ST / TCD / SER.E / 28

Government Information Systems

A GUIDE TO EFFECTIVE USE OF INFORMATION TECHNOLOGY IN THE PUBLIC SECTOR OF DEVELOPING COUNTRIES

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Division of Public Administration and Development Management
Department for Development Support and Management Services
United Nations
New York 1995

NOTE

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PREFACE

Inexpensive and powerful microcomputers, telecommunications technologies, and information systems have become an essential element of the development process of developing countries. Information systems for governance and public administration, as one of the most important aspects of computer applications in developing countries, have been a high priority concern in almost all developing countries. Governance and public administration can not be productive, effective and efficient without the support of modern information technology. The use of information technology has been an absolute requirement for public administration and management development. The Governance and Public Administration Branch, Division of Public Administration and Development Management of UN/DDSMS has been continuously and increasingly under pressure from developing countries to provide advisory services and technical assistance in this important area.

In practice, however, effective use of information technology and successful development of information systems in public sector are not easy. This is evidenced by the numerous government computerization and information systems projects which have failed, not only in developing countries but also in developed world. The tremendous speed with which information technology is evolving causes confusion, delays, and false expectations for these solutions by many decision makers and government officers. Misconceptions about the capabilities and limitations of this new technology, inappropriate development strategies, ambiguous development priorities, inadequate resource planning, incomplete cost estimates, misjudged user needs, selection of wrong products, etc. often cause information projects to fail.

The main difficulties hampering the success, in principle, are on the management side rather than the technical side. Understanding what is government information system and how to develop it successfully is vital to government decision makers and senior managers responsible for this critical area. The critical issues include: appreciation and understanding of the advanced state of the art of information technology; awareness of the trends of modern information technologies and their impacts on development strategies of developing countries; knowledge on the roles of government policy in stimulating effective use of information technology; and cognizance of the management issues of government information infrastructure and information systems building.

The General Assembly has recognized the importance of the role of information technology in promoting an effective, productive and efficient public administration. A special area, i.e., Integrated Management Information Systems, has been designated in Programme 21: Public

Administration and Finance[1], to assist developing countries in stimulating effective use of information technology in the public sector. In response to the resolution of the General Assembly, studies on the related issues were conducted under the Public Administration and Finance Programme during the Biennium 1994-1995.

This publication, as the outcome of the studies, lays stress on the practices of government information systems and intends to provide a constructive guide to government decision makers and information systems managers of developing countries to assist them in putting the establishment of government information systems on a right track and in effectively using their scarce resources of computer and communications.

Information contained in this work is quite comprehensive and covers a wide range of selected subject areas in the practice of government information systems. These materials can certainly help the readers to establish a solid foundation of up-to-date information upon which to make improved decisions.

This publication is intended for the readers in developing countries and the countries in transition to a market economy, such as government decision-makers, information systems managers and developers, program/project leaders, and senior government officers interested in the areas of information technology. The strategies, methods, and suggestions will not fit all the governments of developing countries. Developing countries at different stages of information systems development and facing different problems require different solutions to the problems. But many of the problems, strategies, and methods presented in this publication are common and can be applied extensively. The readers can pick and choose from this collection of ideas and tools to solve specific problems in his or her own environment.

Following is a brief overview of each chapter.

PART I: MANAGERIAL ISSUES

Chapter 1: Introduction. This chapter gives the basic concepts of information technology (IT) and the evolution of IT use in public sector. The roles of governments in stimulating the use of IT are examined and experiences and lessons of IT use in both developed and developing countries are discussed. The opportunities and challenges that developing countries are facing are reviewed as well.

Chapter 2: Government Policy for IT Use in Public Sector. The crucial role of government policies in stimulating effective IT use is discussed. The main issues to be addressed

[1] refer to: "2 - Public Administration and Development Management, Section 10 - Department for Development Support and Management Services", Volume I, Proposed Programme Budget for the Biennium 1994-1995, General Assembly, Official Records, Forty-Eighth Session, Supplement No.6 (A/48/6/Rev.1), the United Nations, New York, 1994.

are government policies for information infrastructure building, for information systems development, and for public data/information.

Chapter 3: IT Management Issues in the Public Sector. Issues that must be addressed by top management of governments are introduced in this chapter. The importance of strategic systems planning of a government and its main aspects are addressed. In a rapidly changing technological environment, the strategic principles that developing countries should follow for successful information systems development are suggested. Methodologies of information systems development are introduced for the understanding of government decision makers. The significance of standardization of government information systems are stressed. Laws and regulations related to smooth development of government information systems are presented.

Chapter 4: Critical Success Factors. Four points that are widely recognized as the critical success factors of government information systems are introduced in this chapter. The role of top management and the user in information systems development are discussed. Improving communications between information officers and top management, and establishing effective user relations are discussed in detail for information systems managers and developers. Making appropriate institutional arrangements is another key to successful systems development and effective utilization of government resources. Suggestions on this critical factor are provided. The main concerns for the formulation of an open, cooperative government information systems architecture are also presented.

PART II: INFORMATION TECHNOLOGY AWARENESS

Chapter 5: Developments in Computer Technology. This chapter provides the basic information on the development of computer technology, including the evolution of microprocessor technology, the state of the art in microcomputers, a brief introduction to minicomputers, mainframes and the trend of downsizing, optical storage technology, such as CD-ROM, and multimedia technology.

Chapter 6: Developments in Software Technology for Microcomputers. This chapter reviews the development of software technology in terms of PC-based computing. The state of the art of microcomputer operating systems are examined. The evolution of programming languages, in particular, object-oriented technology, is briefed. The progress of applications software, such as word processors, spreadsheet, data base management systems, integrated software packages, etc., are presented. Attention is also given to workgroup computing and groupware - the new generation of software technology.

Chapter 7: Network Computing. As one of the main trends of computer and communications technology, the benefits of network computing are discussed in this chapter. The topologies of Local Area Networks (LANs) and three major standard LANs are familiarized. Client/Server technology is presented. The current status of network operating systems is given. The recent development of wireless LAN is briefed. Finally, internetworking and Wide Area

Network are discussed.

PART III: METHODOLOGIES OF SYSTEMS DEVELOPMENT

Chapter 8: Reengineering and Business Process Redesign. This chapter presents the ideas of making full use of the real power of information technology - reengineering, which enables government agencies to break old rules and outdated assumptions and create new ways of doing the job. The changes of rules brought by modern information technology are discussed. And, a methodology for Business Process Redesign is given for reader's reference.

Chapter 9: Methodology of Structured Information Systems Development. This chapter gives a brief introduction to the methodology of structured information systems development, which is one of the important techniques of information systems engineering and is very useful for information systems managers and developers. Computer-aided software engineering (CASE) technology, as an automation tool of systems development and maintenance, is also briefed in this chapter. The key issues in information systems project management are also discussed.

PART IV: INFORMATION RESOURCE MANAGEMENT

Chapter 10: Information Resource Management. This chapter presents the concept of information assets and discusses several aspects of information resource management: data availability and collection, including data pollution and quality control; the management of data actions in information systems operation and maintenance; the management of hardware and software, including management strategies, anti-virus and vendor policy; and the security of data/information.

Chapter 11: Introduction to the Internet. A brief introduction on what is the Internet and how to Join the Internet is given in this chapter. Popular applications of the Internet, such as electronic mail, mailing lists and newsgroups, File Transfer Protocol (FTP), Telnet, and information servers are described as well.

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C O N T E N T S

PART I:

MANAGERIAL ISSUES

CHAPTER 1

INTRODUCTION

1.1 What Is Information Technology?

001. In general, information technology means all the technologies associated with gathering, processing, storing, and dissemination of information. However, with the lapse of time and the progress of technologies, the term information technology is given different connotation. The modern term Information Technology (IT) acquired widespread use only beginning in the late 1970s and is now used generally to embrace both computer and communications technology and all the related software.

The first functioning electronic digital computer, ENIAC, was built in 1946 in the United States. The old electron-tube mainframe computers filled large rooms, weighed many tons, and generated vast quantities of heat. Thereafter, the decades from the 1950s to 1970s are deemed as the ones for organizational mainframe and mini-computers. The rapid development of microprocessor in 1980s brought a major acceleration of downsizing: replacement of traditional mainframe and minicomputers with micro-based alternatives. Computers of equal or greater power now sit comfortably on the tops of desks or laps. This trend also drives users to low-cost solutions based on Pcs, LANs (Local Area Networks), network servers, and multiple microprocessor-based systems. The 1980s marks the end of the first (traditional) era of computer systems and the beginning of the second (micro-based). Comparing with other technologies of this century, computer technology has experienced the fastest development in the past fifty years, and, has significantly changed the life of human-being and made great contributions to economic and social development of the world. Nevertheless, many people still believe that a real microcomputer revolution is just beginning.

Until about a decade ago, computer and telecommunication technologies were still regarded as quite distinct. However, powerful technology changes in microelectronics, software, optics and increasing integration of telecommunications with computer technologies have made this distinction increasingly less meaningful. Micro-electronics technology has been the common basis both for rapid development and convergence of computer and telecommunications technologies. The shift from analog to digital technologies in telecommunications has led to switching and transmission systems increasingly resembling computers and embedding increasing amount of software. Many communications facilities are now more or less like computers with special uses. On the other hand, with the development of networking technology, communications between computers have expanded tremendously since the early 1960s when on-line computer systems were first developed. Together, these developments have blurred the traditional distinctions between telecommunications and computers technologies and given rise to the contemporary definition of information technology.

002. The quick advance of microcomputers and the demands for communications between microcomputers have greatly stimulated the development of network computing and computer communications systems. LAN technology was developed in the second half of the 1980s. Internetworking of LANs has been leading to the speedy development of Wide Area Networks (WANs) technology during 1980s and early 1990s. Global internetworking and the information superhighway have now put on the agenda and will further promote the development of global computer communications systems. It is obvious that network computing and computer communication systems have become the main trends of both computer and communications technologies.

1.2 Evolution of the Use of IT in Public Sector

003. The use of information technology in the public sector has been developed in two dimensions: office automation and information systems. The first dimension (i.e., office automation) aspires to raise efficiency and productivity of office business; while the second aims at organizing and utilizing information to support administration and management, as well as policy development and decision making, so as to improve effectiveness, efficiency, and productivity of an organization as a whole.

Office automation consists mainly of three components: word/text processing, data processing and calculation, and communication. Word/text processing technology includes word processors, electronic editors, xerox machines, scanners, printers, plotters, project panels, and desk-top publishing. Capture devices (OMR, OCR, digitizer) and mass storage support (magnetic, optical: CD-ROM, WORM, CD-R/W) are designed for accelerating data input and storage. Data base and spreadsheet software are used for data processing and calculation issues in an office environment. Multi-function telephones, facsimile machines, electronic mail, electronic conference, etc., are the tools provided by information technology to improve communications between offices. In addition to the three aspects, some other applications of computer software, such as presentation, graphics, and various business software, are also extensively used to raise the efficiency and productivity of office business.

An information system is a mechanism used for acquiring, filing, storing, and retrieving an organized body of knowledge. Generally speaking, an information system is composed of computing hardware, software, and communication facilities. These are tangible portions of an information system. The intangible portion of an information system, which is very crucial and usually neglected, is the organizational issues of an information system. User requirements analysis, data capturing and cleaning, data maintenance and updating, information dissemination and utilization, etc., all need to be well planned and organized. Any information system, no matter how advanced its hardware and software are, can not possibly be successful unless management and organizational issues are a top concern.

004. The integration of the microcomputer and other electronic office facilities is becoming one of the main trends of office automation. A typical example is the first wave of smart officewares shown on the market. The software allows standalone computers to send and receive messages, including binary or editable files or standard facsimiles, using a mail-enabled application and a fax modem. Uniting computers and telephones into one logical unit is another example. In its simplest form, call control lets user's computer control telephone functions. Software and a user-friendly interface simplify calls, transfers, and conference calling. Auto-dialling for single-party and multiparty calls can be integrated with information databases or organization's directories to support custom applications. Moving to unified massaging is another trend of microcomputers being used in office automation. The day when an end user can retrieve voice mail, electronic mail and facsimile messages using a telephone or personal computer will arrive soon.

It is obvious that office automation and information systems will be finally integrated in comprehensive information systems and will be working together for pursuing high efficiency, quality and productivity.

005. Computers were originally designed for the purpose of scientific calculations. Computers, however, are now commonplace in schools, offices, and homes and are used to store and retrieve enormous quantities of information for an incredible variety of purposes. The use of computers and communications facilities has experienced fundamental changes over the past fifty tears.

At the early stages of computer applications, computing power was largely concentrated in data processing (DP), such as the first computer payroll system, deployed in 1954. The applications development was then directed towards support of management and decision-making of organizations, i.e., so-called management information systems (MIS) and decision-making support systems (DSS). Before 1980s, people had been making efforts on computerizing their business processes, i.e, using computers to automate or aid business activities as much as possible.

With the rapid development of information technology, particularly distributed processing and network computing, the concept of IT use in public sector has been changed dramatically. It has been found that information technology often enables completely new ways of doing the job, and sometimes it is the essential factor in completely transforming a business process. The focus of IT use, therefore, has shifted from the acquisition and implementation of computer equipment and systems to ensuring their optimal exploitation by means of adjustments to procedures, organization and staff utilization. Accordingly, a shift in emphasis has taken place from efficiency and productivity gains by automating routine tasks, to achievement of effectiveness expressed in terms of applying new solutions to traditional tasks and providing solutions to new tasks. The applications development of computers in organizations has been redirected from computerizing existing business processes of organizations to redesigning business processes and/or reengineering organizations so as to take full advantage of and best benefit from information technology. Many government agencies and enterprises in developed countries are quickly restructuring their organizations to make them computer friendly and implementing more appropriate procedures compatible with an IT environment. In the process, they are eliminating layers of traditional management, compressing job categories, creating work teams, training employees in multilevel skills, shortening and simplifying various business processes, and streamlining administration. The results have been impressive.

1.3 The Roles of Governments in the Use of IT

006. *Largest user of information technology*. Governments exist to serve their citizens. Their primary activity is record-keeping. The public administration process is, to a large extent, virtually a process of data/information processing. Government authorities collect and process various data and information - on individuals, families, organizations, and companies, and then on the basis of these data and information, produce new information for the public, such as, policies, strategies, plans, regulations, and various services to the public. Essentially, information technology is used to support information processing of governments, including data gathering, storing, processing, dissemination and utilization.

In general, government is the single largest user of information technology in many countries. In many developing countries, the government is the predominant consumer of information technology products. Many of the IT use are well-known - taxation, customs, and financial management, statistics and census data gathering, elections, development planning, health, education and welfare, social security, land management and agriculture, and so forth. Other areas are police, national security and defense, and research, etc.

Using the revolution in computer and communications systems, many governments have found that they can provide better service. For example, an integrated revenue management information system will improve tax data available to collection employees in the field; revenue officers will be able to receive cases more quickly and depose of them sooner. A system using distributed computing architecture to automate and modernize tax collection process will enable the treasury department to collect tax more efficiently, which is, of course, a benefit to all government agencies.

It can be said that governance and public administration can not be productive, effective and efficient without the support of modern information technology. The use of information technology has been an absolute requirement for public administration and management development.

007. *Biggest owner of public information.* Government is, to some extent, the biggest public information owner and distributes vast amounts of information used by all segments of the public. In many developing countries, it is often the only producer of relevant economic and social information. Making information accessible to the public has become an important part of service to the citizen. Information resources managers within government agencies are the key participants in general civil service. Experience among industrial and newly industrializing countries show that public policies which enable efficient private access to public data are a key ingredient to achieving competitiveness.

Moving information elements efficiently is one of the major challenges in modern computing. It is also one of the primary impediments to making even greater use of communications and computer capabilities in the public sector. Before and after text, data, graphs, images, or voices are manipulated, they must be moved many times. They must be captured, stored in and retrieved from memory, displayed on screens, copied, and sent to remote sites.

