursty in nature with long periods of silence between bursts. Storing the message of many different hosts allows them to be forwarded at a steady rate without the bursts and the idle periods associated with a single host-to-host transfer. Even though the cost of a store forward network may be higher than a circuit switched one, greater sharing of cost may be achieved.

There are two types of store and forward switching - message switching and packet switching.

Packet Switching

Packet switching is special case of message switching. In these switchings, circuits remain permanently connected and the data are received at the switching nodes and are routed onward to the requisite destination. The data (message) contain the address of the destination and the network takes care of delivering it. It gives better line utilisation. These switching methods are better suited to the handing of a large volume of data traffic on complex networks. The interesting feature of this type of switching is the ability to make use of the same



KEY
H Host
T Terminal
S Switching equipment (Node)
PAD Packet Assembly deassembly equipment
(Remark : Each switching equipment is a node with multiple paths)

Figure 10.10 : A Packet Switching Network with a PAD

circuit by several hosts via the switching equipnent. The packets are routed dynamically. It is possible that two packets of a message may take different paths to reach the same destination.

Most of the todays major networks use packet switching techniques. In the packet switching networks, the data is broken into small packets. These packets are routed independently through the network to its destination. The packets contain the address and other information. Because of this the terminals conneted to the network should have the intelligence to identify the packet. It should also have the capability to re-assemble the individual packets into their original messages. Less capable computers are attached to the packet switching network through an intermediary device that implements a packet assembly and de-assembly (FAD) function. High speed communication links are normally used to interconnect the packet switching equipment. The network is usally designed so that if one of the lines fails, there is always an alternative path to the destination. **The packet switching equipment form the nodes of a multipath network (Figrue 10.10). The packet switching equipment determines the route for each packet which is quickly passed from one node to another. The packets are stored long enough to get acknowledgement of correct delivery from the next node on the route.**

Message Switching

Store-and-forward techniques are used at switching exchanges to receive and acknowledge messages from the originator, then to store these messages until appropriate circuits are available to forward the message to its destinations. Private and military teleprinter networks commonly employ message switching.

Classical and forward switching relays the entire message through the network while storing the message in full at each relay point. This concept permits code, speed, or format conversions to take place during the in-switch processing, and appears essentially non-blocking to the subscribers. Powerful processing, with large storage capacities are required at each node of the data network. There is a very large variance in delivery delay, especially for messages which find themselevs in queue behind a very long one, leading to poor responsiveness for interactive traffic.

10.8 COMPARISON OF THE SWITCHING TECHNIQUES

Figure 10.11 presents a comparison of the switching techniques. The message delay varies according to the switching technique employed. Circuit switching imposes the minimum dealy on the transmission once the call has been set up but the setting up time may be lengthy and it is possible that an inadequate number of circuit stages are available when required. When channels are not fully utilised, circuit switching is less efficient than the other techniques in utilising trunk capacity. No addressing data is required in messages sent by circuit switched networks which simplifies the protocol.

Message switching may introduce a long delay because the message is stored at the exchange until suitable circuits are available to transmit the message to the next stage in the transmission path. Each store and forward stage must wait until it has received the complete message which is then relayed to the next stage.

Packet switched systems reduce the long delays inherent in message switching exchanges. Message delays are lower in packet switched systems and the trunk capacity utilisation is greater than that of circuit switched systems but the interface equipment is more complex.

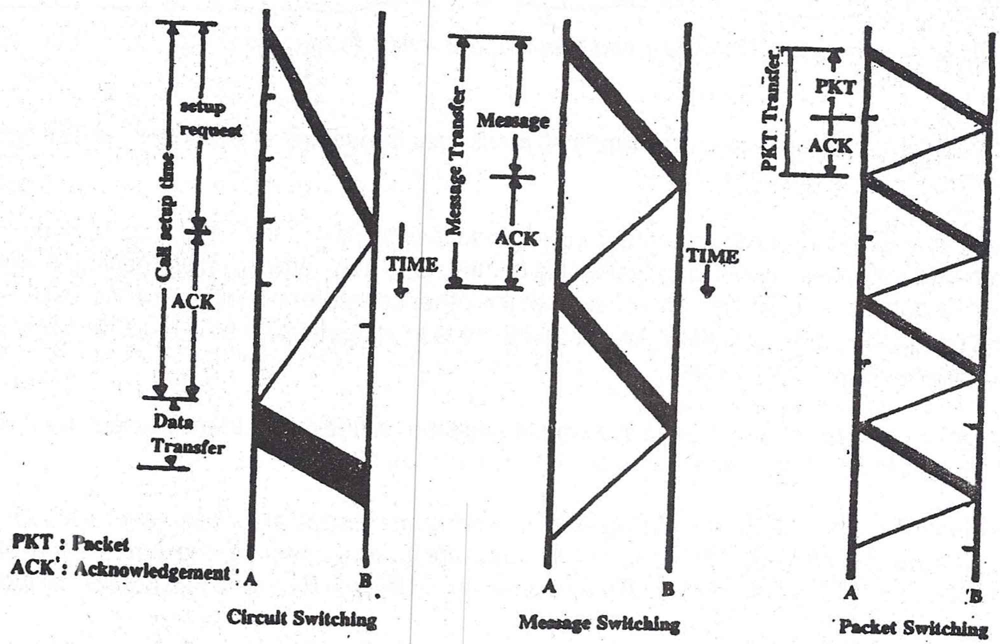


Figure 10.11 : Comparison of Switching Techniques.

Activity B

List the three impotant Switching Techniques for networks.

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Non-Switched Networks

These networks do not use switches to connect host computers to each other. All hosts are physically connected to each other, although they may have to share a common physical media. Non-Switched Networks use two kinds of connections as building blocks: point-to-point and multipoint (multidrop). By multipoint we mean a connection with several drop points. On multipoint connections, only one host can transmit at any one time. Each receiver must have an address and must have the ability to recognise that a message is being sent to his address. Multipoint configuration also has the capability to make use of multicast (group) or broadcast addresses, in which more than one can receive the data. In multicast (group) the data is transmitted containing the address of a preselected subgroup of receivers and hence only this sub-group receives the data. In broadcast transmission the data is transmitted with a universal address, which is recognised by all.

When hosts share a common communication path it becomes essential to control the right to start data transmission over the path line. It is important to devise procedures and control that will allow allocation of the limited (line) capacity to many hosts. There are two basic approaches -contention and central control and contention

In the central control system, central computer controls all messages transmission to and for from all terminals (computers.)

In the central system, individual hosts are restrained from transmission without the clearance from the central system. Variety of procedures are followed to exercise this control. One such procedure is "polling"in which the central computer sends a 'go-ahead' to the code of each of the other computers in turn. The "polling" methods are used for efficient use of the communication. Another scheme is to allocate fixed time slots media so that all the users have an opportunity to transmit data.

In the contention schemes any terminal is free to transmit at any time. Whoever first seizes the communication media, gets the chance to transmit to others again after a randomised interval.

Sometimes "contention" leads to nobody at all being able to use the line, especially when several stations have heavy transmission demands. Certain arbitration techniques are used to reduce the occurrence of these deadlocks. Carrier Sense Multiple Access with Collision Detection (CSMA/CD) is one such arbitration technique or "protocal".

10.9 MULTI-VENDOR NETWORK

The problem of interlinking different vendor machines is more complex than interlinking the machines of the same vendors. Interlinking a multi-vendor computer systems was initiated way back in late'60s. The first approach of this was, ARPANET, developed by the Department of Defence Advance Research Project agency (DARP) to meet its large number of users requirement. This network allowed its users to transfer files, emulate terminals and perform certain important network functions on the equipment that complies with the protocol. A similar effort was also made by the University of California to design certain software to facilitate multi-vendor network. The protocols were similar to the ARPANET.

These two protocols were widely used for interlinking multi-vendor systems for quite sometimes. In fact, they became de facto standards in the early phase of multi-vendor networking.

In the early' 70s the American National Standard Institute (ANSI) developed a distributed systems reference model. Based on the model, International Standards Organisation (ISO)had come up with Open Systems Interconnection (OSI) reference model in the late' 70s.

10.10 OSI REFERENCE MODEL

International Standards Organisation had published the OSI reference model in 1983. It is a seven layer model that provides a structure for data transfer among different vendor machines through the network (Figure 10.12). It defines the functions that had to be performed by each layer of this reference model. The layers have been organised to reduce complexity and bring clarity. Attempt has also been made so that internationally standardised protocols can be defined.

The layers 1 to 4 of the model define how to establish connection between computers, enabling data in any format to move from its source to its destination. The standardised function of these layers ensures that the transmitted data are received as send. If errors occur, that error is reported and diagnosed. The layers 5 to 7 address the interconnection of computer applications. This standardization of functions of these layers makes it possible for the application to translate data into meaningful information (Figure 10.13)

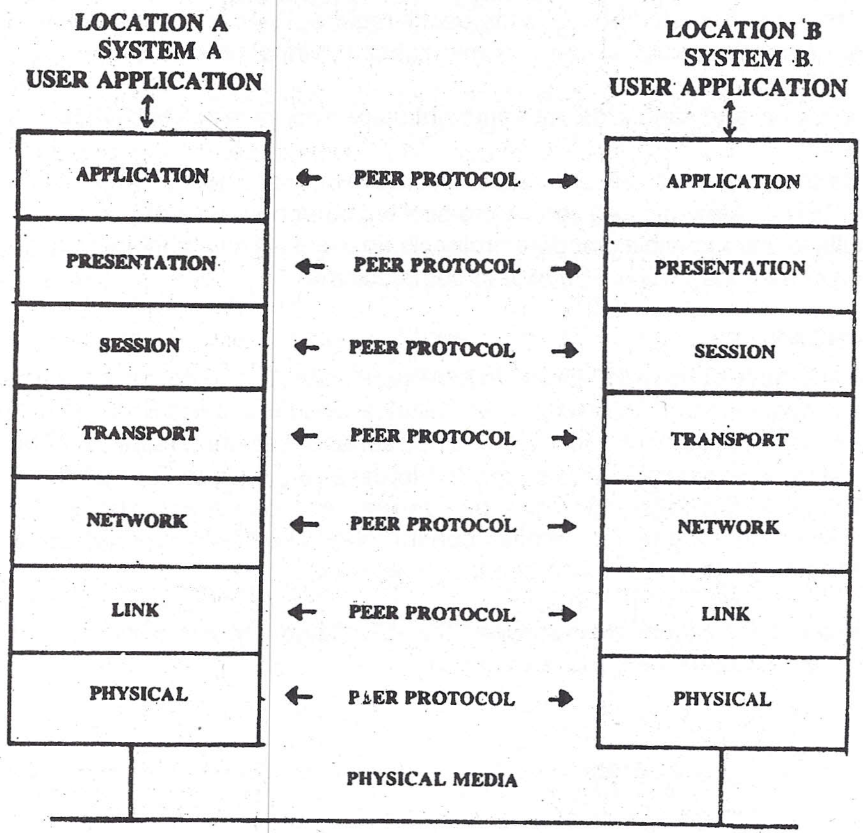


Fig. 10.12. ISO Layers

PHYSICAL LAYER: This layer is responsible for transmitting digital signals from the transmitting node to other nodes. The specifications of the physical layter is concerned with the signal layers, polarities, duration, mechanical attachments, cable lengths etc.

DATA LINK: This layer is responsible for managing access to the physical layer and for transforming data from the medium into a form usable by the network layer. It is responsible also for the integrity of the data. In addition to this it does the error recovery, flow control and multiplexing.

NETWORK LAYER: This layer determines the route to be taken by a packet travelling from the source to the destination. In very large networks where there exist multiple choice of paths it becomes extremely, important to decide the path to be taken based on the speed, reliability, cost, time etc.

TRANSPORT LAYER: This layer ensures reliable end to end transmission of data. The layers above the transport layers deal with data in larger units then do those below it. It is the responsibility of the transport layer to break up the outgoing data into smaller packets and then re-assemble packets in the correct order at the receiving end. It is the transport layer which makes request for retransmission

SESSION LAYER: This layer provides services related to the entire task which may consist of smaller tasks and is responsible for complete transmission and restart if errors occur.

PRESENTATION: This layer provides services to the application layer particularly those dealing with the presentation of the data. In addition to encoding data this layer presentation may also be responsible for data encryption and compression.

APPLICATION: This layer is custom made to the user's requirements. It includes file transfer, electronic mail, directory services, messaging protocol, network managenent, virtual terminals etc.

The OSI reference model and standards are important steps in promoting multi-vendor networking.

The model consists of a framework telling what the layers are but does not itself specify the protocol to be used in each layer. The OSI has standardised certain protocol but other non-standard protocols also exist. However, in some layers multiple, incompatible standard protocols also exist. If two computers at each side use different protocols in any layer then they will not be able to communicate.

