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.

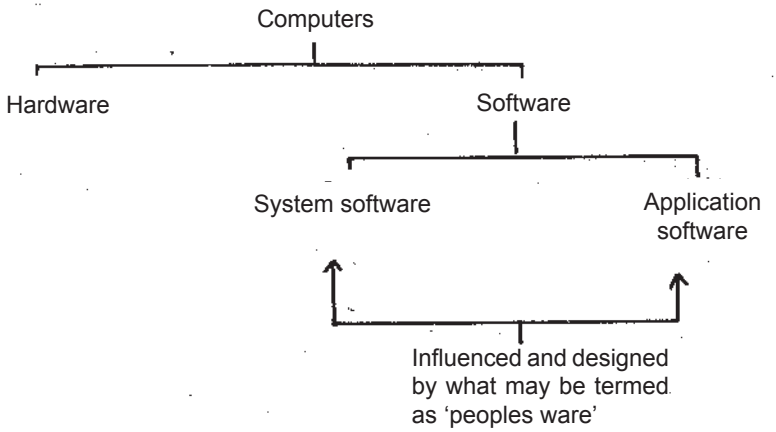

Figure 8.1.: Parts of a Computer

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 are 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.

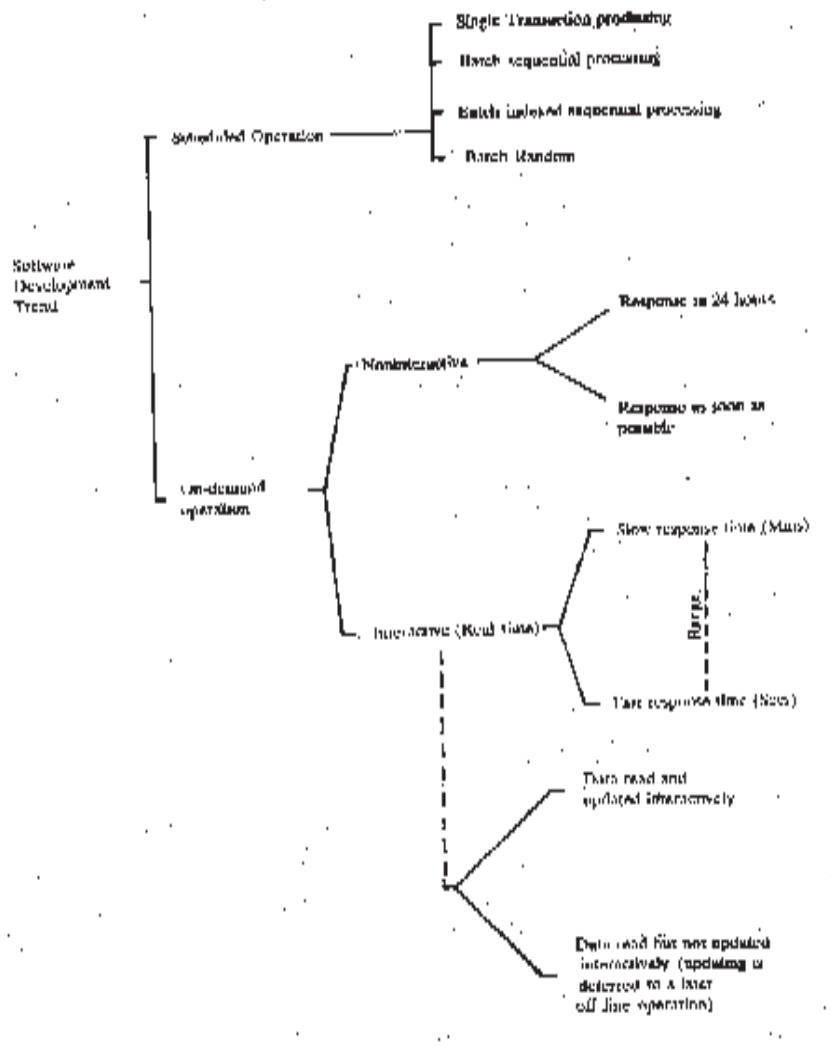

Figure 8.2: Development of Software Systems

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.

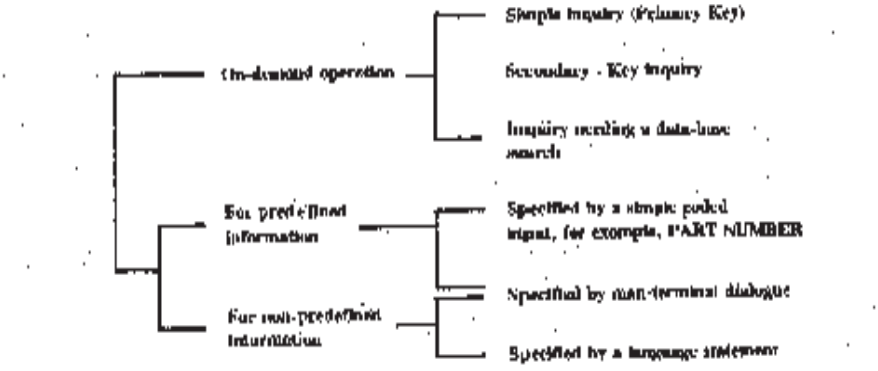

Figure 8.3: Categories of Database Usage

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 primarly 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.