At a fundamental level, information technology is changing or even eliminating many distinctions between reports, publications, databases, records, and the like. Information technology now permits information dissemination on a decentralized basis that is cost-effective at low-levels of demand. Many types of information such as technical, statistical, scientific, and reference may best be stored and disseminated by electronic means. For example, national census statistical reports could be made available on optical disks. Electronic and network distribution of government documents and increasing public access to government data are being developed very fast in industrial countries, such as information systems that let users search, locate, view and download government reports, studies, computer software, data files and databases, and CD-ROMs, with information being updated regularly. There is no doubt that effective use of information technology can make governments work better while costing less.

008. There are, therefore, at least three reasons why effective use of information technology in public sector is crucial to reach objectives of economic and social development of developing countries. First, given the economic importance of the public sector in any developing country, productivity increases in public sector would entail significant gains for the economy as a whole. The public sector accounts for a large percent of total employment, final consumption expenditure, and gross domestic fixed capital formation. Second, the public sector usually is the biggest and most wide-ranging collector of public data and information. These data span economic and social activities to natural and geographic resources. Third, in an increasingly information-intensive global economy, well-functioning government information systems can facilitate access to global knowledge and international databases and the creation of new options for mobilizing and using local knowledge and information resources.

009. *Stimulation of IT use*. Clearly, government is more than simply a user of information technology. Each government has to chart policies and strategies to exploit its information resources, to develop its information infrastructure, and to promote the utilization of information systems for the purposes of achieving more effective growth of public services. Failure to initiate effective and timely action will have serious ramifications for the ability of a government to stimulate effective social and economic development of the country.

The development of information infrastructure, information resources, and information systems has to be planned and managed. This is true of any organization, not just national, local and municipal government establishment. The planning and management of these vast information resources are developing into a strategic sector in the economies of many countries. In some developing countries, planning and management of information resources are either in their infancy or in a state of disarray. Lack of tradition and experience in planning and management of information resources can have a catastrophic impact on the whole process of social and economic development.

In all countries the leadership role of governments is increasing the promotion, enhancement and proliferation of information technology industries, information services industries, and information systems development. In many developing countries, the government is the only existing option for promoting these vital industries and systems. Failure of government to exercise its leadership mandate could be disastrous for these sectors.

In some developing countries, the government is the primary supporter and stimulator of basic and applied research in information systems and technologies. In other developing countries, basic research in technology and systems is virtually non-existent. It can be stated generally that the absence of efforts in applied research is seriously hampering the ability of these countries to benefit from the rapid change in information technology and systems that are taking place.

In this context, governments can provide strategies and policies pertinent to management of the development and operation of national information infrastructure, information systems, and information resource. They can establish methodologies for information systems development and standardize and coordinate relevant reserves. They can efficiently plan, integrate and develop the manpower resources needed for their information infrastructure and systems. They can also establish procurement rules and methods, and set the tone for emerging legal and regulatory issues. In addition, popularizing computer literature in schools is an important long-term strategy as well.

1.4 Three Levels of Government Information Systems

010. Government, like many other organizations, can be viewed as a three-level entity: (i) strategic, (ii) managerial or administrative (tactical), and (iii) operational. Each level represents a different level of control and has a different level of data requirement and extensive view of the government.

The strategic level is the highest level either in a government organization or a government as a whole. This level is responsible for the sector's or entire government's policy and direction; it is primarily oriented toward functions rather than toward processes and tasks. Strategic data are highly concentrated and usually contain little detail. In many case data at this level may be limited to critical success factors (i.e., key numbers or graphs which indicate the basic situation and represent the trends). Strategic data are a mix of internally generated and externally obtained information.

The managerial or administrative level controls and organizes the actions of an organization. It also performs the supervisory activities aimed at ensuring correct input processing and monitors processing rates and quality. The managerial level is responsible for the tactical implementation of the policies and directions received from the strategic level. It is oriented toward functions and processes. Managerial data are more fluid and limited than those of the operational level; the people at that level are more dependent upon information than data. Managerial and administrative data are almost solely derived from internal sources, and they reflect the operating status of the management conducted by the organization. The data provides day-to-day monitoring of operations and may be used at either the summary or the detail level. In most case, data at this level are extracted from operational reports. Managerial data needs are not as immediate as those of the operational level.

The operational level is data and processing-oriented. Its inputs are specific and derived from current data events. It is the operational level which is the predominant recipient of data in the organization. The operational units and their related managerial overseer are fixed in focus; their horizons are limited to their own specific activities. The operational level is primarily oriented toward processing and task, rather than toward functions.

These operational areas are usually the first to be systematized and the first to be computerized. Their activities are particularly suited to proceduralization and systemization, and they are already subject to high degrees of standardization and normalization.

Corresponding to the three levels of government organizations, government information systems also can be divided into three different categories: (i) operational systems, (ii) management information systems, and (iii) decision-making support systems.

011. *Operational Systems*. Operational systems are the systems which support the people at the operational level. They are characterized as being transaction-based, cyclically processed, usually batch-oriented, and usually operating in a current time frame. That is, the transactions are accumulated and processed on a periodic basis. The files created from those transactions represent the accumulation period and are designed for expediency of processing rather than for the production of information. Operational systems are built on a function by function basis or functional collection-by-functional collection basis, and each systems-supported function is traditionally called an application.

Typical operational systems in a government are statistical data processing systems in public sectors, accounting system, payment processing system, revenue system, customs system, and the like.

012. *Management Information Systems*. Systems at this level are developed on a client-specific basis and are used to facilitate and control the day-to-day business of the organization. These systems are customized to the needs of the user client and are usually under the control of the user.

Management information systems are broader-based and more horizontal in nature, and they usually arise from the operational files of the ministry. There are applications within the management information systems, but they are reportive rather than processing in nature. Existing data are arranged and ordered to provide the control, coordination, and planning functions with views of the business.

Examples for management information systems in a government are financial management information systems, personnel management information systems, external finance management information systems, programmes/projects management information systems, civil registration systems, enterprises registration systems, motor vehicle registration systems, passport management systems, patents management information systems, land management information systems, police information systems, judicial information systems, information systems for national defense and security, and information systems for various public sectors.

013. *Decision-making Support Systems*. Emphasis in the use of decision support systems is on providing support to decision makers in terms of increasing the effectiveness of the decision-making efforts. Generally, decision support systems are used for strategic and sometimes tactical situations. The primary components of a decision support system are a data base management system, a model-base management system, and a dialogue generation and management system. Obviously, decision support systems usually are built based on operational systems and management information systems existing within the organizations.

These systems are retrospective in that they are concerned with the past, and projective in nature in that they project future trends from past events. The data in decision support systems tends to be less precise and more statistically oriented. That is, they tend to look at the whole situation rather than individual events.

Examples of decision support systems in a government are national, sectoral, and urban/regional planning information systems, natural resources information systems, laws and regulations information systems, scientific and technological information systems, social and economic information systems, demography information systems, manpower information systems, executive information systems, and so forth. Artificial intelligence and expert systems have been developed rapidly as tools to support decision-making.

There are two special types of information systems which have great potential in public administration and are worth mentioning here: documents management and retrieval systems

(DMRSs) and geographic information systems (GISs).

014. *Document management and retrieval systems (DMRSs)* are being groomed as the preeminent workhorse application for manipulating data across the government, and to support text, image, audio and video data in real-time fashion, providing users with much more flexibility than data base applications to organize and view critical data. What chiefly distinguishes DMRSs from DBMSs (data base management systems) is their ability to manage semi-structured or unstructured information, such as the running text in a word processing file or the bit-mapped patterns in a faxed or scanned drawing. In other words, DMRSs have the potential to manage the vast majority of information handled by any organization. DBMSs, in contrast, work principally with character text that has been broken down into rigidly defined fields and records.

Today, there are three general types of DMRS products available on the market: text indexing and retrieval packages, document image processing software, and compound document management products. However, no single product to date has combined these three functions into an integrated DMRS. The core and historical root of DMRS is the text indexing and retrieval systems, which were developed in the mid-1960s to support bibliographic research by legal assistants. Text indexing and retrieval technology migrated to microcomputer and local area network platforms in the 1980s, making it easier to use. Full-text indexing, key-word searching, profile queries and other capabilities became standard features of commercial word processors and other applications that allow users to originate and manage predominantly textual information. Two fundamental limitations of application-bound text retrieval systems are currently being addressed: the ability to read, index and import different file formats, and sophisticated indexing and query capabilities of DMRSs. Given that document management is a big issue within any government, the development and application of DMRSs ought to be addressed. Experts believe that DBMSs and DMRSs will merge during the next five to ten years as object-relational DBMSs become popular.

015. *Geographic information systems (GISs)* originated in the mid 1960s. The origins of GIS and remote sensing started at a similar point in time. However, the growth of remote sensing in 1960s and 1970s vastly outpaced the growth in GIS. GIS was virtually unknown until early 1980s and often seen as add-on to remote sensing systems - for providing geographic information only. However, people soon found out that GISs were tools that can be used for the purpose of combining spatial data obtained from different sources and relating to different subjects. The power of GIS comes from its ability to look at entities in their geographic context and examine relationships between entities. GIS offers the possibility of visualizing events at a much more spatially detailed level. Thus a GIS database is much more than a collection of objects and attributes. It has long been understood that visualization - e.g. maps, graphs, charts and illustrations - helps the human mind to assimilate and understand information. In addition, GIS let users make decisions based on correct spatial context. The rapid development of microcomputer and software technologies have greatly benefitted the proliferation and popularization of GISs.

GISs are increasingly being employed within public administration for purposes other than those involving traditional surveying and property management. Their applications are becoming more common in sectors such as environmental impact assessment, land management, natural resource management, urban/regional planning, civil registration, population census and demography, optimization of transportation, etc., mainly as tools of planning and decision support systems for public administration and management.

Although GIS represents a powerful tool, until the local computer community can support this type of sophisticated application, it will be difficult for developing countries to use GIS because it is technology-intensive. Government agencies which have a critical need should also be aware that GIS is a data-intensive approach to planning, and if local planning data are of poor quality or nonexistent, GIS does not represent a good use of an agency's computer, and human or financial resources. Prior to installing a complex GIS application, a government agency should develop an overall plan for an information system, computer application, and data support, even possibly gaining management and end-user experience with simple application.

1.5 Experiences and Lessons of IT Use in Governments

016. The use of information technology in the public sector, in particular, computerization and the establishment of government information systems, is not simply an issue of buying computers, communications facilities and software, and delivering them to the users. This is evidenced by the numerous governments computerization and information systems projects which have failed worldwide. Developing countries which seek to emulate successes of information systems development in many industrial countries also have to examine over thirty years of experience for the numerous pitfalls in public sector computerization and in use of IT. Visions of almost effortless leapfrogging in developing countries of several stages of public use of IT need to be tempered by a careful assessment of human resources and infrastructural (notably telecommunications) constraints, among other factors.

An effective approach of information technology use in governments must be based on the overall objectives of civil service management, such as great effectiveness, efficiency and productivity, which require some basic principles to be observed. *Result-orientation* of IT use must be ensured by integrating it with general policies of the government for modernization and improvement of efficiency, including adequate measuring of performance and results. *Demand-driven incentives* should prevail instead of technology-driven. The best technology is the one which can best meet the needs of the users rather than the most advanced ones. *Management awareness and appreciation of IT* and attention to IT efforts must be substantially raised. Without the understanding and support of top management of government agencies, any computerization and information systems development projects of the agency can hardly succeed. *Human resources development*, in terms of both technical professionals of IT and end-users, is the key for any information systems projects to succeed and must be strengthened.

017. Political leadership is especially important for cross-ministerial or cross-departmental IT projects. It is common experience that most computer systems acquired by civil service are intended to serve objectives of individual government departments or public agencies. Incentives

for successful implementation of these systems are usually driven by the ambitions of these departments or agencies. Cases where cross-ministerial systems have been successfully acquired and implemented when government has given them priority at the expense of individual departmental systems are very rare. Civil service has usually given low priority to inter-ministerial IT projects, except in cases of very strong political leadership or in case of consensus about the necessity of the project among departments involved. Illustrative of such difficulties are failed attempts in most countries to establish a unified land registration system. The general lesson to be learned from this apparent reluctance of civil service to accept and support new systems without specific departmental "ownership" is that IT projects are feasible only when clear objectives and proper incentives for their application are given.

An important example of the need for high-level coordination is in the case of large databases on companies, individuals, and geographic resources such as for social security, health care and taxation. Important basic criteria for success of such systems has been the elaboration and efficient maintenance of civil registration systems, company registers, and registers on land and houses. Ideally, such registers should be unique and simple in the sense of holding only data common to all institutions using them. Each item in a register should have only one key identifier, reducing data duplication to a minimum. If this is achieved, tremendous gains in civil service productivity and efficiency could result. In practice, however, this situation is not always easy to establish, not even in the most developed countries. Substantial benefits are achieved also at lower levels of integration and coordination of dataflows. There is a need to ensure widespread understanding and acceptance of such projects before they are implemented. It is also important to identify trade-offs between what is technically optimal and what can be achieved in practice, notably because of human resource and infrastructure constraints.

018. Human resource constraints are a major consideration in designing IT projects for public sector in developing IT use in developing countries. Since demands for both technical and managerial resources are substantial, IT projects must be scaled and timed accordingly.

Human resource scarcity can occur both in terms of the availability of expertise to design and implement new procedures systems and also in terms of the speed at which organizations can efficiently absorb such new procedures and systems. The absorptive capacity of an organization depends both on the willingness and ability of top management concerned to support the organizational changes necessary to effectively implement IT and of the rank and file employees to work effectively in the new environment. Without planning and accounting for this absorptive capacity, even the best technically designed IT solutions are prone to failure during implementation.

Effective use of available human resources in civil service IT projects requires careful choices in terms of priorities and sequencing of projects. Although consultancy services have been widely used in every public sector computerization program, they are not a perfect substitute for the lack of human resources within the public agency concerned. Safeguards are needed in designing consultancy contracts to ensure that there is a sufficient level of transfer of technical and managerial know-how to sustain and further develop a project.

019. Another fundamental lesson is needed to evaluate infrastructure shortcoming, notably in the area of telecommunications services. Where inadequencies in telecommunications services exist, careful choices need to be made between postponing certain projects until better services are available, such as wide area networks (WANs), or redesigning these projects which might in some cases perform well even without relying on telecommunications by wire. Simple solution such as exchange diskettes might suffice in many cases where high-speed data telecommunications are not available. Some public sector IT projects, especially those which cut across many agencies or departments, might require high-quality telecommunications services to help generate the returns needed to justify the investments incurred.

020. Success in IT projects in the public sector in other countries cannot be readily replicated, particularly given the circumstances of most developing countries. These are therefore important considerations in terms of necessary political commitment, proper institutional set-up for planning and implementation, and adequate assessment of human and infrastructural constraints to avoid serious cost overruns and project failures.

1.6 Opportunities and Challenge

021. It may be said, from the viewpoint of the evolution of computing, that the 1960's and 1970's are the decades for organizational mainframe and mini-computing with sharing data respectively; the 1980's is the decade of personal computing with no sharing data; and the 1990's is the decade of networking with organizational computing and sharing data. The integration of computer and communication has become an inevitable trend in the use of information technology. All equipment will be integrated into an efficient network of resources and provide end-users with a friendly interface, making possible a network-wide unique view of transactions and messages.

The trend towards distributed processing and network computing leads to completely different strategies from those in the 1970's and 1980's for developing countries in developing their government information systems. It also provides a greater opportunity for developing countries to expedite the establishment of government information systems. Today, workstation-oriented, distributed processing and network computing, with resources sharing and data/information sharing, have become the main trend of proliferation of government information systems. This trend, in fact, is very much in favour of developing countries in developing the use of IT in the public sector because it provides developing countries with a low cost and low risk, as well as high benefit and high technology strategy to develop their government information systems.

022. On the other hand, with the emergence of low- cost/high-performance microcomputers and relevant technologies, government information systems have become indispensable tools in public administration in developing countries. This is because:

- Rapid technological change has led to shorter product and order cycles from anywhere of the world;

- Competitiveness in a global economy can no longer be fundamentally based on low-cost labour; and

- International competitiveness will require acquisition of improved technology to generate, process, and transmit information.