10.11 LAN STANDARDS

The lower layer of OSI have correspondence with LAN standards. The bottom two layers of the OSI model are specified as a three layer standard by Institution of Electrical and Electronics Engineers. The subcommittee of IEEE has made a series of recommendations called 802 series of recommendations. The 802.3 describes the medium access control technique to be adopted in the case of a Bus or Tree LAN. This is the CSMA\CD protocol. The 802.5 recommendation describes the operation of a token passing ring LAN. The 802.4 series of recommendation describes the-medium access control for a token between two stations of a LAN will be controlled. This is common to 802.3, 802.4 and 802.5 networks.

Figure 10.14 shows the correspondence between the ISO-OSI model for computer networks and the IEEE model for LANs. The OSI model is applicable to any

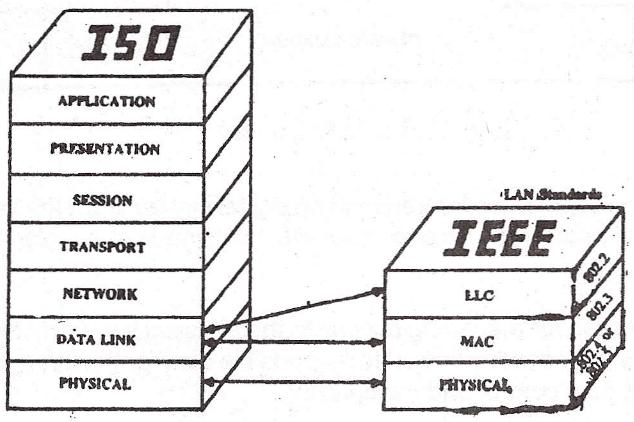


Figure 10.14 : ISO and IEEE Protocol Architecture

computer network, while the IEEE model is specially meant for LAN. Both the models specify the corresponding Protocol Architecture. The seven layers are Physical Layer, Data Link Layer, the Network Layer, Transport Layer, Session Layer, Presentation Layer and the Application Layer. In the case of IEEE Protocol Architecture, the layers are the Physical Layer, the Medium Access Control Layer and the Logical Link Control Layer.

10.12 IEEE 802.3 LAN AND CSMA/CD PROTOCOL

Similar efforts are also made to have certain standards for the LANs. The IEEE 802.3 committee specified the way that a local area network using the bus topology should construct its frames or packets of information and send them over the network to avoid collisions. The protocol is known as Carrier-Sense Multiple Access with Collision Detection (CSMA/CD). The CSMA portion of this protocol can be visualised by imagining a LAN node or station that wishes to send a message. The node listens to the bus to detect carrier signal from another node that is already sending a message. If no other signal is detected, the user sends its message.

There are problems with this seemingly tidy solution to control traffic on a LAN. What happens if two LAN nodes are located fairly far apart? It is possible for them to issue a carrier-sense signal, listen and hear nothing, and then send their messages only to have the data collide. To avoid this type of accident, the committee added Collision Detection (CD) to the CSMA approach. A node continues to listen as it transmits a message. If it detects a collision, then it transmits the message again.

There is still another problen with this approach. Let us look at an analogy. Imagine two drivers who arrive simultaneously at an intersection having four-way stop signs. Both drivers come to a complete stop, wait for a reasonable time, and then begin to move again only to have to slam on their brakes to avoid a collision. Embarrassed by the near collision, the two drivers pause before starting again. Unfortunately, they start again at the same time and once again narrowly avoid a collision.

To avoid this possibility, LAN designers have designed their CSMA/CD approach so that each workstation waits for a (different) random amount of time immediately after a data collision before transmitting the message again. Carrier-Sense Multiple Access with Collision Detection (CSMA/CD) is a protocol for defining the way in which LAN will avoid data collisions. After a collision, a special signal called a **jam** signal is sent through the network. This signal ensures that all network stations, no matter how far apart, are aware that there has been a collision.

After repeated collisions, the network will double its random delays before permitting stations to transmit again. This approach doesn't totally eliminate collisions since it is still theoretically possible for two well separated workstations to wait different amounts of time and still transmit messages that collide. These accidents, however, are infrequent and thus manageable.

Despite the ingenuity of this approach to avoid collision, there is one additional consideration. A heavily used bus based LAN utilising CSMA/CD can begin to look like a highway during rush hour. Even though data is supposed to move at 10 million bits per second, the doubling and redoubling of the delay duration after a few collisions can reduce the LAN's throughput to as little as 1-3 million bits per second.

10.13 ACCESS METHODS AND TOPOLOGIES

The access methods associated with LANs depend on the topology used. For example, in the access method used in the ring networks, a token is constantly circulating from node to node. For any node, the reception of a token signifies the opportunity, to transmit data using the ring. Whenever a station receives a token, and if the station already has data to be sent, then the station makes use of the token and sends the data around the ring. The data is sent in the form of a collection of bytes called a 'packet'. The 'packet' carries information about the station from which the packet has originated and the station to which it is destined. The receiving station or the destination picks up the 'information' and sends an acknowledgement back to the sender. The data after travelling around the ring reaches back to the sender and the sender removes the data from the ring. The token is now handed over to the neighbouring node. What is described here is one particular (popular) approach to control the access to the ring. There are several variations of this scheme available for accessing a ring.

In the case of a Bus or Tree, the access to the medium is independently available to all the stations connected to the LAN. That means a station of LAN which uses Bus or Tree Topology can freely transmit and/or receive data simultaneously. This is true for all the stations that are connected on to the LAN. Therefore, very often 'Collision' will occur in such LAN. As the medium is shared by all the nodes, detection of collision and controlling the time of transmission are seen as the responsibility of the individual stations connected to the LAN. Here again, there are many variations available which control the transmission time or those which differ in the way in which collision is detected and a corrective action is taken.

In the case of Star topology, either a token passing scheme or a circuit switching sceme, can be used. When the token passing scheme is used, the centralised switch in the star is seen as a shared resource and the availability to a token has the same significance as that of a ring. When circuit switching is used, the situation is analogous to the exchange in a telephone network. A dedicated path is established between the source and the destination for the duration of transmission.

We have seen so far in this unit, the concepts relating to LANs, technologies and topologies relevant to LANs and so various access methods associated with the LANs. In the next section we will discuss the architectural issues relating to LANs. By LAN architecture we refer to the functional division of tasks from technology at one end to the user applications at the other end.

10.14 LAN ARCHITECTURE

In a LAN, both the hardware and the software have different components. In the hardware, there are stations specific and network specific subsystems which have to coexist. Supporting local requirements of the user and conforming to the network specifications are the tasks to be performed in order to coexist with other workstations on the LAN. This necessitates an unambiguous definition of the functional division of tasks from the technology to the application. The software has three specific components namely the **Application Software, Network System Software and Network Management Software.** The appliction software makes the facilities of the network available to the user in a friendly way. The network system software ensures that the stations have error free communication with each other. The network management software helps the network supervisor in maintaining, administering and operating the network.

The interaction between hardware and sofware can occur at different levels. Obviously, the work performed by hardware will be faster as compared to the same work carried out by an equivalent software. Many functions can be done directly in hardware if they are very well understood and standardised to a level that VLSI implementation of these functions are available.

10.15 NETWORK MANAGEMENT

Another important aspect that needs to be considered in the multi-vendor network involves the management aspect of this network. OSI made efforts to deveolop standards that satisfy services and protocol for the communication of network management information in a multi-vendor network. These standards enable users to manage entire multi-vendor network, including monitoring the network for traffic, performance and communication problems and controlling the network to correct faults and optimize performance. In 1988 a Network Management Forum under OSI was formed to evolve guidelines (Frame work) towords this. The OSI Management Framework addressed five areas of functional requirements for multi-vendor network management called specific management functional areas of SMFAs. These functional requirement must be met by the network management to be effective. Specific standards in the network management functions have been developed individually. However, these can be combined in different ways to achieve this specific result. The Framework also defined common functions required by two or more of these functional areas, called Common Management Information Services and Protocol. (CMIS and CMIP).

The specific management functional areas fault management, configuration management, performance management, accounting management and security management.

The multi-vendor network management gives the organisation maximum flexibility to choose among projects of different vendors to meet their particular computing and network requirements. Multi-vendor network systems will be delivering the best information services by maximizing the performance and availability of complex multi-vendor computing and data communication networks.

10.16 APPLICATIONS OF NETWORKS

Popular network application are file transfer, electomic mail, bulletin board, remote **login,** remote program execution, remote database access and resource sharing. The three applications namely file transfer, electronic mail and bulletin board result in transfer of data from one station to another. The applications like remote login, remote program execution and remote database access imply that a conversational link be established between two systems. The resource sharing application implies that all the stations share a particular resource available in anyone or a few stations on the network. A resource can be either hardware like a powerful CPU, laser printer, plotter etc. or software like a language compiler or an application program. All these applications have their own requirements and they have to be mapped on to the network in an appropriate manner. While the layers of software as described by the standards ensure error free communication between two stations, the applications have thier own requirements of protocols. For example, even though data is physically transferred from one station to another in the case of file transfer and electronic mail the protocol requirements for these two applications are quite different. For example, the file transfer tries to identify receiver station and establishes a logical link over which the entire file is transmitted. At every step, messages are exchanged between the sender and the receiver so that both of them krow that the file has been transmitted fully and correctly. On the other hand, the electronic mail system functionally is very similar to the postal system in our country. The sender gives the message to an 'Agent' who then transfers it to another agent in whose domain the recipient of the message resides. This is similar to one person writing a letter to another using the postal system. The sender may be in Madras and the receiver may be in Delhi. The sender prepares the letter, writes the address and gives it to the agent through Mail Box. The agent (in this case is the Post Office in whose domain the sender lives) sorts the letter and sends it to his counterpart in Delhi. The exchange of letters between the post offices is similar to the exchange between Mail Transfer Agents. The post office in Delhi through a delivery mechanism delivers the letter to the receiver. Thus the application requirements of an electronic mail is quite different from that of file transfer.

In the case of an electronic bulletin boards, a given message is transmitted in a broadcast mode a group of users called recipients. The group is a subset of the total number of users available on the network and is selectively chosen depending on the message. For example, in an academic department, a notice about a particular conference will be of interest only to those people who are actively working in the area covered by the conference and who are likely to contribute to the conference. On the contrary, a general, information like a faculty meeting will be of interest to everybody. Such things can be transacted using the bulletin board. The situation is similar to the physical bulletin board in which a number of notices are struck on the board and the reader only picks up the notices that are of relevance to him/her.

The networks can be used in a variety of environments. For each environment, the major activities in the environment will decide the applicability of Netwoks to that environment. Some examples of environments are administrative offices, finance and insurance, transport, hotels, manufacturers and hospitals.

An adminitrative office has got both clerical service supporting the main business of the organisation and the supervisory service supporting the decision-making process of the organisation. Traditionally, a single mainframe computer with terminals in each department was the model of an automated office. But today, each department can own one or more PCs of varying capacity. Word processing has fast become a national substitute for the typewriter.

With the full availability of PCs, an internal electronic mail can effectively replace the movement of paper within the office. The traditional services like client-account servicing, client-record accessing, documentation control and distribution, financial administration and purchasing and sales can all be integrated into a Network which is nothing but an effective interconnection of PCs.

10.17. SUMMARY

This unit described certain hardware and software components of networks and how they operate. Definition and characteristics of Local Area Networks were given. Network topologies of various kinds of switching involved in networks was also discussed. Multi - vendor compatibility standards establishment in networks was discussed in the context of network management. In conclusion, various applications to which networks can be put was discussed.

10.18. KEY WORDS

Application Layer : Layer 7 of the OSI model. This layer determines the interface of the system with the user.

Bandwidth : Refers to the relative range of frequencies, that is, the difference between the highest and lowest frequencies transmitted. For example, the bandwidth of a TV channel is 6 MHz.

Baseband : Transmission of signals without modulation. In the baseband local network, digital signals. (1s and 0s) are inserted directly on to the cable as voltage pulses. The scheme does not allow for frequency division multiplexing.

Broadband : The use of coaxial cable for providing data transfer by means of analog or radio-frequency signals. Digital signals are passed through the modem and trasmitted over one of the frequency bands of the cable.

Carrier : A continuous frequency capable of being modulated or impressed with the second (information carrying) signal.

Channel : A means for transporting information signals. Several channels can share the same media.

Channel Capacity : The maximum rate at which information can be transmitted over a given channel. It is normally measured in bauds but can be stated in bits per second.

Character Terminal : A terminal which cannot construct its packets, thus needs an additional device Packet Assembler and Disassembler (PAD) for connection to Packet Switched network.

Coaxial Cable : An electro-magnetic transmission medium consisting of a center conductor and an outer concentric conductor.

Connectivity : In a LAN, the ability of any device attached to distribution system to establish a session with any other device.

Data Link Layer : In a layered architecture, the data link protocol provides for channel level addressing, packet framing, and CRC check generation and application. It also serves as a channel bandwidth allocater using, for instance, distributed CSMA/CD control.

Ethernet : A local area network and its associated protocol developed for (but not limited to) Xerox Corporation. Ethernet is a baseband system.

Fiber Optics : A technology for transmitting the information via light waves moving through a fine filament. Signals are encoded by varying some characteristics of the light waves generated by low powered laser. Output is sent through light conducting fiber to a receiving device that encodes the signal.

Four Wire (4 Wire) Circuit: A two away circuit in which signals simultaneously follow separate and distinct paths in opposite directions in the transmission medium. It is called four wire because it uses a pair of wires in each direction in the most simple form.

Headend: A component of broadband network that translates the "transmit frequency band" to "receive frequency band", thus, making it possible for a station to transmit and receive on a single cable network.

IEEE 802: A committee of IEEE organised to produce a LAN standard.

Logical Link Control: A protocol specified in IEEE 802.2 for data link level transmission control.

Medium Access Control (MAC): For bus, tree and ring topologies the method of determining which device has access to the transmission medium at any time. CSMA/CD and token are common access methods.

Message : A logically related collection of data to be moved.

Network Layer: Layer 3 of the OSI model. Responsible for routing data through a communication network.

Packet : A group of bits that includes data plus source and destination addresses. Generally refers to a network layer (layer 3) protocol.

Packet Assembler/Disassembler (PAD): A device used with an X.25 network to provide service to asynchronous terminals.

Packet Terminal: A terminal which can form its own packet. This terminal is also capable of interacting with a network character terminal.

Physical Layer: Layer 1 of the OSI model. Concerned with the electrical, mechanical and timing aspects of signal transmission over a medium.

Polling: A method of network control where nodes are instructed to transmit in turn, under the command of a master node.

Presentation Layer: Layer 6 of the OSI model. Concerned with data format and display.

Public Data Networks (PDN): A government controlled or national monopoly packet switched network. This service is publicity available to data processing users.

Public Switched Telephone Network (PSTN) : A telephone switching system that provides switching transmission facilities to customers.

Remote Terminal: A terminal connected via a data link to a system.

Repeater: A device that receives data on one communication link and transmits it, bit by bit, on another link as fast as it is received, without buffering. An integral part of the ring topology. Also used to connect linear segments in a baseband bus LAN.

Satellite Links: The links which are established using a satellite communication system.

Security: In computing it is Prevention/ Protection of information against retrieval, alteration or destruction by unauthorised user.

Session Layer: Layer 5 of the OSI model. This layer deals with active interconnections of one device to another over a communication system.

Teleprocessing: It refers to data processing combined with telecommunications.

Token: A special bit pattern, generally a 8 bit pattern e.g. 11111111, which ciruculates around the ring for control purposes. It helps in identifying the state of the ring i.e., idle or some station transmiting.

Token Bus: A medium access protocol technique for bus/tree. Stations form a logical ring around which token is passed. A station receiving a token may transmit data, and then must pass the token to the next station in the ring.

Token Ring: A medium access protocol technique for rings. A token circulates around the ring. A station may transmit by seizing the token, inserting the packet onto the ring and then transmitting the token.

Transport Layer: Layer 4 of the OSI model. Provides reliable, transparent transfer of data between endpoints.

VLSI : An abbreviation for Very Large Scale Integration, a fabrication technology in micro-electronics in which more than 1000 gates are integrated on a single silicon chip.

10.19. SELF-ASSESSMENT EXERCISES

1) What are the various kinds of network topologies?

2) Describe the types of switching available in networks.

3) Describe the various applications to which networks can be put.

10.20 FURTHER READINGS

Indira Gandhi National Open University, School of Engineering and Technology, *Modern Office, Block-1, Communication in the Office*, Units 2B and 3.

BLOCK 4 MANAGING CORPORATE DATA RESOURCES

INTRODUCTION

One of the purposes behind the development of database systems was to overcome the inefficiencies and consequent difficulties of multi-file organisation.

As an organisation grows, and handles more and more of its information on and with computers this need becomes more acute. This block describes some of these products based on a relational database design. Conceptually, a database can be thought of as providing a more flexible data structure than files and as holding all the data from several files together.

Unit 11 briefly describes the limitations of the traditional approach to system development, the motivation for database approach and the basic concept of database designing.

Unit 12 focusses on the relational model, enumerates the 12 commandments of CODD, lists almost 50 products available commercially and mentions some features of the most popular ones.

Unit 13 discusses query languages, which allow easy access to the information stored in the database. This unit also illustrates the syntax used in SQL to run queries on single tables as well as multiple tables. Embedding SQL statements in a host programming language for batch process is also described.

The last unit, **Unit no. 14,** deals with the real-life managerial issues of product selection and acquisition, of emerging standards, and human aspects of organisational resistance to DBMS tools.

UNIT 11 ORGANISING DATA

Objectives

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

- identify data as more important than the tools for its handling
- appreciate the limitations of the traditional approach to application system development
- enumerate the considerations that motivate a database approach
- classify data structures into records, files, object-relations etc.
- appreciate the stages of database design, such as logical design and normalisation.

Structure

11.1 INTRODUCTION

Since computer professionals have proclaimed database and DBMS technology as revolutionary, many managers may regard the database approach as disruptive and may therefore avoid it; or they may think it must be embraced at any cost for their organization to remain efficient, modern, and competitive. Neither position is entirely acceptable, yet both contain some truth.

To say the database approach is entirely new reflects a lack of historical perspective. Data has always existed in organisations, and accountants and bureaucrats have traditionally controlled it to provide information in support of operations and management. The approach may seem radically new to people in data processing, but it is not. Many electronic data processing (EDP) departments have been so over whelmed with the programming aspects, that they have not applied well-known, sound management practices such as accountability and control. This "radical new concept" is merely a return to good management-of an old resource.

Growing recognition of data as a valuable corporate resource has led to the establishment of organisational units such as "Information Systems and Management Services" or "Information Resource Management" which have responsibility for data processing, management information systems, and the computer. Database technology is forcing a re-examination of the goals and operations of conventional EDP departments; in other words, it is forcing top management and users to change the way they view the EDP department.

Traditionally, EDP/MIS departments have been viewed as managing the hardware and software systems. Yet these are only the factors of production, that is, the tools. The real product of the EDP/MIS department is data to support organisational operations and management decisions. Viewing the EDP/MIS department as a service function to the organisation focuses attention on the product to be delivered. The real resource being managed is data.

The database approach is rooted in an attitude of :

* Sharing valued data resources
* Releasing control of those resources to a common responsible authority
* Cooperating in the maintenance of those shared data resources

The database approach is :

* More than simply acquiring a DBMS
* More than collecting and storing data in one integrated database
* More than designating someone to centrally control the data

It involves tools to collect and manage the data, a responsible and cooperative attitude among users, and a database administrator.

An organisation must not become overly optimistic. The database approach is not a panacea for information systems and the use of computers. Neither is acquiring a DBMS. After all it is only a tool; it must be made to work in and for an organisation.

11.2 TRADITIONAL APPROACH TO APPLICATION SYSTEM DEVELOPMENT

A strong focus on application programs and processes characterizes the traditional approach to application system development. With a primary focus on processes, application systems often develop separately and operate independently. Figure 11.2 shows a set of application subsystems developed in a petroleum exploration and production organisation.

Level separation can result in a separation of data used for management reporting and analysis from data used in operations. For example, salespersons who enter customer orders into the computer system every day may also be asked to prepare a summary of the number of customers visited during the month in each customer class.

To retrieve data that is stored redundantly, the user must decide which application to use to obtain the data. Data updating, an even larger problem, must be coordinated across application systems to ensure that the same data is updated in the same way and at the same time wherever it exists.

Preparing top management reports is always more difficult. Independent master files with relatively homogeneous data cannot easily represent the data relationships across files. This makes it difficult to prepare top-level management reports containing aggregates of more heterogeneous data.

Developing a new application system presents additional problems. To use the data from an existing application may require adding new items of information or restructuring an existing file. Both alternatives require rewriting existing programs. With programs tied very closely to the physical layout of the data (e.g. the size of data values or the relative position of data items within a record), program modification is very difficult, which explains the great reluctance of most organisations to revise existing files or databases.

With no attempt to use existing data directly from the existing application developing a new application means solving the data problem all over again-capturing the data, putting it in a form suited for the new application, and writing programs to store, retrieve, and update the data. Entirely new and separate master files are created, often resulting in duplication of already stored data. Data files are designed to suit the individual application. In the resulting collection of application systems, marked differences can occur in data quality. It may also be difficult to answer new ad hoc questions not previously considered in the design of the system.

Sometimes the designers try to minimize data redundancy. The result is often excessive transfer of data between subsystems. Without good multiple processing and reporting facilities, increased data redundancy may be the best short run solution to the problem of intersystem file transfers.

In early computer systems, available storage media constrained the data structure. In any organization, all master files were stored on magnetic tape and the input data transactions on punched cards. Punched cards and magnetic tape (often viewed as a long strip of punched cards) impose a sequential structure on the file and a periodic batching discipline on its processing. In the early 1960s, direct access storage devices and online equipment expanded the possibilities for storing and processing data. Unfortunately, some systems in use today still carry the legacy of this batch processing mentality. During the 1960s and early 1970s, several DBMS emerged. Most systems provided facilities which augmented a conventional programming language. A host language DBMS was designed to serve application programmers. While such a system may have allowed the integration of multiple, independent data files, it still relied on traditional tools for application systems development - namely, writing programs.

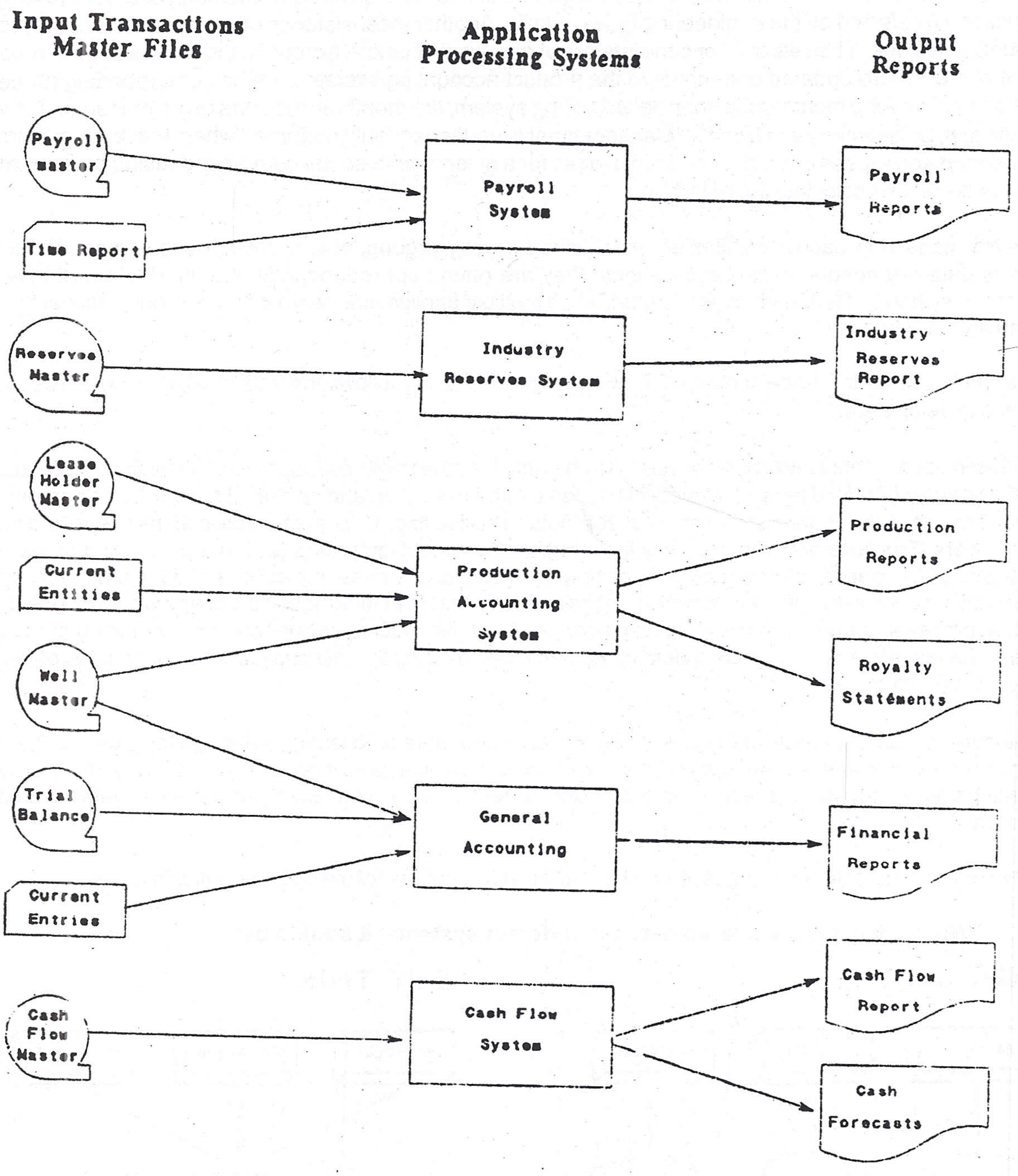


Fig. 11.2. Traditional Application System Development in a Typical Organization, in the Oil & Natural Gas Sector.