The role of information technology in a competitive national economy is two-fold:

- Using information technology to upgrade and reform national economy; and

- Using information technology to acquire and produce information.

The advent of increasingly information-intensive activities and the disparities in the use of information technology among industrial countries and developing countries is likely to widen the gap between "information-rich" and "information-poor" economies. How to effectively apply information technology to national social and economic development as well as public administration and management, has become a great challenge to all the governments of developing countries. The awareness of the importance and utilization of information technology has been an essential requirement that every modern manager of governments of developing countries must satisfy.

023. The problem which hampers the effective use of IT in some developing countries actually is not so much poverty. It is instructive for developing countries to consider the problems and pitfalls encountered in implementing of IT projects. The experience of developing countries is especially relevant because they are facing the same human and infrastructure constraints. Table 1 illustrates some of the typical problems encountered based on experience of implementation of IT in World Bank-financed projects in Africa, mainly in public agencies. Institutional weakness, human resources, funding and the local availability of hardware and software were all the major constraints to successful implementation. Nonetheless, some IT projects have succeeded, usually because the technologies used were well adapted to the problem at hand and there was extensive training and development of human resources preceding or as part of implementation of IT. The specific experience of developing countries suggests a strong need to make careful use of available financial and human resources to meet well defined priorities in IT without seeking over-sophisticated solutions.

TABLE 1. KEY PROBLEMS IN IMPLEMENTATION OF IT PROJECTS IN DEVELOPING COUNTRIES

	Core Factors	Symptoms	Consequences
1.	**Institutional Weaknesses**	- Insufficient planning - Lack of management commitment to and responsibility for IT programmes - Unclear objectives and priorities - Impractical strategies - Tendency for "quick fix" - Unpredictable absorption capacity	- Inadequately designed system - Cost overruns of varying degrees - Implementation delays and chaotic development - User dissatisfaction - Improper sequencing of activities - Inappropriate technology - Resistance to change
2.	**Human Resources**	- Shortage of qualified personnel - Inadequate compensation of technical staff - High turnover of technical and competent managerial staff - Insufficient counterparts to consultant - Lack of professional training programs and career profiles - Inadequate users' awareness	- Insufficient support - Problems in operation - High turnover - Implementations delays - Risk that project may come to a halt - Technical know-how not transferred - Isolation from sources of technology
3.	**Funding**	- Underestimated project costs - Lack of recurring budget	- Unfinished projects - Implementation delays - Higher costs for software development, training, repairs
4.	**Local Environment**	- Lack of vendor representation - Lack of back-up equipment, spares - Imbalance between public/private sector wages - Inappropriate procurement policies and practices - Inadequate site preparation	- General lack of professionals to solve technical problems - Implementation problems and delays - High staff turnover - Inappropriate or misprocurement - Equipment problems and Implementation delays
5.	**Technology and**	- Limited Hardware and software	- Dependence on individual suppliers

Information availability		- Incompatible hard-software technology
	- Data not shared	
- Inappropriate software		- Over-reliance on customized applications
	- Uncontrolled costs	

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Source: A. Moussa and R. Schware, Informatics in Africa: Lessons From World Bank Experiences in *World Development*, December 1992

CHAPTER 2

GOVERNMENT POLICY
FOR IT USE
IN THE PUBLIC SECTOR

2.1 The Role of Government Policy for IT Use

024. A complete set of government policies for information technology should take into consideration both demand and supply side. In general, it should embrace the following five aspects:

- *Government policy for information technology industry*. For example, software is the fastest growing sector in the world and many countries have tried to get a share of the market and various policies and strategies have been adopted.

- *Government policy for information service industry*. For example, Videotex, an interactive service which allows users to communicate with databases via telecommunication networks, has become more and more popular in industrial countries. Information increasingly serves as a primary factor in production, distribution, administration, work, and leisure. How Information is produced and made available are crucial determinants of the competitiveness and development of a country.

- *Government policy for information infrastructure*. Due to the digitization of telecommunication technology and the development of network computing, data communication systems have become the most important information infrastructure a country can have.

- *Government policy for information systems*. This includes government information systems at all levels: operational, management, and decision support systems, as well as office automation, and so forth.

- *Government policy for information resources.* This includes exploitation, development, administration and management of national information resources, in particular, government data and information.

Considering that the development of national information technology industry and information service industry has not been put on the agenda in many developing countries, this chapter only focuses on the government policies for the last three aspects mentioned, which are more related to the development of a base for using IT and the management and utilization of information resources.

025. The development of IT use and the utilization of information resources have become a matter of strategic importance in all countries today. Government decision-makers and policy developers are facing pressing demands to meet the challenges of this technologically driven change. The impact of modern information technology in developing and developed countries is evident. No longer is it possible to consider development in any socio-economic sector without considering the issues associated with information infrastructure, information systems, and information resources.

The use of information technologies in public administration and management will not end with the implementation of two or three information technology projects. Computerization, establishment of information systems, and other IT uses in public sector, are processes instead of events. Once information systems are established in a government agency, they must be continuously improved. Established systems and adopted technologies need to be continuously upgraded and renewed in order to keep pace with the state of the art in information technologies and to pursue higher efficiency and productivity. Also, data stored in government information systems need to be updated regularly. Public information, as valuable information resources, needs to be continuously explored and developed. Rapidly increasing technical performance and a continuing decline in costs will probably characterize IT for the foreseeable future. Computerization will no doubt be one of the indispensable essentials of the development process of developing countries in their efforts to modernize. In view of this, having a long term plan is necessary for smooth and healthy development of IT use.

The central government can play a crucial role in the development of IT use in the public sector. The way to motivate and guide activities in this important area is to formulate government policies for information technology.

026. Public policy is crucial to successful acquisition and diffusion of IT. Appropriate government policies are necessary to remove distortions in any macroeconomic or social policies which would prevent efficient supply and demand for IT. Government can also play an important

role as facilitator, coordinator and strategist.

Appropriate public policies for IT will most likely involves a careful combination of the roles of government as a consumer, regulator, policy maker and strategy developer of IT. Such interventions would have to be selective, giving priority to those areas where government intention can have a maximum impact without distorting market forces. At the same time, there has to be a consciousness of the limited government capacity to intervene. A massive government investment in improvements to the quality of public information services and to use IT to improve delivery of these services can easily run into constraints of implementation capacity of the government. Developing countries must also safeguard against overly ambitious attempts to catalyze IT use and diffusion through supply-led approaches which neglect to consider underlying demand for IT. Supply-led approaches are often associated with national or industry ambitions to establish rapid technological advances on crash investment and can therefore be highly risky.

2.2 Government Policy for Information Infrastructure

027. It is obvious that information technology is the key factor leading to today's globalized economy. Rapid technological change has led to shorter product and order cycles from anywhere of the world. Competitiveness in a global economy can no longer be fundamentally based on low-cost labour. And, international competitiveness will require acquisition of improved technology to generate, process, and transmit information. Information infrastructure thus has become more and more critical in an increasing trend of globalization and competitive world economy. Worldwide experience confirms that telecommunications are a major strategic investment to maintain competitive advantage at all levels - national, sectoral, and firm - without which countries and firms will not be able to participate in the increasingly information-intensive global economy. There is a widespread understanding of telecommunications as a strategic factor for developing countries in the efforts to improve the investment environment and increase productivity and business opportunities.

However, in developing countries, the availability and quality of the necessary facilities offered by the telecommunication authorities very often constitute an obstacle to the installation of data communications facilities - today's information infrastructure. Generally speaking, users in most developing countries have increasing access to computer and communication technology which they can not fully exploit because of constraints in the public telecommunications network and the quality of services provided, a slow approval process, rules restricting the use of the communications technology, or inadequate availability of high quality lines. Many governments agencies or firms are also aware of the information available internationally (in various databases) but are deterred from accessing these databases because of the telecommunications costs do not appear to make doing so attractive. Experience from developed countries show that a good policy environment will greatly help the country to accelerate its information infrastructure development.

028. The provision of telecommunications was regarded as belonging to a traditional public utility until about a decade ago. Economies of scale and large externalities as well as

political and military considerations led to the sector being considered and regulated as a natural monopoly usually operated by a government department or state enterprise. Powerful technology changes in microelectronics, network computing, software and optical fibres technology, and the integration of telecommunications with computer technologies have transformed telecommunications into a highly dynamic sector with lower barriers than before to entry of new providers and users. Computer communications technologies such as electronic-mail, teleconferencing, bulletin boards, cellular radio, and small satellite terminals and the emergence of new online services have made it cheaper and more convenient to communicate by means other than the traditional public switched telephone network. As a result, ownership and management structure and regulatory issues in telecommunications have been evolving dramatically in the last ten years throughout the industrial and developing world. This is because governments are being forced to re-evaluate their role in telecommunications and to ensure that national competitiveness is not jeopardized by continuing constraints on rapid development of the telecommunication sector.

The challenges posed to developing countries are tremendous. Unlike industrial countries which are facing policy and institutional reforms after already having built extensive national networks that meet objectives of universal coverage, developing countries are facing trade-offs between network expansion to meet social goals and providing adequate services to meet growing demands of major business customers in an increasingly information-intensive economy. Many governments are actively pursuing and implementing reforms which diversify the supply of telecommunication services, achieve more cost-related tariffs, and regulates the sector in ways which seek to maximize the opportunities of providing services.

Virtually all reforms already implemented or being considered around the world involve some reduction of the monopoly status of the traditional state-owned public network operator and increases in the influence of market forces over the pricing and supply of service and investment. Degrees of competition seen throughout the world range from unrestricted competition in all kinds of basic and value-added services to some monopoly remaining on both basic and value-added services. A clear telecommunication policy is therefore needed which clarifies the responsibility of the public network operator and that of the private network operators, and their equipment suppliers.

029. The range of competition also determines the extent and type of necessary regulation. In the new context of rapidly evolving technologies, no optimal model for regulation exists. Nonetheless, it is clear that for telecommunications to become a dynamic force for enabling national competitiveness, the regulatory framework must be one which: is independent of likely interests groups while being accessible to all competing interests; is consistent and predictable; and is strong enough to enforce its will and ensure fair and relatively unimpeded supply of telecommunications services. There should be special consideration of the negative impact of too much control by a small number of cooperations or groups. Also, the control companies/interests that control the networks should not supply content of information.

The increasingly important areas for strengthening telecommunications regulation in developing countries embrace:

(a) *Radiocommunications Regulation*, such as frequency management, formulation of licenses for public or private radio communications networks, management of radio licenses for persons, resolving interference problems, and inspection and control;

(b) *Standardization*, such as formulation of type approval procedures of telecommunications facilities, determination of standards, management of type approvals, and enforcement and sample control of equipment;

(c) *Rate and Tariff Regulation and Legal Analysis*, including rate, tariff and charge regulation, auditing, definition of rules for determining cost related tariffs and price caps for tariffs, definition of quality performance standards;

(d) *Arbitration*, such as handling of end user complaints and complaints about unfair competition within telecommunication; and

(e) *International Relations*, keeping in contact with international organizations such as CCITT (Consultative Committee for International telegraph and Telephony), ITU (International Telecommunications Union), etc.

030. A government policy for information infrastructure should clearly distinguish between different elements needed in telecommunications such as the provision of network capacity, the provision of telecommunications services, the provision of value added services and the supply of customer premises equipment. In fully developed telecommunications sector, these different elements are treated differently and even governed by different laws. The ultimate aim of this differentiation is to create an environment where new telecommunications technology can be offered to the end users at the most attractive prices. Ideally, hardware and information services are never controlled by the same institution, so as to reduce the likelihood of monopolization of telecommunication by a few interests.

Decision makers and policy developers of developing countries are facing complex choices in responding to the potential of IT. Improved procurement policies and guidelines are one of the main areas that government policy for information infrastructure should address. By encouraging open and competitive tendering and procurement procedures in the public sector, the government can use public sector demand for telecommunications facilities and services to create markets and learning opportunities for qualified local suppliers. Government policy should, through its national strategy for information infrastructure, shape both government and private sector demand to promote more advantageous relationship with different suppliers. Government, as the largest user of IT, should formulate its demand for IT by working out specifications which could then be tendered to different suppliers. These specifications should be defined to ensure that the standards are also compatible with systems to be acquired by the private sector. The government should strive to provide regulations that maintain an open system to which many different users may connect with little difficulty and minimal cost. It must also strive to prevent monopolization by a handful of large media companies.

Government policies for information infrastructure should also address the changes to legal and regulation framework. An effective regulatory environment which lays down a minimum set of clear and transparently enforced rules for type approval of communication facilities and ensures that the necessary resources are available for type approval processes. Duties imposed for telecommunications, in particular, data and computer communications, facilities and services, may need to be adjusted to prompt the development of information infrastructure of the country. The issues related to transborder data flow need to be carefully examined to stimulate international information exchanges while securing national security.

Government policies for information infrastructure should also adapt to the advent of information and computer communications age. For example, the tariffs paid for the telephone lines should not be affected by the fact that a modem is connected.

2.3 Government Policy for Information Systems

031. The existence of such a policy provides the development and management of government information systems with legitimacy and direction, while avoiding the waste of sophisticated systems being developed in a haphazard manner, without regard for government-wide concerns and priorities. Moreover, a policy also provides the donors with guidelines for their activities relating to this area.

Generally speaking, the following issues are expected to be addressed in a policy framework.

032. *Establish strategies*. The pursuit of effective IT use in the public sector will necessitate enormous investments by both public and private sectors in physical infrastructure, equipment, and training as well as a substantial planning and implementation effort. This will place heavy demands on available financial, managerial and technical resources, even if these are substantially completed by external resources. It is important that these investments and efforts be guided by a well structured and understood strategy which establishes priorities and an action plan for the short, medium and long term.

Information technology is a potentially powerful tool within a dynamic organizational structure. In order to effectively use IT, governments should improve the organizational environment in their agencies, consider the consequences with respect to the role of professional staff, remove legal obstacles when applicable, and adopt a realistic attitude to other types of constraints arising from cultural, historical, economic and political issues.

033. *Define the goals of government information systems*. The general goals to be defined are:

- To improve external efficiency (e.g., quality of service at the same or a lower cost);

- To improve co-operation and management in government;

- To improve policy decisions (i.e., to give high priority to information systems that assist policy-making);

- To improve cooperation with the private sector (e.g., by reducing the cost of providing information).

034. *Assign priorities*. The priorities in the development of government information systems should be directed towards removing obstacles that could hamper the design, approval, implementation and operation of a particular system. Government policy should stress the "co-operation" as opposed to the "confrontational" aspects in the design of information systems projects and promote efficiency by dealing with the interrelationship between information technologies and the need for restructuring government activities. Priority should also be given to avoid creating ministerial monopolies, or de facto corporate monopolies, to use incentives to recruit and retain technical professionals, and to train personnel, both professionals and end-users.

In accordance with the national conditions of developing countries, the following areas may be suggested as the development priorities of government information systems: Information systems directly associated with strengthening macro-economic management, and improving administration and management of the government as a whole; Information systems stimulating sectoral development and improving sectoral administration and management with direct economic benefit to the country; Information systems stimulating sectoral development and improving sectoral administration and management with indirect but obvious economic benefit to the country; Information systems possessing extensively significance to the country's progress and economic and social development; and Other information systems that the government deems very necessary and of urgent demands.

As a good penetrating strategy, priorities should also given to those information systems that are low-cost, high-benefit, and easy to implement.

035. *Create the appropriate institutional framework*. The issue of centralization versus decentralization of government information systems must be addressed to define the central government's role in information systems development.

Two key arrangements are crucial: create a high-level commission that will concentrate on establishing a long-term strategy and key parameters for evaluating policy implementation; and select a key agency as the focal point of the government responsible for co-ordination and implementation of policy on information systems development.

The focal point should be located in an organization that gives it authority, such as the office of the president or the prime minister, and staffed with an adequate mix of managerial and technical experts. The focal point should be the liaison within the government as a whole, carrying out its duties through close relationships among the ministries concerned.

Policies should be feasible and practical, reflecting the state of the art of computerization in the government and the focal point's own capabilities.