In this abbreviated schematic of the system, relatively independent application processes have their own master files. Six master files of data are associated with five application processing subsystems. One of the master files is shared by two applications. Designing relatively independent subsystems results in redundancy and inconsistency. Within the same organization, different codes represent the geographical location of wells, leases, and lands. Product accounting and financial accounting each have their own location codes, while the legal department and government report use a legal location (based on Khasra Khatauni) or a latitude-longitude designation (preferred by the engineering type of staff). Another inconsistency often results because 'produce accounting' is done in barrels of oil or cubic meters of gas, while financial accounting is always done in rupees. If the barrels of oil are updated one month in the product accounting system and the corresponding rupees are updated the following month in the financial accouting system, the month-end reports to top management will be inconsistent, sometimes even bizarre! Manangement is understandably perturbed when the reported barrels of oil produced and rupees of production from a lease for a given month do not correspond (using an approximate price per barrel to recalculate the revenue).

In the traditional approach, data files are established as a by-product of application development. If the same items of data are needed in two applications, they are often kept redundantly, that is, duplicated in several application systems. Redundancy also occurs when multiple applications serve different organisational functions or managerial levels.

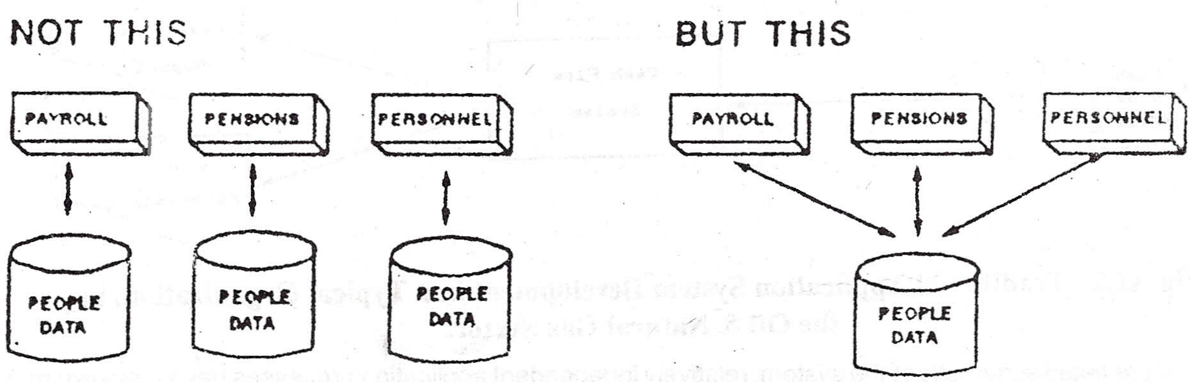
Some times, even with a host-language DBMS, an organisation still follows the traditional approach to application systems development.

Centralised development and operation has also characterized the traditional approach. The high cost of equipment and the scarcity of skilled personnel dictated strong central execution and control of system development. As a result, users often faced unavailable or unreliable data. This led to private, manual collections of data maintained by end users. The emergence of realively inexpensive Personal Computers (with the power and capacity of a mainframe of 20 years ago) now makes it possible for these local, private collections of data to be mechanized. Local orgnisational units press for decentralisation believing that their information problems would be overcome if the data processing operations were locally controlled. In fact, local users often end up making many of the same mistakes made by central DP a decade earlier, rediscovering the lessons learned from past experience in the computer industry.

The above discussion reveals many symptoms of problems in data processing. Although the example illustrated in Fig. 11.2. may be worse than current practice in some organisations, it does illustrate many of the problems stemming from the traditional approach to application system development. Such problems motivate the database approach.

The essence of the data base concept, can be appreciated from the following schematic diagram:

"Where data can be shared between different systems, it should be"



This Requires :

* Flexible data storage and access methods to meet the different needs of different users
* Absolutely reliable recovery methods

11.3 MOTIVATION FOR DATABASE APPROACH

Several problems may motivate management in an organisation to adopt the database approach-focusing on the problem of data, and perhaps acquiring a DBMS. Difficulties may be manifest in an inability to get something done, or do economically, quickly, and accurately. Though this need may initially justify acquiring a DBMS, solving a particular problem or building a particular system must not be the sole criterion for selecting a DBMS. Management must look at the application environment and the data processing requirements from a global perspective.

Five major problems motivate a database approach:

* Inability to get quick answers to "simple" ad hoc requests.
* High development costs.
* Low responsiveness to change.
* Low data integrity and quality.
* Inadequate data model of the real world.

Four major trends in the evolution of DBMS especially those based on a relational approach have led to an increased interest on the part of managers to adopt the new technology.

1) increase in commercially available products
2) recognition of relational databases as practical and desirable approach to cope with the information management needs of organisation.
3) emergence of relational DBMS products that satisfy a broad range of business requirements.
4) increasing possibility of associating people with limited database backgroud in the design of relational databases.

11.4 TAXONOMY OF DATA STRUCTURES

In current DBMS literature, systems are most often classified according to the logical structures of the underlying data "model", * that is, the class of data structures which can be defined in and processed by a given DBMS. A database is formally defined to a DBMS by writing statements in its Data Definition Language (DDL)

The following paragraphs introduce the taxonomy of data structures by naming and briefly describing various types of structures. At this point the reader should visualize the taxonomy as presented in Figure 11.4. This brief overview provides an initial understanding by placing the pieces of the taxonomy into aconsistent, overall picture.

A database is a collection of information about entities (People, orgnisations, postions, policies, orders, parts, projects, events, etc.). Attributes describe entities (e.g., age of person, budget of organisation). A particular entity ("instance") is described by the values of a set of attributes. (Age of "Rakesh Kumar" is 52). The database designer selects some set of attributes to describe entities in the database.

The first division in the taxonomy of data structures is based upon whether or not the attributes or data items are grouped into records (Records represent entities). Historically, most data structures have been record-based. Most people in data processing are familiar with collections of data consisting of files of records. Assuming a grouping of data items at the outset of database design leads to some difficulties in the resulting structures,

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*The term "model" is widely used although it is somewhat misleading. The phrase "data structure class is more accurate. Something is a "model" if it bears a likeness to or is an imitation of something else. A defined database is a data model of reality to the users; a DBMS is a data modelling system.

particulaly when they expand to encompass more of the data in an organisation. Recognising these limitations, several authors proposed a class data structures which omit the dual notion of entity-attribute, replacing it with the single notion of "object". ; These are called the **object-relation** class of data structurers.

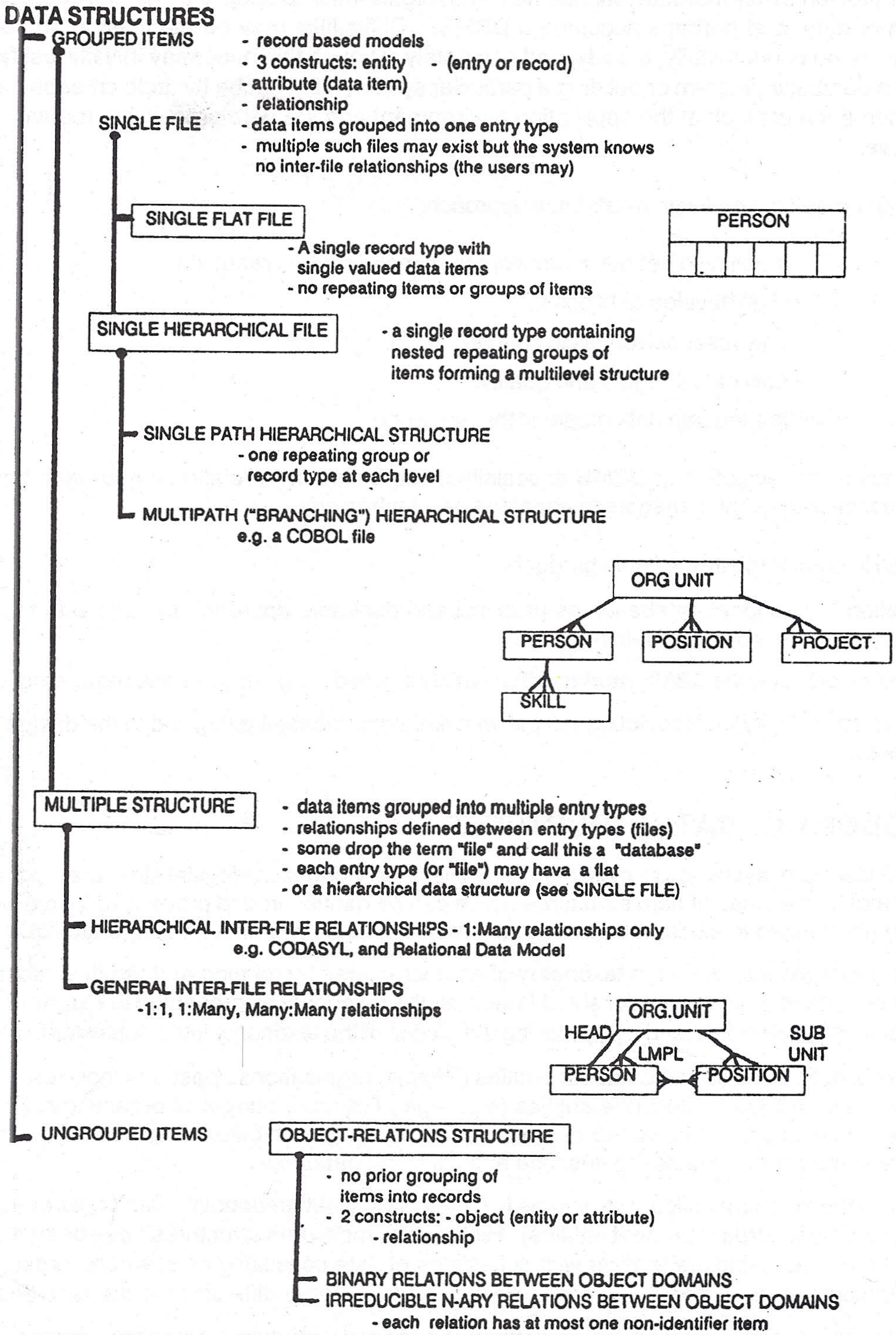

Fig 11.4 A Taxanomy of Data Structures (Taken from Everest Data Base Management)

Data structures with grouped items can first be divided into single-file structures and multifile structures. **In a single-file structure,** all information in the database can be grouped according to a single entry type. In other words, there is one primary entity connotation for the entire database. Single-file structures are further divided into flat file structures and hierarchical file structures. **In a single hierarchical file structure,** each primary entity may have subentities (that is, the primary record, corresponding to the primary entity, contains nested repeating groups of data items representing attributes of the subentities). Single hierarchical structures are further divided into single path and multipath ("branching") hierarchical file structures or data structurers.

A multifile data structure consists of multiple, related files. All the data items in the database are grouped into multiple record types. There is no longer one primary entity or record type in the database. Entities may exist independently of each other and may be related to each other. Multifile data structures offer greater flexibility than single-file structures, therefore, enabling greater fidelity in modelling the world of interest to the user(s).

Multifile data structures are further divided into those which only permit a hierarchical relationship between entity types and those which permit a general relationship between entity types. (Multifile data structures are also further divided depending on whether each file must be flat or may be a hierarchical structure).

11.5 DATA BASE DESIGNING

There are two aspects to the database design. First, the data items, entities, relationships, and other concepts need to be translated into their equivalent logical database structures of tables and columns. Next, the logical database design needs to be turned into physical database structures such as indices, permits, and integrities.

Logical Design

The process of database logical design entails translating entities and relationships into database tables. For exmple, consider a one-to-one relationship between two entities. This could entail the fact that each employee has a single office and each office has a single employee in it. In this case, the translation from the entity-relationship models to the relational database model is fairly simple. An employee table is constructed and that table has columns for both employee and location.

For one-to-many relationships, the process is slightly more complicated. If a sales-person has several sales outstanding, this is a one-to-many relationship. In this case, two tables are constructed. One table is for the entity salesperson. This table has a unique key for the salesperson, say the last name.

The sales table needs to have one line for each sales order. It also needs to have the name of the salesperson. The salesperson name is the same name as is in the other table and is known as a foreign key. By joining the two tables together, the user can find out information about the relationship. Some information in the entity-relationship model cannot be reflected in a relational database. For example, the cardinality of a relationship cannot be directly reflected in a design consisting of a series of tables. Instead the cardinality aspect of a relationship would have to be implemented as an integrity constraint that regulates the input and update of information in one or more tables.