The focal point should identify critical matters in information systems development. Co-ordination of information systems may best be achieved if the role of the focal point is supportive and advisory, rather than prescriptive and authoritative.

036. There are variety of measures and activities that can be taken to stimulate the management and co-ordination of government information systems. Periodic surveys on the current status of information systems development in each ministry should be conducted regularly to assess existing computer resources and information systems and identify major problems requiring the focal point's attention. Co-ordination of budgets with respect to information systems in each ministry should be carried out through close working relationship with the budget bureau. Government should encourage each ministry to make its own medium-term plan for systems development and combine them to form an overall plan within the long term strategy. Information systems requirements that are common to several ministries should be identified and a common solution should be found. Pilot projects should be undertaken to test and develop solutions to important and difficult problems.

Guidelines on both managerial and technical matters, in particular, materials promoting the application of methodologies of information systems engineering should be produced with the development of information systems. All the ministries should be provided with training courses and common services, such as the state of the art of information technology, methodologies of information systems development, local area networks, common databases, data communication facilities, and technical consultations. Developing standardization of data, procedures, procurement and training is also a significant issue that should be addressed.

037. Other issues that need to be addressed by a government policy for information systems development include: acquisition of computers and communication resources; guidelines on employment and working conditions; issues relating to legislation and regulations on information systems; and education and training for self-reliance and sustaining development of information systems.

Irrespective of the current status of information systems in a country, it is essential to note that technological changes are setting a clear trend towards massive sharing and integration of information and towards extensive sharing of information technology resources. The implications of this strong trend for the formulation of national policies, especially in the developing countries, have to be ascertained and forced into a national plan for the future.

2.4 Government Policy for Public Data/Information

038. Information has been recognized as a strategic and valuable resource for the development and management of any countries. New disciplines in information resource planning and management as well as information economics are emerging in developed countries. Developing countries have to acquire some capacity in these disciplines to narrow the gap between "information-rich" and "information-poor" economies.

Information, as a resource, needs to be exploited and developed so that it can be better served to the people who need it. The traditional methods (industrial society) of developing information resources are, for example, newspaper, books, journals, TV, radio, indexes, and libraries, archives, etc. The modernized method (information society) for developing information resources, provided by information technology, is digitizing and computerizing information and make it ready to be cheaply accessed and retrieved by any authorized users. The collection, consolidation, and updating of data require large amount of resources and effort. An elaborated government policy, therefore, becomes very critical for effectively using scarce resources of the government to digitize the most important information.

The sharing of information that has already been computerized through statistical activities and substantive computer applications should be a high priority policy, and promotion of it would be one of the most urgent tasks for the government responsible authority.

Standardizing basic government data/information should be a fundamental government policy simply because if information is not standardized, it can not be shared. For example, responsible government agencies should compile and distribute an inventory of computerized information which could be shared among ministries; each ministry should identify a specific section to be responsible for the management of information within the ministry and for reference services.

The sharing of information could begin by transferring data files on to magnetic media and providing each ministry with common information on data bases built in the national computer or information center. Data/information sharing could also be implemented on an integrated government information network when it is established and matured.

As far as dissemination of public information is concerned, advanced technology has changed the situation which may be has not been anticipated by existing statutes and policies. The crucial issues, for example, are how to maintain ready access to electronic media and to define the respective roles of the government and private information handlers in the electronic dissemination of information.

039. With respect to information policy for governments, the specified issues concerned are as follows: The development, implementation, and oversight of uniform information resources management policies and guidelines; The initiation and review of proposals for legislation, regulations, and agency procedures to improve information management; An integrated long term plan for the exploitation and development of public data/information; The coordination, through budget review and other means, of agency information practices; The promotion of great

information sharing among agencies, through the review of budget proposals and other means; The evolution of agency information practices; and The oversight of planning and research regarding the government collection, processing, storage, transmission, and use of information.

Developing countries are situated in different stages of information resources development. Accordingly, the stresses of the government policy for information resources may be different from country to country.

CHAPTER 3

IT MANAGEMENT ISSUES IN THE PUBLIC SECTOR

3.1 Integrated Planning of IT Use in Public Sector

040. Information systems and information resources have to be planned and managed. Every institution has to do so, including national, sectoral, local and municipal government establishments. The planning and management of these vast information resources are evolving into a strategic sector in the economy of many countries. In many developing countries the planning and management of information resources have not yet been put on the agenda, or are still in a state of disarray. Some countries have realized that a lack of tradition and experience in the planning and management of information system and its resources can have a catastrophic impact on the whole socio-economic development process of the country.

Government policy should encourage information infrastructure and systems planning and coordination. Success of an information system depends largely on a clear understanding of the objectives and requirements of the system. This means that IT use planning and a thorough requirements study based on a understanding of priority programme needs are essential.

IT use planning identifies a long-term strategy and ensures an overall consistency of information infrastructure and systems development with the main objectives and priorities of the government as a whole. Planning is the key to success and the only way to manage change effectively. Planning also brings control and leads to better resources management and priority setting. Under a long-term plan, the projects undertaken will be those most needed by the government agencies and will form an integrated set of systems that work together without conflict or duplication. Planning improves communications between government agencies and helps to close the communications gap with users and top management. Furthermore, technical approaches of information infrastructure and systems and manpower development will also be addressed in an integrated strategic plan.

Without planning, there is no firm basis for funding; there is no benchmark for measuring operating efficiency; procurement is frequently made without the benefit of competition; and finally, the needs of users may not be satisfied on time, if at all. This critical need for good planning has long been recognized in the developed countries, and has been the experience of developing countries in successfully developing their government information systems as well.

041. There are two levels of IT use planning: strategic and operational. The strategic level deals with the whole government, its objectives, priorities, and major management and organizational choices on a long-range time scale (3 to 5 years). The operational level handles a specific information domain, a subset of the government organization's functions and/or processes, and the related day-to-day management and organizational choices and roles in a medium-range time scale (1 to 3 years).

In a rapidly changing technological and political environment, it is difficult to plan very far in advance, even five years ahead, which is generally accepted as the optimum planning period. Although planning in the areas of information infrastructure and systems is subject to unanticipated changes, it must be done if economy and efficiency of operations are to be achieved. Good planning, supported by sound requirements analysis, should be a prerequisite for funding any IT projects.

The following aspects are expected to be included in an integrated plan for government information systems:

(a) The development strategies of government information systems;

(b) The relative priorities to be assigned to government institutions;

(c) The underlying aims of computerization as regards the organization's productivity, quality improvement and image;

(d) The main technological approaches and procurement standards for computers, microcomputers, office automation, networks and communication technologies;

(e) The policy of government agencies regarding information flows, from and to its environment;

(f) Resources allocation, budget and financial policy; and

(g) A timeframe for human resources development which synchronizes with the systems development.

The central government can support effective management practices on the part of government agencies by requiring regular plans for information systems. Government agencies should ideally be required to prepare on an annual basis:

(a) A statement of the information processing requirements of the agency, based on mission needs of the agency, which stem from national programme goals and priorities;

(b) A plan that identifies the agency's approach for satisfying information systems requirements for the medium term (i.e., up to five years) and also provides a general statement of longer range plans. A medium-term plan should be supported by appropriate justification for any information systems service that a department/agency proposes to provide in-house and/or any significant project development, equipment or service proposed for the reminder of the current year or a new year.

In addition, each agency should produce a yearly report on the past fiscal year and current year-to-date. The report would highlight the major uses of information systems in support of departmental programmes and activities, comparing actual use with previous plans, identifying any departure from these plans and providing an assessment of services received or provided.

042. The method for information systems planning is generally a five-step process, including:

(a) Assessment of opportunity and preparation;

(b) Critical analysis of the existing situation, assessment of user requirements, and choice of orientations;

(c) Elaboration of possible scenarios for development;

(d) Development of a programme for the scenario selected; and

(e) Implementation and follow-up.

3.2 Development Strategy of Developing Countries for IT Use in Public Sector

043. It is well known that presently the life cycles for microcomputers and mainframe computers are about three and five years respectively. It is also notable that the life cycles of government information systems projects in developing countries are at least two to three years on average, if not longer. Comparing these two facts, the question is: what is the life cycle of a newly

developed government information system? The same question could be raised to information infrastructure building. And, more importantly, what is the development strategy of developing countries for information infrastructure and systems under the condition of such a rapid upgrading and renewing technology so that a newly developed infrastructure or system will not immediately become obsolete at its establishment? These are the questions which most decision makers of information infrastructure building and systems development in developing countries are concerned with all the time.

An IT use strategy is an overall decision made in consideration of the management, personnel and government policies, as well as the state-of-the-art of information technology. It describes the principles that shows how the objective of the government's organizational development is attained by use of information technology. The strategy should deal with overall questions and it can be relatively timeless. If the direct result of a strategy is decisions on purchases of technology, these will normally be a part of the action programmes.

An IT use strategy could also be described as a long-term plan indicating the scopes and principles of the government's information infrastructure and systems investments over a long period of time. The objective is to create a connection between the different purchases, to manage new technologies with older ones, and to adjust them to the institution's development.

The actual structure for preparing an IT use strategy should be determined on the basis of the present situation of computerization, telecommunications, and information systems development of each country, the size of the government of the country, and its development stage, etc. However, when preparing the strategy it is important to try to reflect the genuine requirements for data and information on the basis of present and expected functions of every government agency and to set up possibilities for meeting these requirements in the future.

The following strategic principles are recommended for the consideration of decision makers in developing countries:

(a) The principle of dynamic balance between three elements: information gathering capacities, information utilization capacities, and the capacities of information infrastructure and systems;

(b) The principle of evolution rather than revolution;

(c) The principle of physically decentralized as well as logically centralized; and

(d) The principle of function-oriented rather than institution-oriented.

The strategic principles are further illustrated in the following paragraphs.

044. *The principle of dynamic balance between three elements:*

- information gathering capacities;
- information utilization capacities;
- the capacities of information infrastructure and systems.

These three elements have to be balanced so as to ensure actual utilization of the overwhelming parts of the available capacities of the information infrastructure and systems.

The principle of dynamic balance between the three capacities establishes to a large degree the modalities for successful growth in information infrastructure and systems. The current situation in developing countries, generally speaking, is that the capacities of information infrastructure are underdeveloped, while the capacities of information systems have been established to different extent. Microcomputers spread everywhere in the offices of government agencies and local area networks have been established in some government buildings. However, information gathering capacities and information utilization capacities in many developing countries are still weak and need to be strengthened urgently. This can be proved by the fact that many microcomputers now are still merely used for word processing and spreadsheet purposes and only few are utilized to provide information services. Therefore, more efforts should be made in, and more attention be given to, strengthening data/information gathering and utilization capabilities. Of course, administrative capacities to utilize information are dependent on major reforms of the manpower skills available and on the organizational structure. Similarly, information gathering capacities depends on data availability and quality and the management of data actions. This relationship requires reforms of administrative processes and control, as well as human resource development.

045. *The principle of evolution rather than revolution.* The development of government information infrastructure and systems in developing countries may span two dimensions: establishing new applications systems, and upgrading and renewing, i.e., re-engineering, currently existing systems, most of which are mainframe-oriented and were established for electronic data processing purposes in the 1970s or 1980s.

Today, workstation-oriented, network computing with client/server architecture to achieve distribution processing, resource sharing, and data/information sharing, have become the primary paradigm of proliferation of information systems. It is likely that all countries will move in the direction of this type of proliferation, whether developing new systems or reengineering existing systems. This paradigm is in favour of developing countries because it provides developing countries with a flexible strategy which is low cost, low risk, and high benefit. This paradigm also suggests the strategy of evolution instead of revolution to develop information infrastructure and systems.

Following this strategy, the evolution track for developing countries is most likely to be as follows:

- Start from and popularize single microcomputer (workstation) applications development while training users and technical professionals in government agencies;

One of the prerequisites for any government information system, particularly for the least developed countries, is to clearly define basic requirements, and to develop a system that is very simplistic at the beginning. It is also very important that everyone has realistic expectations from the product.

- Connect microcomputers, on the basis of applications developed, to formulate a local area network (LAN) to strengthen the power of the system and share the resources and the information;

- Add mini or mainframe computers into local area network if larger capacity is justified and definitely required by increasing applications;

- Connect local area networks (LANs) sited in various government agencies to formulate an integrated government information network, e.g., wide area network (WAN), and share the resources and the information on a larger scale.

From the point of view of the three levels of government information systems characterized in Chapter 1, the evolution track of computer applications in developing countries may take the following course:

- Develop operational systems first and computerize day-to-day routines as well as possible;

- Develop management information systems on the basis of developed operational systems; and

- Develop decision support systems on the basis of developed operational systems and management information systems cautiously.

On the whole, the proliferation processes of government information systems in developing countries should be gradually improved and upgraded, and any overly-ambitious plans for information systems should be avoided.

046. *The principle of physical decentralization as well as logical centralization.* Information technology has been experiencing a continuous drop in the price of processing power, data storage, and networking technology. With the rapid development of software and communication technology, it is now possible, at a reasonable cost, to obtain information processing power in a small manageable unit or in a network environment - which would have been inconceivable a decade ago. The technical progress creates favourable conditions for distributed processing and decentralization of government information systems.

The trend towards decentralization has been fostered by pressure from user requirements for real-time and real-space information accessibility. The advantages of both consistency and flexibility of decentralized information systems make them very attractive and full of vitality. In particular, decentralization provides developing countries with a cost-effective approach towards computerization of public administration.

The issue of decentralizing government information systems depends primarily on political choices concerning the organizational structure of administration and public services. This is true for both sectoral decentralization and geographic decentralization. Of course, technical factors (availability of communication facilities) and economic factors (cost of communication, cost of computing, and cost of personnel) should be taken into consideration as well. Today, most newly developed information systems are physically decentralized, either partially or entirely.

Effective decentralization, however, requires some centralized coordination or control. Without this, redundancy in data collection, duplication of efforts in system development, incompatibilities of hardware and software between government agencies, and lack of standardization and normalization, could result in increased costs over the centralized alternative. Moreover, resource sharing, in terms of both computer equipment and data/information, can become very difficult, if not impossible.

Logical centralization of government information systems requires integrated policy, integrated planning, and integrated logical design of the government information systems as a whole. These imply that the planning and design of government information systems as a whole should be centralized; so does the management of government information systems and government data/information resources. In addition, logical centralization also means to put emphasize on standardization and normalization of information systems.

Logical concentration requires centralized management of information resources as well. For example, data collection needs centralized management and coordination. The same data or information should be collected only once within government agencies, at the most convenient source, and shared within the government, i.e., no redundancy in data collection. Hence, data or information collection within one government agency must take into consideration the needs of other agencies of the government and/or the public. In addition, data or information collected should be retrievable to all legal users.

047. *The principle of function-oriented rather than institution-oriented.* The environment of certain developing countries, under which government information infrastructure and systems are to be developed, are usually unstable in terms of institution or structure. Some countries are in a transitional status either politically or economically. Administration reforms in developing countries often result in restructuring the government organizations. Obviously, an unstable government structure may lead to a unstable structure government information systems.

Management Information System, just as its name implies, is a ***system*** for ***management*** to obtain and produce ***information***. In principle, a management information system is always attached to its management process, i.e., the organization. When an institution is restructured or removed, the information system attached to it will die along with it.

In order to avoid the waste and losses of scarce resources, the principle of function-oriented instead of institution-oriented in the development of any government information systems must be followed so that any restructuring of government agencies will not have fundamental influence on the performance of established information systems. For example, government financial management is usually divided into four functional processes: planning and programming process; budget formulation and presentation process; budget execution and accounting process; and audit and evaluation process. Correspondingly, a government financial management information system should be designed and implemented in accordance with these four functional processes and with less concern for the organizational structure of the ministry of finance. No matter how a ministry of finance is structured, the four functional processes of financial management are universal and should not vary even in an unstable environment.

3.3 Methodologies for Information Systems Development

048. Methodologies, specifically systems development life-cycle methodologies, provide the framework and the sets of procedures within which the myriad of development tasks can be performed. Most methodologies cover the entire span of development activities from project initiation through the post-implementation review. A methodology for systems development is a formal and structured approach that outlines and describes sequentially all phases, tasks and considerations that are necessary for a successful project. The framework and the set of procedures will ensure that each development phase is carefully planned, controlled and approved, that each complies with set standards, that each is adequately documented, and that each is properly staffed.

From the viewpoint of management and control, the methodologies of information systems will:

(a) Use the experiences of experts and other system developers for reference, and thus provide managers who are new to the process with a check list of steps that should be taken and questions that should be answered so as to facilitate the development of information systems;

(b) Provide a historical record of the development process, through the use of a formal methodology and the documentation it requires, that could be useful for future planning and for evaluation of information systems;

(c) Allow user-managers better control over the progress of the project and thus increase the usability of the end results; and

(d) Permit the transfer of design from one application to another, and the transfer of personnel from one project to another.

It is most important, therefore, that the development or improvement of information systems be undertaken according to a set of formal procedures or methodologies.

049. Before an information system is going to be developed, an in-depth examination of business processes in association with the information system, interactions within of the government agency or between the government agencies, must be carried out. Information systems are designed to computerize and support related business processes so as to improve effectiveness, efficiency, and productivity of government business. Obviously, without streamlined business processes, or business flows, there will never be streamlined information flow within or between government agencies. That is the reason why Business Process Redesign (BPR) and Reengineering have been very popular in industrial countries since the 1980s.

The purpose of BPR and reengineering is to introduce imperative changes in organizational structure to accommodate the new information technologies. Under the broad rubric of reengineering, institutions are flattening traditional organizational pyramids and transferring more and more decision-making responsibilities to networks and teams. The reengineering phenomenon is forcing a fundamental overhaul in the way business is handled, and, in the process, deeply cutting into employment rolls, eliminating traditional jobs and job categories while creating new jobs and job categories. By the introduction of new information and telecommunications technologies, many business processes and positions in institutions hierarchy are also being threatened with extinction. For example, traditionally, middle managers have been responsible for coordinating the flow up and down the organizational ladder. With the introduction of sophisticated new computer technologies, some of these positions and coordinating business processes become increasingly unnecessary and costly. Today, a growing number of government institutions in industrial countries are deconstructing their organizational hierarchies and using the computer to perform the coordination functions preciously carried out by many people often working in separate departments and locations within the institutions.

Reengineering and BPR represent the contemporary concept of IT use in institutions and are no doubt a better means to pursue higher benefit from modern information technology. Reengineering and BPR also provide developing countries with a short-cut to modernize their public administration by the use of information technology.

050. There are three different types of information systems development:

(a) Information systems with custom-designed software, i.e, the systems applications software is custom-designed to meet the special needs of the users of the information systems to be developed;

(b) Information systems using packaged software, i.e., the software developed by a third party, either vendors or consultants, is used as the fundamental applications software. Of course, some customization work may be inevitable; and

(c) Reengineering of existing information systems, i.e., through reengineering existing code and data and migrating them to a new advanced software technology environment and platform to modernize and enhance the functionality of existing information systems. Or, getting old "legacy" systems to fit into a modern system, by use of connectivity products.

With the development of software technology, it can be expected that more and more information systems will be developed using packaged software. Regardless of which type of information system mentioned above is being developed, an appropriate methodology of information systems engineering must be adopted to ensure the success of the system development.

051. There are four different systems development methods as follows:

(a) *The Data Oriented Method*, used when data/information necessary to carry out the institution's work forms the basis. The data oriented method is suitable for the processing of large, non-homogeneous amounts of information and very dynamic procedures;

(b) *The Functional Method*, used when the organizational units (functions) and their mutual communications form the basis. The functional method is suitable for the processing of complicated procedures with many surfaces of contact and processing rules. In addition, the method is suitable for well defined tasks;

(c) *The Evolutionary Method*, which involves a successive development. Higher priority system parts are introduced before the lower priority parts, but in such a way that all parts of the system form part of a planned totality. The evolutionary method is suitable for the introduction of systems in phases, or when parts of the system are more important than the others. Further, the method is well suited for complicated systems; and

(d) *The Prototyping Method*, used when a functioning model of the future system is desired. The prototyping method is suitable for highly nonstructured tasks, e.g., dynamic environments, experimental situations, dialogue systems, and for preparing organizations for the introduction of information systems. Prototyping is a method where development of test versions (prototypes) of the system are carried out at a very early stage. The method is also called experimental system development, systems development with prototypes or interactive systems development.

Selecting a systems development method is based on an evaluation of the totality of the four main areas: the nature of the tasks; the organization involved; the technology available; and the personnel which includes users and technical professionals.

3.4 Standardization of Government Information Systems

052. Standardization plays a key role in a healthy and smooth development of government information infrastructure and systems. The compatibilities of hardware, software, and communications facilities of government information systems are secured by standardization, and would include the compatibilities and sharing of data/information within and outside government agencies. The broad social and economic benefits in the proliferation of information systems largely rely on standardization because standards are the tools for raising productivity, avoiding duplication of efforts, and reducing the risk of investing in complex systems. Standardization practices help government agencies to more fully utilize the skills of their staff members and reduce their training costs. Standardization is a tool for managing change and for protecting the increasing volume of computer data/information, as well as a method of raising the level of science and technology and the quality levels of management.

Standardization is particularly important for developing countries because it can save a substantial amount of resources, accelerate the development of government information systems, and assist developing countries in following the main trends of information technologies development if existing international standards are extensively adopted.

Information systems standards are usually composed of data standards, technical standards, methodological standards, and security standards.

053. Data standards help to eliminate duplication and incompatibilities in the collection, processing and dissemination of data, and to promote useful information interchange. Standard data elements and representations for geographic places, dates, time, industrial classifications, government organizations, and other identified priority entities (individuals, business enterprises, land units, buildings, vehicles, etc.) are the prerequisites for the development of government information systems.

During the establishment of data standards, the lists of basic entities and priorities should be identified first and unambiguous definitions should then be assigned to those basic entities according to the legal environment. A thorough evaluation of the quality (coverage, reliability) of existing registers needs to be conducted and amended as necessary, meanwhile missing registers should be identified and set up. Adequate common identifiers for each basic entity will then be designated to identify the minimum set of information to be included in the basic register according to existing privacy regulations. Finally, access to and use of the basic registers within the public sector information systems can then be organized.

Data classification is another important issue in data standards. In this connection, key information items of common use in government information systems, or which are essential for planning and development, for instance economic data, need to be identified. Each information item should be defined and related to the relevant basic entity. Classification(s) to be used for these information items could then be identified.

054. Technical standards include those for hardware, software, and telecommunication, as well as information systems as a whole. As the common foundation of government information

systems development, a consistent set of standards for the description of the technical architecture of government information systems (network, mainframe, workstation, etc.) should be chosen. A limited set of hardware standards needs to be selected to facilitate compatibility and data communications (operating systems, floppy disk types and formatting). A unique set of telecommunication standards and protocols should be designated in order to ensure the development of data transmission within the government, from the cabling systems to the user interface. A limited set of software for mainframe as well as microcomputer (e.g., database management system, word processing) should be chosen in order to facilitate the setting up and use of common data bases, and to reduce costs of development and training.

055. Methodological standards involves choosing a unique and consistent set of methodologies covering all the steps of information systems planning, design, implementation and evaluation, for example:

(a) Information systems planning methods;

(b) Information systems design methods;

(c) Software engineering methods;

(d) Quality assurance and testing methods;

(e) Security and maintenance methods; and

(f) Performance assessment methods.

It is the popularization of these standards of methods that guarantees the quality and success of information systems development. Therefore, it is necessary to make sure that these methods are made mandatory and are applied by contractors in all public sector service projects, including procurement; and that these methods are introduced at the appropriate level in the training curricula provided by the various institutions contributing to the initial and in-service training for public administration professionals and managers. Also, it is important that the processes are designed in such a way that they may be amended or replaced when necessary or useful.

056. Security standards. A government policy can be issued to establish and fix the responsibility for security within the Government. This will be a useful strategy to set the stage for the subsequent issuance of security standards within the government. Security standards should be formulated on the basis of risk assessment. These standards should specify security issues and problems, the ownership of government information resources, and the protection afforded (over those resources), including the responsibility of users/owners for the care of the information resources entrusted to them, access control, and formal programme. This responsibility would also include physical security over the physical resources, e.g. microcomputers, minicomputers, and LANs etc. under their care.

057. Government plays a key role in the standardization of information systems. It is the government's mandate to set clear policies and objectives for the standardization of information systems, through precise definition of their fields of applications, nature (descriptive or normative) and process of development, updating and application. Of course, the State Bureau of Standardization, if it exists, would take the main responsibility for the development of various standards of information systems. In the meantime, it is helpful to set up an ad hoc national commission responsible for setting priorities, planning, organizing, supervising and maintaining the various kinds of standards identified. The terms of reference of the commission are suggested as follows:

(a) Make sure that standards are taken into account in other fields of information systems policy, training, procurement, regulations and laws;

(b) Organize a review of existing information systems according to development priorities to ensure the use of standards where necessary;

(c) Review all significant information systems projects to ensure that information standards are taken into account;

(d) Organize the updating of standards (especially classifications) in order to keep them consistent with developments in legislation, as well as in technology;

(e) Make sure that when changes are made in legislation, the necessary time is allowed for adapting the information systems using the data standards affected by these changes; and

(f) Avoid setting standards that could prove inapplicable and counterproductive, or obstacles to innovation, by associating all the relevant institutions of the public and/or private sectors with their development.

While developing and issuing the standards of information systems, it is very necessary to edit and disseminate various guidelines to the government agencies to assist in the selection and evaluation of information technology resources; to provide technical or economic criteria for making choices among several alternative practices; to assist in the implementation of a standard; to establish a recommended practice when a mandatory standard might inhibit developing technology or overly constrain management options. In addition, enough attention should be paid to existing corporate, national, and international standards, such as ANSI (American National Standards Institute), ISO (International Standards Organization), Microsoft.

3.5 Related Laws and Regulations

058. The tremendous importance of computer applications and information systems has

made the relevant laws and regulations issues more and more crucial in developed countries. As far as developing countries are concerned, some issues require immediate attention while some will be faced in the near future. Early attention to laws and regulations will benefit the creation of an environment for the development of government information systems. Issues that are of immediate and pressing importance include data security, privacy, statistical disclosure, protection of intellectual property, vulnerability, computer crime and fraud, and transborder data flow legislation.

059. As a result of computerization, there is an increased danger of unauthorized penetration and use of sensitive and confidential data, or the destruction of data bases and communication networks. Concern over the security of data and information systems has led to regulations that address information system design, personnel, operation, and data transmission. For example, a standard rule for data security may include guidelines on the designation of a data security manager, management of magnetic data files and records of inputs and outputs, management of documents (on system design, operation procedures, code books etc.), management of the operation of computers and terminals, maintenance and security of computer rooms and facilities to store magnetic files, contracting out computer work and providing data to outside people. Regulations regarding the handling and transmission of classified data and information stipulate that scramblers and encoding devices must be used to prevent unauthorized access to information while it is being transmitted.

060. The provision for privacy of data normally involves legislation and administrative guidelines for ensuring that the collection, maintenance, and dissemination of an individual's information by the government is consistent with the laws relating to confidentiality. The acceptability of the use of the data must be based on the individual's fundamental confidence that government organs and other data users will deal justly with him/her, that he/she is legally protected and that despite his/her relative impotence, he/she will not be abused. The government information systems should prevent access to data that is legitimately secret, confidential, private, or otherwise not accessible under the law and prevent improper interference with or erasure of the record. A most controversial case is a national individual identification number that information systems can use for various administrative purposes. Easy access to data on individuals from various administrative offices makes public administration extremely efficient. However, crucial questions arise concerning protection of the privacy of individuals, the extent to which the data can be retrieved, and so on. Consequently, different mechanisms of securing privacy must be devised.

061. Much of the data gathered or information compiled by government agencies is legitimately of interest to organizations and individuals outside the government. Accordingly, legislation should exist to make information of interest available to the public. In particular, surveys and statistics on various subjects should be routinely made available to the public. In addition, data subjects should know what personal data relating to them is on file, why this data is needed, how it will be used, who will use it, for what purpose, and for how long. Data subjects should be able to verify data related to them and have the right of redress.

062. One of the major areas in terms of computer law is concerned with the relation between copyright and patent law and the legal protection of software. The emergence of

sophisticated equipment, software programs and application packages emphasizes the importance of legal protection of intellectual property through national legislation. This would include software protection, patenting and copyrighting. The development of software and computers must be protected against illegal copying to ensure that developers are properly rewarded for their work and to encourage others to enter the marketplace. Traditional means of protecting intellectual property are copyrights and patents. There is the problem of distinguishing between the central idea captured in a program and the program itself. Another problem is that the distinction between hardware and software is increasingly blurred.

063. Computer crime is one of the major areas of concern in terms of computers and the law, which has become one of the most publicized aspect of computer use. The various crimes associated with computers are difficult to evaluate in terms of either magnitude or frequency, but it seems safe to say that the number and variety are increasing and the stakes are growing. Computer crime involves the use of the computer, with or without computer networks, to steal or embezzle money in a manner that could not easily have been done otherwise. There are also such crimes as stealing computer time, unlawful access to files, the acquisition of privileged information, and the actual destruction of computer files. This last activity has probably become the most highly publicized, as such terms as "virus" and "worm" penetrated the public consciousness. In industrial countries, while much computer crime has traditionally been perpetrated in banks, small and large companies, and government bureaucracies, viruses have had a direct impact on the ordinary citizen at home. Computer viruses seem to arrive as regularly as biological ones and with occasionally the same devastating effect.

To safeguard against computer crime in government information systems, it is necessary to adopt "minimum" legislation with regard to: data safety and requirements, which should be based on internationally accepted technical standards; protection of users and the public under predetermined conditions; and transborder data flow, to ensure that confidential or sensitive information of vital national interest is stored and processed only within the borders of the country itself.

CHAPTER 4

CRITICAL SUCCESS FACTORS

4.1 Commitment of Top Management

064. The top management's awareness of the role that government information systems are to play, and how they are to provide support to government agency's decision-making, policy development, and administration and management, is crucial if government information systems are to be successfully developed. The better understanding of information systems that the top management of a government agency has, the more opportunity the management information system has to be successful. It is obvious that a commitment to the development of a management information system must begin with the top management of the government agency. On the one hand, all systems development must have a system sponsor, normally a top administration officer. The responsibilities of the sponsor are: establish the goals and objectives of the system; provide funding; designate the project manager; and carry out other development activities. On the other hand, the interest conflicts taking place in systems development between different departments within a government agency also need to be coordinated at the highest level. In addition, the resistance to the changes and revisions of original business systems brought by new computerized operational systems must be overcome with the leadership of top management. Needless to say, top management's evaluation and oversight of applications requirements provides the impetus for the government information systems staff to meet the needs of the users.

065. Effective communication between the information managers and top management, as well as participation by senior management in information management decisions, is important to the success of IT use in getting top management's support for needed actions and resources. This is

because information technology is an area in which few top managements of government agencies have much experience; thus, it is hard for them to understand and participate in the problems, issues, and decisions that must be made by the information managers. It is even harder for them to evaluate information management performance in the absence of industry standards for performance measurement.

It is the information manager's job to promote this improvement, not top management's. In general, surprisingly few information managers make strong efforts to get time with senior management in order to help them understand the issues, trends, and problems of information management and few information managers report directly to the top. The place to start is education - not technical educations about computers and the like, but the business problems, the management problems, and the key decisions to be made in the information management area; and the issues, the trends, and the impacts of technological forecasting on the business of the organization.

066. A year plan is an important medium of communication with senior management. Preparation of a year plan in support of the annual information management budget could help win top management support for needed resources. The budget review process could be used as a means of communicating to senior executives the current technological issues and trends of which they should be aware, and together with their likely impact on the organization. The year plan also shows how information management objectives are tied to the organization objectives, and it discusses major accomplishments toward those objectives in the year just past as well as plans to meet objectives in the year coming. The year plan will go not only to the chief executive officers but to the executive directors of all user divisions as well. Although a simple device, it can be an effective communication tool with top and line managements. More importantly, it can help gain senior management support for needed resources.