Translating an entity-relationship model into a relational database logical design usually consists of two steps. First, the formal method of normalization is applied to the entities and relationships to break them down into a series of tables. Normalization ensures that updates to the database can be performed in a consistent fashion and that data are not overly redundant.

The next step is to change the logical design to reflect the nature of the applications that will use that data. Normalization, by reducing redundancy, also makes retrieval of data more difficult because many small tables may have to be joined together. Based on the types of applications that will use the data, the designer may add redundancy or otherwise violate the rules of normalization.

Normalization

Normalization is a formal method that attempts to solve the problem of update anomalies. An anomaly results when data are stored twice and are only updated once. It should be stressed that normalization is only one of several database design techniques. Although normalization reduces update anomalies to data, it does often make retrievals more inefficient by breaking data up into many different tables.

The process of normalization consists of breaking tables down into smaller tables. There are various levels of normalization. This unit contains a brief discussion of the first three normal forms. There are also fourth and fifth normal forms available and research continues on further extensions of this technique. The reader is referred to C.J. Date 'An Introduction to Database Systems', Volume 1 (4th ed., Addison Wesley, 1986, Reading, Mass.) for a more formal treatment of this technique.

First normal form consists of eliminating repeating groups. A repeating group means that a table has several columns, each of which represents the same piece of data. For example, an employee might have multiple phone numbers. First normal form is violated when there are two columns, one for each phone number. The update anomaly results when a user attempts to update a phone number. The application program would have to search both columns to find the relevant phone number. In a design conforming to first normal form, employee information would be broken into two tables. The employee table would have one row for each employee. The phone table would consist of two columns, one for employee name and the other for the phone number.

A relation is in second normal form if every nonkey column is dependent, directly or indirectly, on the key for that table. For example, a projects table could have as the primary key the columns employee and project name. Storing a deparment's budget in the same table would be a violation of second normal form because the budget is not dependent on either portion of the key.

Third normal forms states that any nonkey column in a table must be dependent on the whole key for the table. Using the same projects table, storing employee office locations would be a violation of third normal form because the office location is only dependent on a portion of the key- the employee name and not the project name.

To achieve normalizaion, the table would be broken up into two tables. One would have project-specific information, such as the number of hours worked by the employee. The second table would contain only employee-specific information such as office location. The update anomaly in a violation of third normal form exists because the employee office location exists once for each project that the employee participates in. If the user updates the office location, he would have to ensure that every instance of the phone number is updated.

As can be seen, the process of normalization consists of breaking a table down into a series of tables, each containing a well-defined group of information. The rigorous process of normalization helps the database designer identify potential problems in the design and some ways of curing those problems.

11.6 SUMMARY

In this unit, we have seen the need for an approach to Data Base Management as an alternative to the traditional approach of establishing data files as a by-product of application development. The motivation for data base approach arises from being able to provide the users direct access to his data and to be able to respond to ad-hoc queries. In order to understand the concept of the data base, a brief taxonomy of data structures was discussed.

In order that the real world's needs of information for the organization are met, some effort is required for data base designing. The concepts of logical design and normalisation were discussed briefly.

11.7 SELF ASSESSMENT EXERCISE

1. In what sense does the database constitute the 'image' of an organization?
2. what are the main disadvantages of separately developing application systems and their associated data files?
3. List the five problems which may motivate an organization to move toward the database approach. Explain the significance of each one to a manager to an organization.
4. What is the effect of normalisation on database storage and database performance?

11.8 FURTHER READINGS

1. Atre S. *Database Structural Techniques for Design, Performance & Management*, John Wiley & Sons, 1980
2. Date C.J. *A Guide to DB2* Addison - Wesley. 1984
3. Everest, G.C., *Database Management: Objectives System functions & Administration*, McGraw Hill, 1986
4. Ven Halle Fleming, *Handbook of Relational Database Design*, Wesley, 1990.

UNIT 12 RELATIONAL DATA BASE MANAGEMENT SYSTEM

Objectives

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

- identify the relational approach as one which organizes data in tables
- enumerate various options for field type specifications
- define the meaning of relational operations such as SELECT, PROJECT, JOIN etc.
- identify and enumerate the features suggested by E.F. Codd for determining how relational a DBMS product is.

Structure

12.1 INTRODUCTION

The relational system is a major development in database management even though full-fledged relational DBMSs became available commercially only in the early 1980s, more than a decade after the network and the hierarchical systems appeared. The relational approach is substantially different from other database approaches in terms of its logical structures and mode of I/O operations. In the relational approach, data are organised into tables called relations, each of which is implemented as a file. A row in a relation is called a tuple in the relational terminology, and it represents a record or an entity, each column in a relation represents a field or an attribute implemented as fields. For example, a CUSTOMER relation consists of a number of customer entities. The characteristics of a customer entity are described by its attributes such as customer's number, customer's name and customer's address.

The following are some relational terms and their equivalent conventional names:

Relational terms	Conventional terms
relation,base table	file
tuple	record, entity
column	field, attribute
foreigrn key	connection field

One of the characteristic of the relational approach is the simplicity of its logical representation. For the users, tables are much easier to understand than complex tree or nework structures.

12.2 RELATIONAL DATA MODEL

Logically, a relational data model consists of a collection of tables, each of which represents a conceptual record type. Thus, the schema for a relational system includes data definitions for a number of base tables. A base table can be described with the the SQL as follows:

```
CREATE TABLE base-table-name
(field-name-1 data-type(NOT NULL)
.
.
.
field -name-n data-type (NOT NULL)
```

The tables given at the end of this section illustrates the relational data model. The relational data model is composed of three relations, INVENTORY, CUSTOMER and TRANSACTION. A one-to-many relationship between INVENTORY, and TRANSACTION is implicity established by the presence of a common field (INV-NO) in both relations. Similarly, the one-to-many relationship between CUSTOMER and INVENTORY is implicity described by the presence of the common field, CUST-ID.

The set of statements below shows the creation of the relations given above with the SQL CREATE TABLE command. The following are various options for a field type specification:

(1) CHAR:a fixed-length character string

(2) VARCHAR:a variable-length character string

(3) INTEGER:a full word binary integer

(4) FLOAT:a floating point number

(5) DECIMAL(m,n):a decimal number of m digits with n digits after the decimal point.

INVENTORY (INV-NO, INV-NAME, UNIT-PRICE)

CUSTOMER (CUST-ID, CUST-NAME)

TRANSACTION (TRANS-NO, INV-NO, CUST-ID-, QTY, DATE-OF-TRANS)

```
CREATE TABLE INVENTORY
        (TRANS-NO)        CHAR (5) NOT NULL.
        INV-NAME          VARCHAR (15)
        UNIT-PRICE        FLOAT
```

CREATE TABLE CUSTOMER

(CUST-ID	CHAR (4) NOT NULL.
(CUST-NAME	VARCHAR (20))

CREATE TABLE TRANSACTION

(TRANS-NO	CHAR (4) NOT NULL.
INV-NO	CHAR (5) NOT NULL.
CUST-ID	CHAR (4) NOT NULL.
QTY	INTEGER
DATE-OF-TRANS	CHAR (4))

The NOT NULL option is used to specify that the content of a data field should not be left undefined. The primary key is not explicity declared, but the primary key and all foreign keys must be specified at NOT NULL.

In SQL /DS or DB2, new fields may be added to an existing base table with an ALTER TABLE command. In SYSTEM R, however, an EXPAND TABLE command is used instead. For example:

SQL/DS or DB2 ALTER TABLE CUSTOMER ADD CUST-ADDR

CHAR (20)

SYSTEM R: EXPAND TABLE CUSTOMER ADD CUST-ADDR

CHAR (20)

A new field, CUST-ADDR, with a data type CHAR(20) is added to the CUSTOMER base table. These commands allow users to expand a base table even after it is loaded with data.

Once a table is defined with a CREATE TABLE command, a new empty base table is created, and the table may be loaded immediately with an interactive SQL INSERT command. For example, the following statement inserts a new record in the CUSTOMER base table:

INSERT INTO CUSTOMER VALUES ('C3', 'JANE')

In SQL/DS, a system supplied utility called Data Base Services (DBS) can be used to initially load or add rows to tables from a sequential file. In DB2, the LOAD utility is used to load base tables with sequential files.

A base table may be deleted wth a DROP TABLE statement as follows:

DROP TABLE base table name.

Inventory

INV - No	INV - NAME	UNIT - PRICE
11	CHAIR	75.00
12	TABLE	259.15
13	DESK	399.00

Customer

CUST - ID	CUST - NAME
C1	DAVE
C2	EDDIE
C3	JANE

TRANSCTION

TRANS-NO	INV-NO	CUST-ID	QTY	DATE-OF-TRANS (DD/MM)
T1	11	C1	12	O5/06
T2	13	C1	2	12/08
13	12	C2	1	25/07
14	13	C3	2	21/10

Sample data for the relations : INVENTORY, CUSTOMER and TRANSACTION.

12.3 RELATIONAL OPERATIONS

The following operations can be performed on the tables illustrated in the previous section.

1) SELECT operation

The SELECT operation is used to select rows from a table or, to select records from a file,in the conventional terminology.

2) PROJECT operation

A PROJECT operation is used to select desired columns (or vertical subsets) from a source relation. Duplicated tuples will be automatically eliminated from the resulting relation.

3) JOIN operation

The JOIN operation combines two tables horizontally over common values in a specified field of each relation. The two fields to be compared must have a common domain.

The JOIN operation is accomplished by comparing each record in the first table with every record in the second table for a possible match in the specified field. The two records are joined and all the records thus combined from the new relation. The JOIN operation terminates when the last record in the first table has been compared with all records in the second.

4)DIVISION operation

The DIVISION operation selects rows from a table based on a range of values specified in another table, To perform such an operation, we first sort the first relation on the ascending order of say CUST-ID. A CUST-ID value will be selected from the first table if its associated INV-NO values include all the INV-NO values specified in the second.

Not all commercial DBMSs can perform all the functions described above.

Set Operations

Three traditional set operators of relational algebra are UNION, DIFFERENCE and INTERSECTION.These three operators can be applied only to source relations that have compatible layouts. In other words, operand realtions must be of the same degree (same number of fields) and the corresponding columns of each relation must have the same domain. Using the two such source relations each of the three operations can be performed as follows:

(1) UNION Operation

The UNION operation merges records in two tables.

(2) DIFFERENCE Operation

The DIFFERENCE operation is similar to subtraction. It removes from a relation those records that appear in another relation.

(3) INTERSECTION Operation

The intersection of two relations produces a new relation which consists only of records which belong to both source relations.

12.4 THE 12 COMMANDMENTS OF CODD

12 COMMANDMENTS FOR DETERMINING HOW RELATIONAL A DBMS PRODUCT IS :

Informaion Rule : Tables format

Rule 1: All information in a relational data base is represented explicitly at the logical level and in exactly one way - by values in R-tables.

Guaranteed Access Rule: via combination of table name/primary key, column name

Rule 2 : Each and evey datum (atomic value) in a reational data base is guaranteed to be logically accessable bvy resorting to a combination of R-table name, primary key value and column name.

Systematic treatment of null values

Rule 3 : Indicator (distinct from the empty character string or a string of blank characters and distinct from zero or any other number) are suppoted in fully relational DBMS for representing at the logical level the fact that the information is missing (applicable and inapplicable information) in a systematic way - independent of data type. Besides the logical representation, the DBMS must support manipulative functions for these indicators and these must also be independent of the data type of the missing information.

Dynamic on-line catalique in relational form --so users can interrogate it

Rule 4 : The data base description is represented at the logical level just like ordinary data, so that authorised users can apply the same relational language to its interrogation as they apply to the regular data.

Comprehensive data sub-language rule --one language for every thing, data/view definition, data manipulation integrity constraints etc.

Rule 5 : A relational DBMS (no matter how many languages and what modes of terminal use it supports - for example, the fill in the blanks mode) must support at least one language (1) whose statements are expressable per some well defined syntax as character strings; and (2) which is comprehensive in supporting all of the following terms:

1. Data definition
2. View definition
3. Data manipulation (interactive and by program)
4. Integrity constraints
5. Authorisation
6. Transaction boundaries (begin, commit and roll-back)

View updating rule--all views updatable

Rule 6 : The DBMS includes an algorithm for determining (at view definition time) whether that view is tuple-insertible and tuple-deletable; and whether each of its columns is updatable. It records the result of this investigation in the catalogue.

High level INSERT/UPDATE/DELETE One command updates many records.

Rule 7 : The capability of handling a base relation or a derived relation as a single operand applies not only to the retrieval of data but also the insertion, update and deletion of data.

Physical data independence .. users not affected by changes to storage representation to access method

Rule 8 : Application programs and terminal activities remain logically unimpaired whenever any changes are made in either storage representation or access methods.

Logical data independence .. users not affected by change to the base tables that preserve information

Rule 9 : Application programs and terminal activites remain logically unimpaired when information-preserving changes of any kind that theoretically permit unimpairment are made to the base tables.

Integrity independence .. integrity constraints defined in the catalogue, not programs. Include

.. entity integrity .. no prime key rule

.. referential integrity .. a prime key exists for each non-nul foreign key

Rule 10 : Integrity constraints specific to a particular relational data base must be definable in the relational data sub-language and storable in the catalogue (not in the application programs).

Distribution independence ...users not affected by distribution and re-distribution of data. All data appears local to the site.

Rule 11 : A relational DBMS has distribution independence.

Non-subversion rule..no low level interfaces to bypass integrity rules

Rule 12 : If a relational system has a low-level (single-record-at-a-time) language, that low level cannot be used to subvert or bypass the integrity rules and constraints expressed in the higher-level relational language (multiple-records-at-a-time).

12.5 EXAMPLES OF RELATIONAL DATA BASE

Mention of some Relational Databases has been made earlier. A number of products are now available in the market which fulfil broadly requirements of a relational database enumerated in the earlier sub-section 12.4

The number of products available worldwide may be very large, and a list of almost 50 commercial well-known products are given in alphabetically order as follows :

ACCENT R	MILLDATA
ADABAS/NATURAL	MIMER
AMBASE	MISTRESS
ARCHON:QDMS	OMNIBASE
AUTOPRO	ORACLE
BASIS-DM	PEDMS
CLIO	QDMS
CORTEX	RAMIS II
CUPID	RAPPORT
DATA BOSS/4	RDB
DATA BOSS/32	RELIANT
DM	REVEAL-DBMS
DATACOM/DB	RTFILE
DB2	SEED-DBMS
FOCUS	SEQUITUR
GEM	SIMBAD
GUVNOR	SIR
IMPRS	SYBASE

INFO	SYSTEM 1032
INFOCEN	SYSTEM 2000
INFORM	TOTAL
INFORMIX	ULTRA
INGRES	UNIFY
INTAC	USER II
MAPS/DB	X-AMPLE

When an organisation decides to go in for a relational database it adopts certain criteria, which depend on the specific need of the organisation. However, a fairly reasonable check-list to pick out the relevant criteria for short-listings relational database would be as follows :

Short - List Criteria

1. Portability : - Must be easily transportable from machine to machine regardless of type. Must be able to run under UNIX. Software produced independent of hardware manufacturer preferable.
2. Programmability : - Must allow for the production of maintainable application code and macros. Must have host language interface for commonly used DP languages, i.e. COBOL
3. Query Language : - Must provide a query language processor.
4. Report Writer : - Must provide a report writing facility.
5. Data Dictionary : - An integrated data dictionary must be provided as an integral of the system.
6. Security / integrity : - Security features such as automatic out back recovery, as well as data integrity features, such as password protection and recordlocking, must be included as standard.
7. Database : - Full support for relational database design techniques must be in evidence.
8. Screen generator . - A facility for producing data entry / retrieval / update screens must be available.
9. User - base / Stability - A good user-base in the country and a good stable market position must be evident.
10. PC Version : - A version of the product must be available for PC use, and must be compatible with the full version.
11. Other : - Must show no bias towards a specific discipline e.g. accounting, statistics etc.

When such criteria are applied the actual product which is most appropriate for an organisation may be any of these, but the most important market players who have acquired reasonable significant share of the market players are as follows : (arranged in alphabetical order) Informix, Ingres, Oracle and Unify.

Of these Oracle and Ingres are almost in neck and neck competition and each subsequent release try to inculculate features which have been found to be appreciated by the competing product. The information is based on data sheets of vendors and is meant to identify points of comparison, rather than conveying whether a product is superior.

The final choice of the most appropriate package would need a detailed consideration of technical and administrative criteria as indicated in Unit 14.

Some features of comparison between Informix and Unify given below :

	FEATURE	INFORMIX	UNIFY
1.	Program Development	Need not have to be a programmer to develop programs.	Has to be more of 'C' programmer to develop applications.
2.	Implementation	Full ANSI SQL compatible with	Limited SQL Implementation with
		- Data definitions	- No data definition statement
		- Data control	- No data control statement
		- Integrated SQL Dictionary	- No callable data dictionaries
3.	Embedded SQL Products	Available	No Embedded SQL
		- ESQL /C	Products
		- ESQL / COBOL	No dynamic capabilities
		- ESQL / ADA	Must use 'C' function library
4.	Integration with Office automation products	Full Integration between SQL and "SMART WARE" office automation tools namely - Spread Sheet with business graphics - Word Processor - Database Manager - Communications - Application generator	No Integration with automation products.
5.	Support of Networks	AT & T STARLAN, TCP/1P DEC NET, MS-NET like NOVELL, 3 COM etc.	DOS NETWORKS like NOVELL etc. are not available. Limited networking under Unix environment.

6.	Maintenance	Reconfiguring of database is very simple. Automatic reconfiguration takes place while changing tables and adding Indexes.	Have to reconfigure entire database to change tables add Indexes, change pointers etc.
		The DBCHEK, facility helps to retrieve the corrupted table information	Have to rebuilt entire database if single table gets corrupted
		There is no concept of pointers	Pointers used for explicit relationships (pre-joins) becomes corrupted and has been rebuilt (REPOINTS)
7.	RAW I/O	Raw I/O Installation option option bypasses UNIX for faster through puts	Only does raw sequential reads; all writes are synchronous (very slow)
8.	Forms	Multi-Screen Forms Multi-table Forms features are available.	No Multi-Screen Forms and Multi-table Forms
9.	Transactions support	Rollback & Forward features available	Incomplete transaction support. No rollback
10.	Range of environment	Broad - VMS / NETWORKS/ MVS / DOS / XENIX 286, 386 / UNIX	Only supported on UNIX
11.	Other Products	Has a wide range of products available	Does not have a wide range of products
12.	REPORT Generator	Default report generator available. No limit on the length of line	Must start report from scratch Line length is limited to 240 characters.
13.	DOS Program size	2.5 MB	4.5 MB
14.	Indexes	Unlimited	Indexes Limited to 255
15.	Access to	Through SQL and Data-Dictionary	Only through menus
16.	Disk Space	Occupies 3 MB	Occupies 5 MB
17.	Fourth Generation Language	Full 4 GL Interpreter / Debugger	Accell is not a 4 GL. It relies on 3rd Generation languages such as 'C', to Program

			procedural logic in to the applications. Maintanence is difficult
18.	Database Parameters	- No limit on tables - No limit on records - Record size limit 32 MB	- Limit of 256 tables - Limit of 256 fields per record - Record size limit 25.6 MB
19.	Security Features	Locking is possible - Field level - Record Level - File Level - Database level	Only file level

Some features of comparison between Informix and Oracle given below :

SL NO.	FUNCTION	INFORMIX	ORACLE
1.	Features of 4GL debugger along with SQL based tools.	Full 4GL Interpreter/ complex applications would require 3 GL interface.	Limited 4GL functions
2.	Windowing capability	Displays 2 lines	Triggers several pages
3.	Expanded memory	Can run without expanded memory Runs on 640 K DOS	Can not run without extended memory.
4.	DOS NETWORK	NOVELL, 3 COM	No DOS Network etc. products
5.	Spread Sheet features	Full fledged Spread Sheet interface with Business Graphics and macro are available.	ORACLE-CALC has no macros and limited financial functions + expensive.
6.	Portability	Same versions run on various machines.	Several different incompatible versions exist on various machines.
7.	Currency data types	YES	No money data type very difficult to format money in forms, reports.
8.	Recovery process	Turbo module is available which is fault tolerant and	Entire database reside in a single file. If any parts

		automatic recovery module. recover except to back up.	gets corrupted, no way to
9.	Embedded Languages	Informix provide an embedded approach to using SQL from C. The SQL statements are embedded into the source code (This source code is pre-processed by a utility provided with the data manager and compiled and linked as normal C code)	Oracle provides a call level approach to embedding SQL in C Code (SQL statements are passed to Oracle sub-routines as strings of character. Therefore, there is no pre-processor step however). The code is readable since the queries are burried in functions call argument lists.
10.	Exporting data files.	Easy to export data files.	Oracle's ODL facility does not provide a means of determining the actual space being consumed by an individual table.
11.	Table size	With Informix one can look at file size and get an accurate size for the tables. table.	Oracle does not provide a means of determining the actual space being consumed by an individual
12.	Database size	No limit on database size.	Pre-allocation of space is required. One has to use a trial and error approach to determine the amount of space to use.
		informix dynamically size the files associated with the database.	There is no way to shrink an oversized database, other than to export the entire database and to recreate space.
13.	Possibility of obtaining runtime versions	Runtime and development versions are separately available.	No run-time versions available.
14.	Report generation features	Superior reporting statements are available in this product. available.	All required functions of report writer are not
15.	Market spread (UNIX)	Large number of installations since it is designed to operate under UNIX.	Not much installation under UNIX.

16.	Graphic capability	Interface is available thru 'SMARTWARE' Spread Sheet.	Not available in UNIX environment.
17.	Availability in UNIX V.3	Runs under UNIX V.3 as of today.	UNIX V.3 is not available
18.	Security features	Database, user, table page, record and field level security features supported.	Page level security is not available.
19.	Development tools	All development tools like data base creation, report writer, query, Form generator, menu driven table creation are	Weak in report writer only SQL is available for table creation.
20.	User friendliness /learn time	Menu driven non-procedural and has English language like commands.	Not very user-friendly. Non uniform function key assignment. Forms handling is cumbersome.
21.	Integrated package	products available as one package. It is easier to upgrade. during integration	Not available as on integrated packages which could result into confusion
22.	Single screen multi-table access	Allows such an access. the others can be	Only base table is accessible from one form,
	accessed through an (Triggers.)		interface
23.	Docummentation quality of manuals	More examples and better structure of manuals.	Fewer examples.
24.	Product reliability UNIX world.	More user experience in environment.	Fewer installations in UNIX

12.6 SUMMARY

In relational database systems, datas are organised into tables, or relations. Data relationships between relations are implicitly established via foreign keys. Each relation is implemented as a separate file called a base table or a stored table, and indexes can be created for random access of records in a table via either primary or secondary keys. A data sub-model is the relational term for an external schema. It consists of one or more views which derive data from one or more tables.

The two relational sublanguages called relational algebra and relational calculus suggested by Codd have triggered much research and development in the relational data manipulation languages. One of the unique features of the relational DML is its ability to manipulate relations in their entirely. In other words, a whole table may be retrieved as a result of a single SQL statement.

Some basic operations of the relational algebra described are SELECT, PROJECT, JOIN, DIVISION, UNION, DIFFERENCE and INTERSECT. On the other hand, the relational calculus is a nonprocedural language with which the user specified fields to be retrieved and a predicate to indicate the selection criteria. Thus, the user can specify what is needed without having to code the detailed procedural steps to achieve it.

12.7 SELF-ASSESSMENT EXERCISE

1. With reference to your own organisation, further refine the short-listing criterion given in section 12.5 to 5 most important ones.

2. Constant dummy data for the 3 tables show in Section 12.2 and see for yourself how you could use tne INSERT statement to add one record to each of the tables.

3. Elaborate role 8 of codds commandments to illustrates its managerial importance and implications.

12.8 FURTHER READINGS

1. Atre S. — *Database Structural Techniques for Design, Performance & Management,* John Wiley & Sons, 1980

2. Date C.J. — *An Introduction to Database systems,* Addison-Wesley, 1981

3. Hawry Stkiewycz I.T. — *Database Analysis and Design,* SRA, 1984

4. Weiderhold, G, — *Database Design* 2nd Edition, Mc Graw Hill, 1983

5. Ven Halle Fleming, — *Handbook of Relational Database Design,* Wesley, 1990

UNIT 13 QUERY LANGUAGE

Objectives

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

- appreciate the nature of Query languages and their ease of use
- use the correct syntax for query processing, involving variants of SELECT command
- use feafures of embedded SQL in a host programming language.

Structure

13.1 Introduction

SQL, previously called SEQUEL, is one of the most important relational data manipulation languages developed based on the principles of relational calculus. A prototype implementation of the original version of SQL was developed by IBM at their San Jose, California Research Laboratory as a data definition language and a data manipulation language. Its statements can be issued interactively with a terminal or embedded in a host programming language. The interactive commands are processed by the ISQL (interactive SQL) processor.

In the following sections, various SQL expressions for database retrievals and updates will be illustrated. All the examples given below will be based on the relations in referred to in the earlier unit.

An SQL query expression consists of one or more **retrieval blocks** called SELECT - FROM - WHERE blocks. Each block has the following structure :

```
SELECT  fieids
FROM            relations
(WHERE logical Conditions)
```

The SELECT clause specifies one or more target columns to be retrieved, and the FROM clause specifies source relations (either base table or view) from which desired columns may be obtained. The optional WHERE clause specifies conditions for selecting rows. For example, the following SQL statement will retrieve INV-NO and QTY for transactions made by customer CI.

```
SELECT          INV_NO, QTY
```

FROM TRANSACTION

WHERE CUST-ID = 'C1'

13.2 QUERY PROCESSING

The simplest form of SQL expressions involve operations on one relation only.