067. One of the persistent problems which information managers have always had is the inability of top management to evaluate and measure the contribution of the information management function to the organization. Although computers and systems services benefit the users of those services, it is not always easy to demonstrate the productivity and the project contribution which the information management function makes possible for the organization. Therefore, performance reporting is required if information management is to gain top management support.

The performance reporting strategy is concerned with measuring the contribution of information systems to the organization. Measuring improved productivity or effectiveness has not always been easy, because there are no industry standards against which to measure. Thus, there are no easy ways for management to evaluate the true contribution of information management to the organization. Evaluation is even made more difficult because few top managers understand enough about computerization and information systems business to be able to make intelligent judgments about its performance. Hence, information managers are left with the task of finding ways to demonstrate the value of their contribution and performance, if for no other reasons than to get needed resources approved. With this regard, cost-benefit analysis of information systems is a good tool to be used.

Another performance management strategy which can be useful to information managers and top management as a vehicle for measuring the performance of information systems in the organization is to establish an information management performance reporting and evaluation system. Information managers usually manage six major areas: planning, projects, data/information, human resources, technology, and money. By the use of the system, the efficiency and effectiveness of the six areas of can be measured and reported. On the efficiency side, it measures how resources are utilized (equipment and people). On the effectiveness side, it measures user service levels and systems project performance (user concerns). Finally, it measures overall financial performance.

068. Information managers cannot afford to neglect the information needs of senior management of the organization. Efforts to provide information service to senior management can provide a far greater contribution to the performance of the organization and higher rewards for information management than the use of resources to serve lower-level managers and clerical staffs.

In this regard, executive information system can be developed to meet specific executive information needs. However, research shows that most of top management data are "soft" data rather than "hard" data, and very little executive information comes from computer-based systems. Even computer-prepared financial data are usually reformulated before they get to executive level. This is because most hard information going to top executives is usually a by-product of underlying record-keeping systems which were designed for another purpose and may not meet exactly the needs of top executives. Therefore, a true executive information system should be a top-down system rather than a bottom-up system. This means starting at the top, with the executives themselves, to find out what information they need to do their jobs.

Another way to address the information needs of top management is the development of decision support systems (DSSs). A DSS is an interactive information system which is used directly by a manager to help improve his or her judgment and decision making in a semi-structured environment. Developing such system for management, however, is a difficult task because it requires two-way education. The information manager has to learn a great deal more about the business and the decision making process of the managers, and the managers need a better understanding of how the computer can help them to do their job better.

069. Necessary measures must be taken to promote correct understanding of government information systems. It will create a very favourable situation if top management understand what a management information system is; what it can do and what it can not do; and more importantly, how to make a government information system successful and how tough a job it is.

High-level training is imperative. Workshops on government information systems are a good way to popularize the awareness of information technology and information resource management. To some extent, it is an urgent issue to be addressed in developing countries to promote a better understanding of information systems. The participants of the workshops are expected to involve government ministers, principal secretaries, directors of departments, information systems planners and decision makers, and those at higher levels of the government. Their knowledge about information technology will no doubt greatly favour the development of government information systems in their country.

The main topics of the workshops might cover: general knowledge of information technology, critical success factors of government information systems; government policy, strategy and planning for government information systems; methodologies of information systems development, including case studies of successful systems development and those that failed; information resources management; and trends in computer technology and information systems.

4.2 Effective User Relations

070. Another critical factor to the success of any information systems development lies in the effectiveness of its user relations. However, this is one of the most difficult challenges faced by information managers. Many organizations do an excellent job in managing their technical resources while doing a dismal job in user relations. The inadequacy in this area has, in fact, caused the fall of many information managers over the years. The reason is not simple. High demand and expectations, shortage of resources, the rapid pace of technological growth, the long lead times needed for equipment planning and systems development, constantly changing requirements, technical obsolescence, communications problems, interpersonal relationships - all of these are contributing factors. However, part of the answer must lie in a better understanding of each other's business problems and opportunities. Information managers need to understand the user's business needs; user managers need to understand more about data processing and information systems work. Learning more about each other requires more involvement in each other's business. The successful marriage of business and technology requires participatory management by information managers and user managers. In addition, it is important to understand that attitude, sensitivity, and good communications, rather than technical competence, are what impress users.

071. Information systems serve various users at different levels of an organization. Discovering user characteristics is important. There are *passive users* who will almost never ask for assistance from the information system regardless of the opportunities for improved management effectiveness or operational efficiency that can be achieved with information systems applications. There are *overly active users* who want information systems to produce solutions even when such application cannot be cost-justified. This kind of user tends not even to think about costs and benefits when requesting such service. There are *semi-informed users* who consider themselves systems-wise and tend to insist on their right to make decisions about information services and equipment. This is a frequent cause for the serious difficulties that have given information systems a bad reputation in some organizations.

Noting that users can range from top management to a middle-level director to a junior clerk, a user-service strategy should be developed. Often, information professionals spend most of their time serving junior level people, neglecting the needs of top and middle-level management. In fact, users who contribute most to the organization's business should receive more services from information systems; and, users who are receiving high-quality services from the information system should be aware of it. Of course, a user-service strategy will tightly associate with the development of a long-term plan for future information utilization at the organization, division, and functional levels of management.

072. A formal user-satisfaction survey can be conducted to monitor user satisfaction with the information systems services. The survey can be carried out by the information systems unit itself, but this approach might tend to inhibit frank and candid responses. As an alternative, the management of the organization can initiate such a survey, through either some other function (like auditing) or the appointment of an ad hoc committee. Or, finally, the survey can be conducted by an outside consultant or consulting firm. The value of the latter approach is that it assures objectivity and, in some cases, allows outside comparisons. Obviously, a positive report validates user satisfaction ratings and is meaningful feedback to top management.

The questions in a survey could include: overall evaluation; accuracy; timeliness; ease to use; responsiveness to requests for change in functions, outputs, etc.; support by information systems - answer to questions, user assistance; integration with other applications; average questions for each application; number of responses; and so forth.

073. User involvement in information systems development should cover the entire life cycle, from getting started - strategic planning, through systems development, to the information management activity of the user.

It is frequently a strategic error to attempt a major improvement in the utilization of information systems resources when the potential user has had little experience with modern technology. Such a user is ill prepared to cope with a massive infusion of new technology. Even if information systems specialists see a very favourable cost-benefit ratio for a big investment in information technology, a cautious strategy may be warranted for several reasons: a big proposal may frighten management in the user division; the user may not be prepared to assimilate a major change in its way of doing business; and the user's lack of knowledge of systems and technology could result in communications difficulties and misunderstandings. In such cases, the information systems manager should take an "gradual advance" strategy - one that demonstrates the costs and benefits of the proposed project, starting by providing simple, low-cost, rapid response to users.

074. Involvement of users in their own projects has been a demonstrated success strategy for years. This joint systems development strategy includes the involvement of users in the following four facets of systems project: planning, project team organization, systems development, and post-evaluation.

The planning phase deals with business systems planning; that is, the determination of need and the identification of systems projects that will solve users' business problems. This phase would be more accurately described as systems involvement with the users, rather than the other way around.

High-level user representatives with a thorough grounding in their business should be assigned full time to every major systems project for the duration of the project. This should be a matter of organization's policy endorsed and supported by top management. The user's representatives on the project are responsible for ensuring that the system delivered is, in fact, what is wanted and needed. This means they are responsible for defining the functional requirements of the system, not the technical development.

The user should be committed throughout the project. User management should also be involved in periodic project reviews and approval processes. The user's representatives on the project look out for the user's interests by seeing that systems specifications accurately match needs. Systems development must not simply be left to system professionals; it is the user's responsibility as well.

When the project is completed, a post-evaluation should be conducted to determine whether the project meets its goals and project benefits, what problems were encountered, what lessons were learned, and what improvement should be made, etc. Once again, the user should participate in the reviewing process.

The user plays a key role in information systems development. Without active participation of the users, any information systems development will lose its direction. For instance, the business needs and objectives of an information system can not be properly developed without the user's firm commitment to assist in the initial process of defining them. This is the only way to ensure that the requested system will be precisely aligned with the business goals of their departments and of the entire government agency. Hence, users must actively participate and articulate their own requirements. The system that is developed will be as effective in supporting the users' functional areas, as the users will be in participating in the development of the system's requirements, especially during the crucial stages of the system analysis process. User's participation is also crucial to developing a transition plan which reflects a realistic and feasible measure of improvement that is gradually attainable within a reasonable time frame. Therefore, users must be convinced that their input is not only wanted, but meaningful.

075. The advantages of user participation in purchasing, support, and other development activities are obvious as well. First all, applications development cycles can be shortened if users are involved in all aspects of the effort, from initial requirements analysis to design and implementation. Secondly, government organizations can reduce technology evaluation and testing time, and the potential for missing critical bugs or glitches, if users can participate in widespread pilot or test programs. Thirdly, organizations can dramatically reduce support costs if users can help each other on routine operational questions and take responsibility as specialists for more advanced questions. Finally, especially for developing countries, the end-user participation will favour the internalization of all the project outputs as well as the sustainability of the institution building effort after project completion.

076. A simple strategy for improving user satisfaction is the establishment of a help desk

or customer service center within the information systems department. The responsibility of the service center is to keep apprised of both production and output distribution problems so as to keep users informed when downtime, reruns, or backlog problems will effect on-line operations, report deliveries, and the like. The service center could give users a single telephone number to call about service problems which are effecting them, or simply register complaints about service, late report, etc.

The benefits of the customer service center include: higher user service levels through an increased services orientation; quick response to and resolution of user problems; provision of a single interface for users with service problems; and, assistance to users so that they use the center more efficiently. However, the center's response to the customers must be rapid, accurate, and credible. If the center works in this way, it will likely be welcomed by users as an aid to the resolution of service problems. Otherwise, users will soon lose confidence in its efficacy.

077. It has been noted that there may be some disadvantages that accompany user participation. For example, a large, varied user community can have difficulty reaching a consensus on important development issues. Generally speaking, users are not always aware of the latest technology and not always able to make the best judgements about future directions. Accordingly, users can often fail to see the broader and long-term picture, and are driven by what is needed at a particular moment and fail to see the long-range effects of adopting a particular technology. Therefore, if user participation proceeds without periodic appraisal, particularly in the development and implementation of a new system, the result could be negative.

Another important issue regarding a successful user participation is managing the expectations of the users involved. Difficulty may also arise when employee suggestions or opinions can not be adopted, or when they conflict with each other.

4.3 Institutional Arrangements

078. Appropriate institutional arrangements are required for smooth and effective development of government information systems, particularly for developing countries. Rational formulation and implementation of government policies, integrated planning, development strategies, and standardization on government information systems, can not be carried out without appropriate institutional arrangements within the government. Centralized technical support, including methodologies of modern systems development, hardware and software procurement and maintenance, education and training, etc., will undoubtedly economize a great deal on scarce resources for the government and greatly benefit systems development, operation and maintenance. Whatever these institutional arrangements may be, there should be a central focal agency. When there is no existing appropriate central agency, a new institution must be created for this purpose. Both newly created and existing agencies in different countries have proved successful.

079. At the national level, a ministerial level commission with appropriate representation on both the legislative and executive branches needs to be organized. This commission must

concentrate on the formulation of government policies on information technology; the establishment of long-term goals and strategies of stimulating the use of information technologies in public administration; setting priorities; and the allocation of information resources. The role of the committee or council is to concentrate on:

(a) Instructions on the formulation of government policies for information technology;

(b) The establishment of long-term goals, strategies, priorities, and plans of the government for the use of IT;

(c) Allocation of government resources for the IT use and establishment of realistic funding limits;

(d) Coordination, interpretation and resolution of conflicting interests, needs, and expectations of the ministries and agencies of the government;

(e) Reviewing of long-term and annual plans, evaluation of important investment proposals and approval of key government information systems projects on a prioritized basis consistent with the available resources and the needs of the government;

(f) Other important issues needed to be addressed by the Committee.

One of the most important, but often overlooked, benefits of such a commission is its use as a vehicle for improving communications between government decision-makers and information officers. Be sure that the meeting minutes are circulated to the members of cabinet as well as the members of the commission.

080. A central focal agency, which has principal responsibility for developing government information systems in the country, should be of high-level and headed by a top-ranking official. In many cases this official is of cabinet or ministerial rank. This confirms the importance of the agency's mission and strengthens its position in negotiating matters of policy or coordination with the other ministries and departments. This central focal agency, if established, could not only be an information technology policy initiation body, but also an information systems development and management center as well as technical support center, at least for the use of information technology in the public sector. Functions of the agency are mainly:

(a) To initiate, develop, and ensure the execution of government policies for IT use in public sector;

(b) To work out long-term strategic plan and annual development plans of IT use in public sector;

(c) To administer, manage and coordinate the development projects regarding IT use in the government;

(d) To administer, manage and coordinate data/information resources as a national information center:

(e) To promote the application of methodologies and the development of standardization of government information systems;

(f) To provide technical assistance and support services to government agencies in their information systems development, operation, and maintenance; and

(g) To organize and conduct various training programs and stimulate the popularization of information technology in the public sector.

This agency will play a leading role in the computerization and government information systems development of the country. Therefore, it should be equipped with advanced computer hardware/ software and be staffed by well educated, highly trained, and experienced personnel.

081. The start-up operation of the central focal agency could be done with two or three people. However, if the staff does not increase over time and remains at a low level, it might be difficult to leverage the effort of improving the development process of IT use with the help of the central agency. Efforts must be made to grow steadily until a reasonable number of personnel is staffing the agency. This is done by justifying the increase in staff with corresponding increase in responsibility and productivity. Management should be made aware that it might take a long time and necessitate many resources for the agency to fulfil its role. The benefit will not appear overnight.

Increase in staff should be well planned and not occur all at once. It should be increased gradually with a reasonable number of people. After all, a government department should not hire an outside consultant if there were no project to work on. The same applies to staffing the central focal agency.

082. Another important issue is the rate at which the central agency can afford to introduce new products, tools and techniques within the organization. The central focal agency staff is working on a full-time basis to improve the development process of IT use in the government. At the same time, they must work on satisfying the users' needs. They can always attend a course, but the real effort will only begin when they start using the new hardware and software products and applications development tools in real-life projects. For this reason, too many sophisticated hardware and software products, development tools or communications facilities should not be introduced at once. Chances are that the staff of the central agency will not be able to assimilate them all at once because they still have to devote most of their time to developing the information systems that are needed by the users.

Another point to consider is the number of new development tools and techniques that can be supported by the central agency. As the number increases, the time required to support them will increase proportionately. However, if the central focal agency staff continues to support forever all the tools they introduce, this will soon take all of their time. To avoid such a situation, transferring technical know-how timely to user departments becomes very important. With the progress of technologies, new tools and techniques are becoming more and more user friendly and it is possible to train non-professional end-users to handle the basic operational and maintenance skills. A decentralization strategy for handling new tools and techniques will not only help the central focal agency to improve their services to user departments, but also stimulate the effective use of information technology within the government. In addition, processes and procedures for tool usage should be written down and made easily accessible.

083. In the practice of many developing countries, it is often found that it is easier to create a central focal agency than to maintain it later on. The problems generally are two-fold: on the one hand, the government needs to understand that it takes time for such an agency to get on right track and it is not an easy job to fulfil its functions; on the other hand, searching for a qualified head of the central agency is critically important, who should have not only the knowledge of modern information technology but also, more importantly, management capabilities and political skills to deal with various aspects of the government. However, as long as the central focal agency delivers services of direct value to the IT use and information systems development, there should be no problem in justifying its existence. Unfortunately, if this is not the case, then this agency runs the risk of being dismantled quite rapidly. During that time, government will look only at the cost of supporting the central agency for functioning against the benefits generated in return.