1) Selecting columns

Get INV-NAME and UNIT - PRICE of all inventory items.

SELECT INV NAME, UNIT PRICE

FROM INVENTORY

Since the WHERE clause is omitted, all rows are selected from the INVENTORY relation. The response to the query is :

INV-NO	UNIT-PRICE
CHAIR	75.00
TABLE	259.15
DESK	399.00

2) Selecting rows

Get all INVENTORY records whose UNIT-PRICE<100.00

SELECT

FROM INVENTORY

WHERE UNIT-PRICE<100.00

The response is :

INV-NO	INV-NAME	UNIT-PRICE
11	CHAIR	75.00

The asterisk represents a selection of all columns from the specified relation.

3) WHERE clause involving more than one condition

Get TRANS-NO and INV-NO for all transactions made by customer C1 where the quantity of each transaction is greater than 2.

3) SELECT TRANS-NO, INV-NO

FROM TRANSACTION

WHERE CUST-ID = 'C1' and QTY>2

The answer, as you can verify for yourself, is :

TRANS-NO	INV-NO
T1	11

This last example specifies two conditions in the WHERE clause for a horizontal subset of the TRANSACTION relation.

4) Eliminating duplicate responses

Get INV-NO of inventory items sold after July 1.

```
SELECT          DISTINCT  INV-NO

FROM            TRANSACTION

WHERE           DATE-OF-TRANS 01/07
```

The response is :

INV-NO
13
12

Referring to the sample data in section 12.2, there are two TRANSACTION records in which the inventory item, 13, was sold after July 1. However, duplicated responses will be suppressed due to the specification of the option DISTINCT in the SELECT clause. In SYSTEM R, the key word UNIQUE is used to replace the key word DISTINCT for suppressing duplicate answers.

In general, duplicate responses are not eliminated automatically by the system because of the cost of that operation. Most systems leave it up to the users to decide whether a suppression of duplicate responses is required.

5) Ordering retrieved records

The following SQL expression will answer the same query given in example (4) except that retrieved records will be ordered in the ascending order of INV-NO, and duplicate responses will not be suppressed.

```
SELECT          INV-NO

FROM            TRANSACTION

WHERE           DATE-OF-TRANS 01/07

ORDER           BY INV-NO  ASC
```

the answer is as follows :

<u>INV-NO</u>
12
13
13

13.3 RUNNING QUERIES ON MULTIPLE TABLES.

A query may involve retrieval of data from more than one table. This may be accomplished by joining tables based on a commond field. Here are some examples of retrieving data from more than one relation.

1) Retrieving data from two relations

Get names of customers who bought inventory item 13.

SELECT CUST-NAME
FROM CUSTOMER, TRANSACTION
WHERE CUSTOMER-CUST-ID = TRANSACTION. CUST-ID
AND INV-NO = '13'

Response :

<u>CUST-NAME</u>
DAVE
JANE

Conceptually, the above SQL retrieval may be accomplised with the following equivalent relational algebraic operations :

STEP 1 Join the two relations by matching equal values in the CUST-ID field of each relation

STEP 2 Select from the joined relation those rows containing 13 in INV-NO.

STEP 3 Select the desired columns, CUST-NAME, from the joined relation,

2) Retrieving data by joining a relation with itself

Find pairs of customers who bought the same inventory items.

SELECT A. CUST.ID, B.CUST-ID
FROM TRANSACTION A, TRANSACTION B
WHERE A-INV-NO = B.INV-NO
AND A.TRANS-NO<B,TRANS-NO

Response :

A. CUSTID	B. CUST-ID
C1	C3

To find the answer, two identical TRANSACTION relation as idenified by A and B are joined. In other words, the TRANSACTION relation joins with itself. The WHERE clause specifies that records in the two identical tables are joined over INV-NO except that the same record will not join with itself.

13.4 MANAGING DATA WITH SQL

The SQL includes UPDATE, INSERT and DELETE statements to alter the database content. The following examples are based on the relations in used for illustration in the preceding sections.

1) INSERT

The following INSERT command is used to insert a record, T5 13 C1.1, into the TRANSACTION relation.

INSERT INTO TRANSACTION (TRANS-NO, INV-NO, CUST-ID, QTY) VALUES ('T5,13,C1,1)

When the new record is inserted into the relation, the system will automatically establish necessary pointers or indexes to accommodate the new record. Since the DATE-OF-TRANS fields is omitted in the INSERT statement, its content will be initialized to null.

An insert statement may be issued without specifying any field names. In this case, the list of data fields originally defined in the CREATE TABLE statement in the left-to-right order will be used.

The second type of INSERT statement involves a retrieval of a number of records from the database and a subsequent insertion of retrieved records into an employ relation. Suppose that an empty table, TEMP (TRANS-NO, INV-NO), has been defined with a CREATE TABLE statement. The following INSERT statement will first retrieve the transaction number and the inventory number of all the transactions made by customer C1 and then insert the retrieved data into the empty table TEMP.

INSERT INTO TEMP

SELECT TRANS - NO, INV - NO

FROM TRANSACTION

WHERE CUST - NO = 'C1'

2) Delete

A record in a relation may be deleted with a DELETE command by specifying its unique primary key. For example, the following statement deletes a record with the TRANS-NO T1 from the TRANSACTION relation.

DELETE TRANSACTION

WHERE TRANS-NO - 'T1'

If a secondary key value is specified in the WHERE Clause, one or more records that satisfy the condtion will be deleted from the specified relation. For example :

DELETE TRANSACTION

WHERE CUST-ID = 'C1'

The DELETE statement will delete all those transactions made by customer C1.

3) UPDATE

The SQL UPDATE command is used to change the content of one or more existing records in the database. For exapmle, the unit price of an inventory item 13 can be increased by 2.00 as follows :

UPDATE INVENTORY

SET UNIT-PRICE = UNIT-PRICE + 2

WHERE INV-NO = '13'

After the expression is executed, the unit price of 13 in the INVENTORY relation is changed from 399.00 to 401.00. However, if the field to be updated is a primary key or a foreign key, updates of the field may cause data inconsistency if the corresponding field in its parent or child record is not simultaneously updated. Current relational systems provide no automatic procedures to enforce referential integrity. Thus, when a connection-field value is a relation is to be updated, the user will be responsible for updating the corresponding field in all its parent or child records. For example, if the inventory number, 13, in the INVENTORY relation is to be changed to 15, then records containing 13 in the TRANSACTION relation must all be updated to 15 :

```
UPDATE      INVENTORY
SET         INV-NO = '15'
WHERE       INV-NO = '13'
UPDATE      TRANSACTION
SET         INV-NO = '15'
WHERE       INV-NO = '13'
```

13.5 EMBEDDED SQL

In SYSTEM R, SQL/DS and DB2, the SQL statement can be issued interactively or embedded in a host programming language such as PL/1 or COBOL. This characteristic is generally not available in network or hierarchical database management systems.

The SQL statements embedded in an application program are first preprocessed by the DBMS, so that the SQL statements will be translated into CALL statements to invoke appropriate routines in the DBMS. An application embedded with SQL statements is first passed through a preprocessor and then through a normal compiler for converting host language statements into machine code.

One of the problems with embedding SQL retrieval statements in an application program is that the host procedural language is equipped to handle I/O only one record at a time. However, an SQL SELECT statement may retrieve multiple records from the database. To resolve such conflicting orientation in the code of I/O operations between SQL and the conventional pogramming language, some relational systems (e.g. SYSTEM R, SQL/DS and DB2) proved a cursor mechanism to fetch records one by one from a table retrieved by an SQL command.

13.6 SUMMARY

Structured Query Language (SQL) is a DML derived fom relational calculus. However, an SQL statement can be translated into equivalent relational algebric steps.

The basic consrtuct of an SQL retrieval statement involves a SELECT _ FROM-WHERE block with which object fields and a predicate for selection criteria are specified. An SQL statement may select one or more records at a time. Nested SELECT-FROM-WHERE blocks may be coded within an SQL expression.

Embedding SQL statements in a host programming language for batch processing is described. The I/O operation of a conventional host programming language is record oriented. while the execution of an SQL statement may retrieve an entire table. To accommodate such differences in the I/O processing mode, SYSTEM R,DB2 and SQL / DS all provide a cursor mechanism for application programs to process the table retrieved by an SQL statement one record at a time.

13.7 SELF - ASSESSMENT EXERCISES

1. In the specific context of your own organisation, name one programming language you would need in which SQL statement can be embedded. Similarly find one which is not important for being embedded.

2. Taking the example given in the inventory table, how would you use the UPDATE command to increase the price of each item by 20%

3. Why does a system, of its own accessed not automatically eliminatate duplicate responses when eliminate duplicate responses when executing a SELECT command ?

13.8 FURTHER READINGS

1. Atre S.. *Database Structural Techniques for Design, Performance & Management*, John Wiley & Sons, 1980.

2. Date C.J. *A Guide to DB2* Addison-Wesley. 1984

3. Date C.J *An Introduction to Database Systems,* Addison-Wesley, 1981

4. Hawry Stkiewycz I.T. *Database Analysis and Design,* SRA. 1984

5. Kroenke D.M. *Database Processing : Fundamentals, Design, Implementation* 2nd Edition, SRA, 1983.

UNIT 14 DBMS IMPLEMENTATION AND FUTURE TRENDS

Obejctives

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

- identify the factors causing resistance to the induction of new DBMS tools
- enumerate the advantages of a distributed processing environment
- identify the factors (both technical and administrative) which motivate the move to acquire a DBMS.

Structure

14.1 INTRODUCTION

Having covered the conceptual and theoretical framework for DBMS, this unit focuses attention on the practical aspects of the implementation. Computers in general, and data base systems in particular, have the usual feature that a lot is expected from them. It is often the expectation of the management that when these two are in place, all relevant information would be available "at the press of the button."

It must, however, note that the establishment of a data base management system in an organisation is part of a process of implementaion and radical change in the organisation. When computerisation is attempted to be introduced in an organisation, where hitherto manual systems have been availed, although there is resistance, it can be overcome on the grounds of efficiency and increased productivity. In the case of introduction of data base management system, the resistance comes from the erstwhile computing department itself, because it tends to diminish its role as the controller of greater information.

The recent developements on hardware and software have made distributed and departmental computing a reality, so that the whole EDP department would have to delegate many of its functions from which it used to derive a lot of importance or power. This unit, therefore, deals with issues which managers would have to cope with in successfully establishing a DBMS system.

Having decided to go in for a DBMS, the selection and acquistion still cause major problems. As some say, today, it is in many ways easier to cope with the technical problems associated with establishing a DBMS system. Some of these are covered in section 14.5 of this unit. But, more important and probably the most difficult to cope with is the problem of "human awareness". Since the DBMS approach itself is very new, the kind of management issues arising in relation to personnel involving in the establishment of management of DBMS is still not clear because of lack of sufficient experience and technical studies. In this unit, many of these issues and points are identified and raised, although it is not possible to give any unequivocal answers at the present moment.

14.2 ORGANISATIONAL RESISTANCE TO DBMS TOOLS

There are several points of resistance to new DBMS tools :

* Resistance to acquiring a new tool.
* Resistance to choosing to use a new tool.
* Resistance to learning how to use a new tool.
* Resistance to using a new tool.

The selection and acquisition of a DBMS and related tools is one of the most important computer-related decisions made in an organisation. It is also one of the most difficult. There are many system from which to choose and it is very difficult to obtain the necessary informaion to make a good decision. Vendors always have great things to say, convincing arguments for their systems, and often many satisfied customers. Published literature and software listing services are too cursory to provide sufficient information on which to base a decision. The more difficulty in gathering information and making the selection is one point of resistance to acquiring the new DBMS tools.

The initial cost may also be a barrier to acquisition. However, the subsequent investment in training poeple, developing applications, and entering and maintaining data will be many times more. Selection of an inadequate system can greatly increase these subsequent costs to the point where the initial acquisition cost becomes irrelevant.

In spite of the apparent resistance to acquisition, the projections by the crystal-gaters in the industry are forecasting a multi-billion dollar industry by the year 2000. Even though an organisation may acquire a DBMS, there are still several additional points of resistance to overcome.

Simply having a DBMS does not mean that it will be used. Several factors may contribute to the lack of use of new DBMS tools.

* Lack of familiarity with the tools and what it can do.
* System developers used to writing COBOL (or other language) programs prefer to build systems using the tools they already know.
* The pressure to get new application development projects completed dictates using established tools and techniques.
* Systems development personnel have not been thoroughly trained in the use of the new tool.
* The organisation has not set up a program to train users of new DBMS tools.
* Users are reluctant to use a new tool because there is no one in the organisation to provide advice in its us and to help when problems arise.
* Tool is only known to a few specialists in the data processing organisation.

* No one in the organisation is actively encouraging, even compelling the use of new DBMS tools.