4.4 Formulation of Government Information Systems Architecture

084. Computer and communications systems today are different from traditional computing packages. Microprocessor-based systems, open networks, and industry-standard software now offer a compelling economic alternative to conventional architectures, but there is a need for a new computing strategy that will combine these products to transform traditional computing environments and allow customers to keep pace with future changes while accommodating their current information systems environment. Just as a builder would not break ground on a large housing project without an architect's plan, it would not make sense for a government to add information system on top of information system without an architecture in mind. Therefore, formulating a reasonable government information systems architecture is a critical success factor in optimizing the use of information technology.

An information systems architecture employs design principles, defines relationships between components, and ensures proper interaction between attached devices: hardware, software, and applications programs. It defines formats that are compatible among dissimilar government-wide systems, and it is also a prerequisite for system integration. Given the complex computer and communication aggregates we are dealing with, system architecture and system integration cannot be applied effectively without heuristic approaches.

085. Information systems architecture provides considerable benefits. The beauty of an information systems architecture is that it provides a relatively stable framework within which information systems development, procurement and implementation activities can occur. An information systems architecture also ensures agreement and understanding within the government organizations of which applications, data, and interface are the target for implementation within a special time. This controlled growth minimizes duplication of effort and promotes systems compatibility, inter-connectivity and integration. An architecture also provides enough information to begin project definition and systems planning. An architecture makes dealing with certain business forces and problems easier. An information systems architecture helps government organizations to deal with the increased complexity of business, the increased integration required across applications, the need to ensure the integrity of distributed development, and the need to implement systems. An information systems architecture makes economic sense as well. By having a blueprint in place for systems, development, and so on, an organization avoids the costs of launching the wrong projects, or of building applications systems that will not integrate.

There are five essentials in an "open, cooperative" information systems architecture, which will be described in the following paragraphs.

086. *Open, multivendor environment*. Government agencies of developing countries usually own computer equipment from multiple vendors. Incompatibilities of this equipment have created islands of automation and information isolated from each other. Since some applications are best executed on systems different from those already available, heterogeneity in software and hardware is unavoidable. As a consequence, information that is critical to the success of entire government agencies may be unavailable on a timely basis to those who need it.

One goal of a modern information systems architecture is to enable an open, multivendor environment that integrates these islands into a single government agency-wide network through the use of communications standards such as Open Systems Interconnect (OSI) and Systems Network Architecture (SNA). This is accomplished by providing open interfaces for hardware, software, and networking, helping customers to achieve vendor independence through greater connectivity and application portability across systems from many different sources.

This unprecedented freedom of choice allows customers to integrate new, standard technologies into their computing strategy as they become available, without abandoning their current information systems investment.

087. *Flexible, distributed environment*. The microprocessor revolution, coupled with the emergence of low-cost, high-speed local area networks, open standards in wide area networking and communications, and common application programming interfaces, provides a basis for the creation of a truly open, cooperative computing environment. In such an environment, processing power and services can be placed where they are needed within the organization. The economic and scalable nature of the microprocessor means that incremental slices of power can be added easily as they are needed, with minimal cost and disruption. So, a line of scalable processors allows processing power to be added easily in smaller, more cost-effective slices.

The open, cooperative computing environment is based on a client-server architecture, which provides superior flexibility and configurability by placing common services at the server level where they can be accessed simultaneously by multiple clients.

088. *Transparent access to organization-wide resources*. The combination of new technology with the modern information systems architecture results in an environment in which information and system resources can be shared by all users everywhere in the network. In the past, applications software contained embedded communications protocols and services. That approach acted to limit the portability of applications. It also meant that changes in communication needs often required expensive, time-consuming modifications of the applications themselves. In a modern information systems architecture, applications are separated from the protocols, so new users can easily access remote and local system services without any modification to the application software. For example, databases can be distributed at multiple levels, putting critical information into the hands of those who need it on a timely basis. Providing a standard basis for operation between the application and its system services also permits new applications to be implemented far more quickly than is possible with conventional systems.

089. *Application software availability*. Speeding the implementation of new applications is also facilitated by adherence to industry-standard application programming interfaces. A modern information systems architecture offers an open application framework that enhances application portability. Support for open interfaces for hardware and software, including DOS, Windows, UNIX, and OS/2, gives customers access to a huge library of off-the-shelf software. The emergence of independent software vendors in the 1980s and the spectacular success of mass-market software will continue to shape the applications development environment of the 1990s. The correct strategy is to leverage the success by providing an open applications development environment to support customer, third-party, and vendors software development. This will free the customer from dependence on any one source for applications, eliminating a major bottleneck in the implementation of new applications.

090. *Intuitive user environment*. The need to place greater computing power at all levels of the organization requires that computers be made easier to operate, in order to increase the productivity of less experienced personnel. A modern information systems architecture will address this need through the development of an intuitive graphic interface that will be consistent across all applications and all platforms in the user's environment. The user interface will go beyond current icon-base interfaces through the use of powerful object-oriented metaphors that can automatically execute a series of predetermined tasks. It will eventually integrate the use of image, sound, and full-motion video, allowing the implementation of the multimedia applications of the future. Since it will work in a way that is natural and intuitive, rather than forcing the user to learn the computer's language, the interface will reduce development and training time and their associated costs.

PART II:

INFORMATION TECHNOLOGY AWARENESS

CHAPTER 5

DEVELOPMENTS IN COMPUTER TECHNOLOGY

5.1 Evolution of Microprocessor Technology

091. The first microprocessor was invented by a young engineer, M. E. Hoff, Jr., in 1971 at Intel, a semiconductor company located in California, USA. He invented an integrated circuit that is essentially equivalent to the central processing unit (CPU) of a computer. The CPU on a chip became known as a microprocessor. To the microprocessor, two memory chips were attached, one to move data in and out of the CPU and one to provide the program to drive the CPU. The rudimentary general-purpose computer not only could run a complex calculator but could also control an elevator or a set of traffic lights, and perform many other tasks, depending on its program. This invention was proved to be one of the most significant technological innovations of our time.

Intel brought out its first microprocessor chip, the 4004, in 1971. A large model, the 8008, followed in 1972. Near the end of 1973 came the second generation 8080 chip, more than twenty times faster than the 4004. This last chip formed the basis for the personal computer bonanza that followed. The success of the 8088 microprocessor led other companies - such as Rockwell International, National Semiconductor, Texas Instruments, and Motorola - soon to enter the microprocessor derby.

092. In the last twenty years, people have seen a rapid evolution of microprocessor technology. More than 20 years of development has brought five generations of Intel's microprocessors, from the primitive 8-bit, 6,000-transistor, 2-MHz 8080 design, which was used in

the Altair (the first personal computer), to the 32-bit, 3.1 million-transistor, 120-MHz Pentium processor today. IBM chose the 8088 processor for the first IBM PC. This chip was rated at .33 MIPS (millions of instructions per second). When the 80286 appeared in 1982 (first used in the IBM PC-AT in 1984), it had 134,000 transistors, and, at 1.2 MIPS, was faster and 4 times more powerful than the 8088. In 1985 Intel brought out the 80386, which was a full 32-bit processor with 275,000 transistors, and was available in 16, 20, 25, and 33-MHz speed variant. Initially, it was rated between 5 and 6 MIPS, roughly 15 times the power of an 8088 CPU.

The 80486DX family of processors came out in April 1989, with 1.2 million transistors, the 486 became available in speed ratings of 25, 33, and 50-MHz. Its computing power is 20 MIPS. The latest and fastest 486 chip is 66-MHz 486DX2 with 54 MIPS.

Now the new Pentium processor more than doubles the raw computing ability of the 486DX2/66. The line width of each transistor is 1/100th the thickness of a human hair, or 0.8 microns to be exact. So 3.1 million transistors can be packed into an area of 16.6mm by 17.6mm. Based on SPEC 92, the industry standard workstation benchmark, the Pentium processor is in the same performance class as the best workstation. But the Pentium processor is running at only half the clock frequency, and systems based on the Pentium processor cost only one-half as much. It is expected that the a faster Pentium will be released by the end of 1995, and will weigh in with 10 million transistors.

The Pentium runs three operating systems: DOS/Windows, Unix, and OS/2, and it enjoys a huge applications software base created over the years.

With the introduction of the 32-bit processor, computer designers are of the opinion that ample storage and processing are accessible for most general-purpose computing needs now and in the foreseeable future. New advances can be expected to concentrate on increased processor speed and specialized processors that optimize a specific type of application, e.g., vector processing.

093. After Intel's launching the 8088 processor, Motorola Corporation introduced the 8-bit 6800 microprocessor with nonmultiplexed data and address buses. The 6800 processor also incorporated the concept of double accumulators and has an index addressing scheme. The 6800 became an instant success.

During the mid-1970s, Commodore and Rockwell International introduced the 8-bit 6502 microprocessor, which also became an instant success. This machine is similar to the 6800 processor, but includes additional addressing capabilities such as memory indirect. The design of the Apple computer was based on the 6502 processor. At about the same time, Zelog Corporation introduced the 8-bit Z80 microprocessor. The Z80 is code compatible with the 8085 processor. It has additional resources with which to store data internally, and it also has the index addressing mode of the 6800 and 6502 processors. The Z80 processor found extensive applications in the 8-bit field, even though it entered the 8-bit market late.

To follow the 8086 processor, Motorola Corporation introduced the more powerful and versatile 68000 microprocessor. It has a 16-bit data bus and an effective 24-bit address bus that can access 16 megabytes. The internal architecture of the 68000 is designed to support 8-bit, 16-bit, and 32-bit operations. The architecture, linear address range, and versatile data-handling capability of the 68000 suited the needs of industry. Systems such as Apple's Macintosh further contributed to the popularity of the 68000 processor. Continuous demand by industry resulted in the development of more powerful processors, such as the 68020, 68030, and 68040 family, which correspond in performance with Intel's 80286, 80386 and 80486 family.

094. The present trend of development will continue in the 1990s. In order to obtain more dedicated throughput, RISC (reduced instruction set computer) microprocessor is becoming popular. The new PowerPC microprocessor, created by the IBM/Apple/Motorola alliance, aims to shatter the notion that RISC is strictly a workstation technology and aims squarely at the PC marketplace.

The Motorola PowerPC 601, or MPC601, the first in a series of PowerPC CPUs, is poised to find a home in mainstream desktop PCs and will run in the initial release of PowerPC-based machines for IBM and Apple. The PowerPC processors are based on IBM's existing POWER (Performance Optimized With Enhanced RISC) architecture used in IBM RS/6000 workstations. The MPC601 packs 2.8 million transistors onto a die only 11 millimetres square. By contrast, the Pentium places 3.1 million transistors on a die that is 16.6mm by 17.6mm in size. The MPC601's smaller die helps reduce the cost of its manufacture. The MPC601 is a 32-bit implementation of the PowerPC architecture. It has a 32-bit external address bus that is capable of accessing 4 GB of physical memory. The MPC601 has three execution units, so it can handle three instructions simultaneously.

At least six operating systems are being ported to the PowerPC: Apple's System 7, IBM's OS/2 and AIX, Sun Microsystems' Solaris, the PowerOpen environment, and Taligent's object-oriented Pink - a joint Apple/IBM project. In terms of applications software, the MPC601 has an installed software base in that it can run existing POWER applications.

095. Faster microcomputers start with faster microprocessors. There are three ways to make fast processors.

Increase the number of transistors. Today, the use of sub-micron components lets designers fit more than 3 million transistors on a single chip. So components such as math processors and caches can be integrated right onto the CPU - dramatically cutting access time. Today's advanced manufacturing technology has continued to reduce the processor's size from 3 microns in 1979 to 0.6 microns today. And it will be even smaller in the future. At the same time, microelectronic engineers have increased the silicon wafer size from four to eight inches. Together, this not only allows to integrate more functionality onto processors, but to produce large quantities of chips while lowering the cost of computing power.

Increase the clock speed. Twelve years ago the clock speed ticked along at 4.7 MHz. Today microprocessor can run at an astonishing 100 Mhz - and engineers are still pushing for more.

In its next version, the Pentium processor will run at clock speeds of up to 150 Mhz. The "P6" processor will incorporate even more sophisticated techniques to execute instructions at over 250 MIPS.

Increase the number of executions per clock cycle. Using new superscalar technology, microprocessors are now capable of executing two instructions per clock cycle. The superscalar technology enables information to be processed simultaneously through dual pipelines. To accomplish this, the pipelines divide up an instruction, then send it through five stages. As it passes from one stage to the next, the pipeline is free to begin another instruction. Operations are sped up substantially. On the other hand, designers have been constantly trying to find ways to make the processor more efficient, for example, by performing tasks in parallel and keeping data readily available to the chip.

096. A great microcomputer is the sum of its parts. As processors become faster and more efficient, system designs have also continued to move forward. While some of the first systems introduced with the advanced microprocessor in mid-1993 were not designed "from the ground up" to take full advantage of its performance and features, today's PC designs are better.

Systems available now not only leverage the strengths of the microprocessor, they also integrate other advanced features that, together, give users the best performance from the total system and give users a far more powerful PC than they get with an Intel 486 processor-based system.

The advanced microprocessor can handle data far faster than many memory systems can supply it. When that happens, the processor sits idle, which is a waste of a powerful resource. That is why it is crucial to have a memory subsystem that can keep up with the data processing capabilities of microprocessor.

Well-designed memory systems can increase the flow of data in several ways. One key method is interleaved RAM subsystems. These are dual banks of memory that work together to supply data to processor so it does not sit waiting. One bank provides data while the other prepares data for the next cycle; on the next request, they alternate roles.

A second-level, or off-chip, cache can also substantially increase memory performance in microprocessor systems by retrieving data from the memory in bundles, instead of item-by-item, and making it readily available to the processor. More advanced caches use the write-back method. Unlike the write-through technique, the write-back design caches both information read from and written to RAM.

While it is important that the processor be fed data and instructions as fast as possible, it is not necessary to have it involved in or controlling all of the computer's functions. High-performance PCs incorporate "intelligent" subsystems that increase efficiency by relieving some of the processor's workload. One such subsystem is a disk drive that fetches data before the processor request it (read-caching), and accepts data before the drive is ready to write it (write-caching).

Another key way of increasing performance is with a video graphics card that has the built-in ability to execute functions such as drawing lines, manipulating shapes and zooming in with only minimal instruction from the processor.

System features such as an adequate second-level cache, a PCI local bus, and a full-featured VGA card let the subsystems of a PC operate at maximum efficiency and performance. The cumulative effect is a more powerful microcomputer all the way around.

5.2 The State of the Art of Microcomputers

097. The advent of the microprocessor in the mid-1970s made possible the development of micro or personal computers (PCs). These machines, with their relatively low cost and wide availability, have become the major computing resource in most developing countries. In the late 1980s, the personal computer matured into the workstation concept. The workstation can be viewed as the individual's tool box for various administrative and management purposes. The PCs' resident software applications can be combined with networking and gateway links to provide access to institutional databases and applications.

There is a wide variety of microcomputer hardware in service in developing countries. The majority of these systems are IBM compatible, with Intel 286, 386, or 486 microprocessor family. However, there are also Apple computers, such as Apple II, Macintosh, Macintosh II, Macintosh Plus, and Macintosh SE, using Motorola microprocessors 68010/20/30/40, etc. Since 1985, portable laptop computers have been introduced in developing countries. Other than portability, the machines offer a number of advantages, including battery operation, rugged construction, and software compatibility with existing microcomputers. Aside from the dot-matrix and impact printers, few peripheral devices or add-on capabilities are used with existing systems. Some organizations have begun using pointing devices, such as a mouse, but only a handful of agencies have ventured into the realm of graphics devices, such as digitizers, plotters, scanners, and high-resolution graphic monitors.

098. *Microcomputers in 1995*. The three levels of microcomputers: entry-level, midrange, and high-end systems, in the United States Market in late 1994 and early 1995 are given as follows.

Entry-level Systems. The frenzied pace of progress in the computer industry is made obvious by the fact that Intel's 486DX2/66 CPU had a stranglehold on the high-end of the market in late 1993, but now is merely an entry-level PC in late 1994 - and on the verge of losing even that status. The average price of the entry-level systems is about $ 2,000 usd, and the least expensive models come with under $ 1,500 usd. These machines usually come with 8MB RAM, a 340MB or larger hard disk, a double-speed CD-ROM drive, and a 14- or 15-inch colour monitor.