* DP management is afraid of run away demand on the computing facilities if they allow users to directly access the data on the host computer using an easy to use, high-level retrieval facility.

* Organisational policies which do not demand appropriate justification for the tools chosen (or not chosen) for each system development project.

14.3 DATABASE IN A DISTRIBUTED PROCESSING ENVIRONMENT

Computer at multiple sites linked together through a communications facility provides the basis for distributed processing environment. Distributed processing is driven by two main technological factors :

* Lower hardware costs for computer processing and data storage.

* Moderately higher communications costs.

and three main organisational factors :

* More responsive to local user needs by offering faster access and greater autonomy or control.

* Greater reliability through reduced operational dependence on a single, central site for data processing and data storage.

* Increased sharing and coordination in the use of common resources.

Distributed processing is not a panacea for achieving these organisational goals and reducing costs. A distributed processing environment adds complexity to the data management porblem compared to a single site environment. In spite of the claims of some vendors of networks or distributed DBMS, substantial problems remain to achieve the full potential of distributed data processing.

A distributed processing environment is characterised by a network of multiple computing nodes connected with some communications facility. A node, like a single site computer, can perform some combination of the following functions : execute programs, respond to a user request, run a DBMS, or store data.

A communications facility is the collection of processes and physical facilities which interconnect the nodes. It includes knowledge of the physical location of each node, the physical connections or paths between the nodes, the protocols for sending data from it to one or more other nodes. A network access process (NAP) exists at every node and is the interface between processes at the node and the communications facility. The NAP is usually some combination of software and hardware. The hardware may consist of a standard input-output port on the computer or a special plug-in board to which a network cable is connected. The actual configuration or topology of the network and the communication protocol is secondary - the important point is that any node can communicate with any other node in the network.

14.4 EMERGING STANDARDS

Mention of standards often evokes strong feelings. For some it is what they feel should be the direction and content of a standard, for others it is despair at what is or is not happening in the standards arena. Nevertheless, standards are important to both users and developers of DBMS products. This section reviews the what and why of standards, the evolution and current status of activities in the development of database-related standards, and the direction, likely outcomes and consequences of these current activities.

Advantages and Inhibitors to the Development of Standards

The main purpose of standards is to foster interchangeability of products by defining standard interfaces and to foster the compatibility or coexistence of products by defining standard interchange formats. Interchangeability allows user to mix and match DBMS and related products. Transferability allows different products to be used together by enabling the transfer of data or other materials between them. Standards accomplish the following desirable goals :

* Guide manufacturers and vendors in the design and development of products. They encourage developers to build system with common interfaces.
* Open competition to more developers, particularly small ones, when they can build to a standard and when interchangeable parts are available from different vendors.
* Give conforming products an implicit stamp of approval
* Assist users in choosing from among competing products and result in fewer different products from which to choose.

Increase portability of software and applications across people, machines, and operating system environments.

Reduce the cost of training and increase the productivity of personnel who use the standard products.

All of the above assume that each standard is a "good" standard and is generally accepted. People, however, can disagree on what constitutes a "good" standard. The vendors of existing products will not want to see a standard go beyond or be different from the capabilities of their products. Users may feel that a standard does not go far enough to adequately meet their needs.

The major disadvantage of standards is that a premature standard can inhibit innovation in product development and incorporation of the latest technological advances. Other forces will also inhibit the adoption of standards. A vendor which dominates an industry or a particular type of product may delay or disrupt the standards development process, preferring to see their own position or product become a de facto standard.

The Development of Database - Related Standards

Standards typically follow industry developments, and are therefore strongly influenced by vested interests. A standardization effort begins with some concrete proposal which may be in the form of an operational system or language, or a detailed specification for a system or a language. Furthermore, any proposal should have reasonably wide industry willingness to at least entertain cooperative action toward developing a standard. Wide industry willingness may stem from cooperative industry development of a proposal or from widespread use of an existing system or language.

In 1970, Ted Codd, working for IBM, published a paper introducing the relational data model. That paper generated considerable interest, as evidenced in many subsequent papers of primarily theoretical and academic interest, and spawned several experimental system development projects.

From the perspective of the data structure the differences are few though not insignificant. The major difference being that the earlier network DDL permits nested repeating groups within a record whereas the relational data structure does not. Many people, including those favouring the earlier network approach, argue that good database design means flat files in third normal form (at least initially --including nested repeating groups of data items in records for implementation efficiency).

From the perspective of data manipulation the high-level language of the relational approach is clearly superior to the record-at-a-time-low-level languages.

Direction of Emerging Standards

The first database-related standard to come from ANSI was the Network Database Language. The major features of the proposed standard were :

1. Concepts, introducing the pieces, objects, and common elements of the language which is described in the rest of the document.
2. Schema Definition Language for declaring a network structured database and its integrity constratints.
3. Subschema Definition Language for declaring the user view of a database schema.
4. Data manipulation Language and module language for declaring the executable statements and database procedures for a specific database application.

Implementation of this standard can exist in an environment with :

* Application programming languages.
* End-user and natural language query facilities.
* Report generator and graphics output facilities.
* Data storage definition and device media control languages.
* Access control mechanisms.
* Database copy and reversion ("unload") facilities.
* Schema access facilities for ad hoc users and user-written application procedures.
* Schema manipulation language for revising a database definition.
* Database restructure and reorganization utilities to bring an existing database into conformance with a revised schema.
* Information resource data dictionaries.
* Tools for database design, database administration, and performance monitoring.
* Distributed database facilities in a Network DBMS.
* Interfaces to word processing, spread sheet, decision modelling, and statistical packages.

Development of a Reference Model for Database standards

The development of related but uncoordinated standard is cause for concern. There are several different areas within DBMS technology which are or could be the object of standards development.

* Data structure definition languages which are used to define database schemas and user schemas. Such languages are used in a DBMS, in programming languages, and in Data Dictionaries.

* Integrity control languages to define semantic constraints, validation criteria, access control etc.,

* Physical storage structures, access methods, and device/media control.

* Data manipulation languages which can appear in a host-language interface to a conventional programming language, a self-contained DBMS language, an ad hoc query language, or a report generation facility. Retrieval and manipulation languages are needed to operate on stored databases but also stored schemas, userschemas, and data dictionaries.

* Data mapping and conversion languages for use in database reorganization, restructure, creation, reversion, and schema-user schema translations.

The development and coordination of standards across all these areas is a massive undertaking. It can only be done in stages; some priorities must be set. A comprehensive data structure definition language seems to be the most important first step, since a given data structure is the object of retrieval, manipulation, and conversion. To bring some order to standards development, there have been attempts to define a reference model which includes the major modules of a database system. A reference model establishes a common framework or background for a class of systems such as DBMS to which people may refer when talking about specific products, product design and development, or standards. It serves as a tool for the development and coordination of standards by identifying major interfaces between component parts of the overall system.

A database system has four major types of interfaces :

* End-user who is concerned with getting some job done within the organization. End users interface with the various modules or functions of a database system to access database definitions and to retrieve and manipulate stored data, both in writing procedures for deferred execution and in ad hoc, interactive use.

* Administrative support staff concerned with the design, development, installation, maintenance, and evaluation of database system products, and the training of end users. The database administrator needs to create and revise database definitions, to establish integrity controls, and to monitor performance.

* External interfaces to other computer system components (non-DBMS) such as the operating system and the network access process.

* Internal interfaces between functional parts or modules of the database system.

14.5 DBMS SELECTION AND ACQUISITION

Movement towards the database approach to data processing is not every organisation now. Discerning the right time requires an assessment of organisational need, capacity, and readiness.

Several factors may motivate the move the acquire a DBMS

* The need for more comprehensive data storage and retrieval capabilities
* Faster response to ad hoc queries
* Faster application development
* Reduced data redundancy
* Transferability across hardware
* Reduced program maintenance
* Increased ability to respond to changing requirements

* More consistent data values
* Increased security
* Better audit facilities.
* More realiable backup and recovery
* Reduced operating costs.

Whatever the reasons, they should be clearly documented. This serves to set priorities on the objectives and provides the basis for making trade offs among conflicting objectives and in the selection of various DBMS features.

Selecction criteria are broken down into technical criteria and administrative criteria. Technical selection criteria relate to the functional capabilities. of the DBMS product. Administrative selection criteria include efficiency, ease of use, documentation, acquisition and operating costs, compatibility with the existing organisation and data processing facilities, and characteristics of the vendor.

The most important technical criteria concern the basic type of system required and the set of functional capabilities needed to serve the user community.

Recognising that any statement of selection criteria must be tailored to the needs of the organisation, certain technical criteria are often overlooked. This book gives a comprehensive picture of the functions of database management.

The major categories of technical criteria for selecting a DBMS are as follows :

MAJOR TECHNICAL CRITERIA

1. Database definition, including logical structure and physical stoage structure
2. Generalized retrieval capability - asking questions and getting answers
3. Generalized Updata capability - to add, delete, and modify the data in the database
4. Programmer interface.
5. Maintenance of Database Integrity
6. Modes of operation-online and/or batch, for above functions
7. Database revision and evolvability

The outline of features in these categories provides a starting point for an organisation to begin an evaluation and selection process.

Selection criteria not relating to functional capabilities are considered administrative criteria. These include the required configuration of hardware and software, operational and performance characteristics, vendor support, documentation, required staff support, and cost. While some technical capabilities (or lack of) have administrative implications, it is desirable not to confuse the technical criteria for evaluation with administrative considerations.

Aside from the sytem itself, the next most important, consideration is the vendor (or developer). Are the people genuinely excited about their product ? That is the most important question to ask. Visit their location, mingle with the people in sales and in development, and look into their eyes as they speak of working for this vendor. Are they proud to be on the team ? Are they enthusiastic about the future of this vendor and this product ? Whether or not it's possible to get that close, a prospective buyer should try to get a feel of these questions about the vendor.

The following lists direct attention to various areas which may be important in evaluating the administrative aspects of a candidate system.

MAJOR ADMINISTRATIVE CRITERIA

* Vendor Characteristics and Product Stability-history, size, financial strength, years since product introduced record of enhancements, and number of users.

* Maintenance support - written agreement and are other users satisfied, responsiveness to user problems.

* Documentation and Training - readable, updated with changes, training classes and materials available at reasonable cost.

* Ease of Learning and Use-understandable system architecture, user-freindly interface, and online help facilities.

* Operating and Performance Characteristics - it actually works, and will handle the sized and throughputs required.

* Supporting Environment : Hardware, Software, and Administrative Staff-the system will "fit" into the organisation and the existing (or upgraded) hardware and software environment.

* Costs - direct acquisition or lease plus changes to existing hardware configuration, installation, training and documentation.

14.6 SUMMARY

We have pointed out in this unit that there are resistance to new DBMS tools. In spite of the apparent resistance, many more organisations are moving in towards the use of DBMS. It is also quite clear that organisations will have to move towards DBMS, especially those based on relational approach in order to maintain their competitive position in the emerging market places.

The availability of many more products as well as the appearance of many more features in these products causes a greater responsibility on the managers responsible for the implementation to adopt an approach which would lead to successfully meeting the information needs of the organisation.

It has been emphasised in this unit that apart from identifying the technically right approach and to provide the system on which it could run, other administrative factors must also be borne in mind, so that the new systems actually fit well into the organisation. This unit also briefly refers to the trends in the products and the emerging standards because while putting up a DBMS system, it must be realised that it will have to cope with the information needs of the organisation not only as they stand today, but also for sometime into the future. It has been usually observed that once computerisation is successfully maintained in any organisation, the needs of that organisation for data management grow exponentially in volume. It is, therefore, of paramount importance that the management takes a vision which is somewhat larger than just the needs of the moment, keeping in mind the future trends and emerging standards.

14.7 SELF ASSESSMENT EXERCISE

1. Identify the most important factors inhibiting an organization's move towards a DBMS.
2. Outline the basic sequence of steps to acquiring a DBMS. What steps are the most important ?
3. Describe the problems which may arise if the DBMS evaluation team consists entirely of persons from Systems and Programming in the Data Processing Department.
4. Identify and briefly describe some of the terms which should normally be included in a software acquisition contract.
5. Why should an organization be careful about placing over reliance on "benchmark" tests in selecting a DBMS ?
6. What are the advantages and shortcomings of obtaining information about a candidate system from each of these sources : vendors, current users, demonstration, introductory course, trial use, benchmark, listing services ?

14.8 FURTHER READINGS

1. Atre S. *Database Structural Techniques for Design, Performance & Management,* John Wiley & Sons, 1980
2. Date C.J. *An Introduction to Database Systems,* Addison-Wesley, 1981
3. Kroenke D.M. *Database Processing : Fundamentals, Design, Implementation* 2nd Edition, SRA, 1983
4. Everest, G.C., *Database Management : Objectives System functions & Administration,* McGraw Hill, 1986.
5. Ven Halle Fleming, *Handbook of Relational Database Design,* Wesley 1990