These machines offer performance that is adequate for everyday use. They are more than five times the speed of 386DX/25 machines in average and nearly half the speed of typical fully loaded 90-MHz Pentiums. Their DOS performance is good enough so that even the slowest system can accurately be labelled "fast enough". Of course, entry-level systems are not fast enough to explore all the features of multimedia technology. In some cases, entry-level systems also offers less expansion room than more powerful machines; and many are housed in slimline cases. In addition, not all entry-level systems provide integrated graphics accelerators.

Nearly all entry-level systems use an Intel 486DX2/66 CPU and offer a high-speed expansion bus. In addition, many entry-level PCs are designed to fulfil specific market needs. For instance, some provide telephony capabilities that small- or home-office users should find attractive, and some provide similar capabilities and add a television hookup.

Midrange Systems. Most of midrange PCs are based on the DX4/100, Pentium/60, or Pentium/66 CPUs and split the difference between the low and high ends in terms of price and performance. The Pentium/75 is targeted at the notebook market, but it is likely to become the entry-level CPU of choice on the desktop in the near future because the 75-MHz Pentium runs on 3.3 volts and is the ideal CPU for reasonably priced, home-used PCs.

The average midrange systems are about twice faster than that of 486DX2/66 systems. The average price of midrange PCs in late 1994 was about $ 3,100 usd, which compares with around $ 2,200 for entry-level units and about $ 4,000 for high-end systems. Midrange level PCs usually come with 12MB - 16MB RAM and 430MB - 810MB hard disk.

High-end Systems. The high-end systems are based on the Pentium/90, Pentium/100, and Pentium/120. The Pentium processor is poised to overtake the 486 and become the mainstream CPU of choice. Machines built around the Pentium/90 is about three times the speed of a typical entry-level 486DX2/66 PC. However, component quality is a crucial differentiator among high-end systems at present. The lowest price of the Pentium/90 PCs was $ 2,779 usd, about $ 1,000 usd more than the average entry-level system, and the machines come with 16MB of RAM, a 731MB hard disk, a double-speed CD-ROM drive, and a 15-inch monitor. More typical Pentium/90 machine costs $ 4,000 usd with 1GB hard disk and a 17-inch monitor. A number of high-end systems are equipped with quadruple-speed CD-ROM drives, which are expected to become much more common on high-end systems soon. A couple also had built-in PCMCIA slots to ease data exchange with notebook computers. Usually, larger hard disks, bigger monitors, and larger amounts of graphics memory are designed for the high-end PCs. There are many UNIX workstations made by IBM, Sun, HP, etc. which can also work as high-end systems.

099. Apple's Macintosh. The Power Macintosh series is the most advanced microcomputers produced by Apple Computer, Inc. At the heart of Power Macintosh beats the RISC-based PowerPC microprocessor MPC 601. The Power Macintosh 6100/66 DOS compatible computer has both a PowerPC chip and a 486DX2/66 chip inside. With simply one touch of a key, users can switch from the Mac OS to Windows - or DOS - and back again. And every Power Macintosh can run DOS and Windows software with the aid of a program called SoftWindows. According to a performance comparison report, the Power Macintosh 8100/100 is faster overall than the Pentium PC tested. The speed of the PowerPC processor, coupled with Windows

compatibility, could be a compelling reason to attract some users to move from a PC to a Macintosh platform.

The Performa 6110 models each include 8MB of RAM, a double-speed tray-loading CD_ROM drive (the Apple 300i), high-speed SCSI ports, a floppy disk drive that can read PC or Mac disks, 16-bit stereo sound, a 15-inch monitor with built-in stereo speakers, and an external 14.4-Kpbs fax modem. The only difference among models is the size of hard disks: 250MB, 350MB, or 500MB. The prices of the Performa 6110 models range from about 2,400 usd to 2,700 usd in the United States market in 1995, which cost a bit more than some Pentium systems.

The Power Macintosh also has built-in sophisticated networking capabilities to support LocalTalk and Ethernet (including EtherTalk, TCP/IP and Novell IPX protocols). Users can add Macintosh computers to practically any kind of network, whether it consists of computers running DOS, Windows or OS/2, or UNIX workstations.

100. Trends of microcomputing. The automation of data analysis was a focus of the 1980s. In the l990s, due to increased competitive pressures, organizations are looking for ways to quickly capture data so it can be analyzed. Organizations are evaluating client/server computing as a means of capturing data, in machine-readable form, at its generation point.

Microcomputers are getting more powerful and less expensive, smaller and more portable. Smaller, lighter machines are supporting the computer needs of the mobile worker. As the vendors of these new computers search for a "killer application," their primary focus is on automating two very manual processes: completing forms and capturing data.

Notebook computers, weighing about six pounds, have a de facto minimum of 8 Mbytes of memory and fast hard disks with capacities as large as 430 Mbytes. Minimum configurations use chips that are equal to Intel's 486DX and Pentium products. Portable computers just keep getting more sophisticated. Multimedia notebooks have come to the market with 16MB RAM and 500MB hard disk, some have built-in sound and CD-ROM drives, and others dock with portable multimedia units. These first designs presage the powerful desktop replacements that will enter the mainstream later 1995.

Although earlier notebook computers had inadequate nine-inch displays, current notebook computers come with ten inch diagonal LCD (Liquid Crystal Display) displays with VGA resolution. Easier-to-view active-matrix screens are also available at a higher price. Other categories of machines in this smaller-footprint technology are:

Clipboards and tablets. These machines are generally microcompatible and industry watchers expect them to be used to automate forms processing. They usually run Intel 386/486 (or higher) chips, have small hard drives or use flash memory cards. They are less powerful and smaller in size than notebook computers.

Palmtops. These machines have smaller screens and less power than clipboards and are expected to be used to automate blue-collar tasks and, also, for scheduling and taking notes.

Convertibles. These machines, also called pentops, combine palmtop technology with pen technology (a combination pen and keyboard machine) and are being evaluated as a means of supporting business applications.

Personal digital assistants (PDAs). These hand-held, limited-purpose consumer devices are targeted at personal management applications, such as simple note-taking, address book maintenance, calendar scheduling, and letter-writing. They have some connectivity features for transmitting files to a host.

Docking stations may ultimately replace desktop machines. A docking station is a CPU-less box with a connection to the notebook. It becomes a complete system when the notebook is slid into place. The docking station contains a desktop monitor, full-size keyboard, and a table chassis with expansion slots and drives.

101. Pen-Based Computing. A significant new technology is pen computers. Pens were first introduced as pointing devices. They have since evolved into a self-contained architecture. Pen-based operating systems store ink, a new datatype that displays the strokes of the pen and stores them as they are created by the user. Ink field values can be cut and pasted like normal computer text. Pen computing is aimed at supporting mobile field and office workers. The original concept of using a pen as an interface focused on the elimination of keying hand-written data into an application. However, current handwriting recognition software is not yet industrial strength for the following reasons: It is limited to recognizing printed words rather than handwriting; Users have to stop midstream to reprint unrecognized characters, consequently, most successful pen applications today take a forms approach. Users check an item, fill in boxes, write notes to themselves (which are stored as-is in a text field), and use the pen to draw. Another advantage of pen computers is the ability to do electronic signature capture. The signature is then retrievable like any other piece of data.

The major pen operating systems - Go Corp.'s PenPoint and Microsoft's Windows for Pen Computing (Pen Windows) run on Intel-based CPUs, store text in ASCII, and can output in many standard file formats. Due to its memory and storage requirements, Pen Windows cannot run on as small a palmtop as PenPoint can. Currently Pen Windows uses pens as pointing devices (mouse replacements). As palmtops become more powerful, more robust applications will follow.

102. Although stand-alone microcomputers currently represent the major information technology resource available in most developing countries, it should be recognized that microcomputers may not be capable or appropriate to deal with all the computing needs of government information systems. Some large-scale applications may require the creation and analysis of large, relational databases that include both spatial and non-spatial data. Moreover, no matter how large the capacity or how fast the processing speed, stand-alone microcomputers cannot provide the levels of access needed by groups working together. When the computer is needed to support such activity, a larger, more complex computer system is required. Currently, four

computer configurations address the scope of large-scale applications -- super microcomputers, LANs (local area networks), minicomputers, and mainframes.

103. The larger and faster Intel 80486 or Motorola 68040-based microcomputers, or more powerful ones, can be used as the central processor for a multi-user computer system that processes instructions from more than one end user at a time. Several computer companies manufacture special microcomputers, called "super microcomputers" (supermicros), for use as the processing unit in such multi-user systems. Each user's workstation is connected to the supermicro by a terminal or VDU (video display unit), which is similar to the keyboard and monitor of a personal computer. Usually, supermicros support five to fifteen workstations. Supermicro multi-user system represents a level of computer complexity one step above the microcomputer and, as such, will introduce problems of systems management and availability of technical staff not required for stand-alone microcomputers.

5.3 Minicomputers, Mainframes and Downsizing

104. Minicomputers were first introduced in the early 1970s as low-cost alternatives to mainframe computers. Many of their initial applications would be thought of today as microcomputer tasks. Just as microcomputers have grown in capacity, so have minicomputers. Minicomputers are now multi-user systems which vary greatly among themselves in speed and memory. Currently, minicomputers are used in developing countries for the purposes of statistical data processing, accounting, banking, etc., as well as for geographic information systems and remote sensing image analysis. Minicomputer hardware, especially central processor units and disk drive units, require better environmental control than microcomputers. The larger the minicomputer, the better controlled the environment must be. Usually, a minicomputer needs a dedicated direct power line, a UPS (uninterruptible power system), air conditioning, and a room relatively free from dust and dirt. If the local dealer is providing good support and the environment is properly maintained, the minicomputer should operate reasonably problem free.

However, the use of minicomputers in developing countries is made difficult by the need to develop internal management skills to administer the computer, create the databases, and provide end-user training and support. Because very few off-the-shelf applications packages exist for minicomputers, most applications software is custom prepared. Even commercial software packages may have to be modified to operate on locally available and supported hardware. Also, packaged commercial software is often not locally supported and will require the use of international experts to install and support the software as well as train the personnel to use the package. Unless the software package is extremely well suited for specific needs, or the foreign distributor has a local vendor, it may be better to develop the applications software locally.

Minicomputers may reduce some of the local, hardware support problems identified with microcomputers, but the lack of applications software will probably require the agency to have available internal or consultant personnel who can program applications for the system. Minicomputer systems can be expected to continue to improve in both capacity and operational speed. Also, the cost of hardware should continue to decrease. However, it is uncertain whether more applications packages of interest to public administration will be developed.

105. Mainframe computers are the largest multi-user, multitasked computer systems. General purpose mainframe computers are a shared information resource used by the entire organization. In a government context, a single mainframe installation might provide an information system for a ministry, or possibly the entire government. Mainframe computers were commercialized in the 1960s with the introduction of the IBM 360 series computers. Those computers had a hierarchy of hardware, an operating system, applications language, special tools, and applications. Current versions of mainframe computers have much greater capacities and capabilities than their 1960s forerunners, and they share many applications with larger minicomputers. Mainframes are identified by their capabilities to support hundreds of end-users and run several different applications at what appears to be the same time. In many cases, current mainframe computers have several central processors linked together and controlled by the operating system. Although the cost of mainframe computers has dropped in recent years, a major installation's hardware suite still costs several million dollars.

Mainframe computer operating systems are very complicated, sometimes requiring many megabytes of memory just to load. The operating systems incorporate several layers beyond the control of the basic input-output and utility functions found in a microcomputer's disk operating system, such as MS-DOS. These layers include security and access, telecommunications, multitasking, multi-processor control, multi-user coordination, job prioritization, and output (print) queuing. To install and maintain a complex mainframe, the operating system requires specialized systems programmers, who work exclusively on operating systems to upgrade and maintain them. In a developing country, the shortage of systems programmers makes support of a mainframe computer very difficult.

Many applications programming languages and software engineering tools are available and under development that improve the efficiency and quality of applications programs used with mainframe computers. However, applications software development currently is the major limitation on many mainframe systems. End users can not use the systems without special applications programs to access the data, to conduct the analysis, and to prepare required reports. It is applications programming that creates the bottlenecks and frustrations in using information system dependent on mainframe computers.

106. The rapid development of the microprocessor brings a major acceleration of downsizing: replacement of traditional mainframe and minicomputers with micro-based alternatives. This trend also drives users to low-cost solutions based on PCs, LANs, network servers, and multiple microprocessor-based systems while causing a major fall in demand for traditional mainframe and minicomputer systems of an even greater magnitude than that which occurred in the mid-1980's. For example, in 1989 there were 27,274 IBM or compatible mainframes in the United States. By 1992, that number had dropped to 23,920. Many analysts anticipate even steeper declines in the next few years. As a matter of fact, downsizing marks the end of the first (traditional) era of computer systems and the beginning of the second (micro-based).

The downsizing can best be described as the process of migrating applications from mainframes to small platforms. Many users believe downsizing offers the promise of savings, better performance, greater ease of use and improved productivity. Obvious savings are reduced hardware costs. Other factors to assess are software licensing fees, applications-development costs, maintenance and support budgets, and personnel costs.

The intangible benefits from downsizing, however, are more important then those above-mentioned tangible ones. Downsizing provides a better, more-responsive way to run a business, for example, the ability to change the software rapidly to support changing business requirements. Perhaps one of the biggest benefits of downsizing is the opportunity it provides to incorporate new technologies on the network. Multimedia applications, wireless technologies, pen-based systems and other advanced products are very expensive to implement on a mainframe, if they can be supported at all. Many of downsizing's benefits can not be quantified, but are significant nonetheless. They include desk-top control, rapid data access and user-modifiable applications.

Of course, it is valuable to note downsizing's downside. The greatest difficulty is with people-related issues. This stems from fear of job loss, coupled with ignorance of the new environment. A second problem is the limited availability of knowledgeable people. The lack of skilled people is identified as the single most critical problem. Another problem is the relative immaturity of networking products. In the LAN world, unlike the mainframe world, there are no large vendors carefully ensuring that all products work together.

Consequently, downsizing is a process and can not be done in one night. It is critical not to underestimate the complexity of the transition to the new environment. Downsizing demands quick reflexes, good instincts and decisiveness. In addition, the strategy for downsizing needs to be carefully designed.

5.4 Optical Storage Technology

107. Compact Disk Read-Only Memories (CD-ROMs). CD-ROMs are one of the best ways to provide access to and deliver enormous amounts of information. However, CD-ROMs are read-only, so users cannot update their data stored in the CD-ROM. Government documents, laws and rules, archives, references, education, and other audio and video records are especially good candidates for CD-ROM media because they typically have large amounts of content and are often embellished with graphics and sound. As an inexpensive way to distribute mass amounts of information, CD-ROM can hold around 680MB of information, and cost as little as $ 1.50 usd each to produce. A single 4.72-inch CD-ROM disk can store an enormous amount of information, for instance, 19 hours of mono audio, 7,000 photographic quality color pictures, 300,000 typed pages, 72 minutes of video, or, any combination of the above. Hence, CD-ROMs are the right media for multimedia, which combines sound, text, graphics, and animation. At present, most commercially available CD-ROM players are DOS-compatible and meet the Multimedia PC (MPC) Marketing Council's sustained data transfer requirement of 150 kilobytes per second (Kbps), and use a SCSI

(small computer system interface) or proprietary host adapter.

Currently, CD-ROMs take two distinct approaches to coexisting with the limits of today's technology: low tech or high tech. The low tech route uses low resolution, few colours, smaller pictures, slow, jerky animation, and low-frequency audio cut-offs so that pictures and sound take less space. This makes sense in certain reference applications where graphics and sound are secondary to content. The high tech products use a variety of space-saving methods. There are several new compression techniques, such as joint photographic experts group (JPEG), motion pictures experts group (MPEG), and fractional compression, that make it possible to store high-resolution images in less space.

108. Write Once-Read Many (WORM) System. WORM is a recordable CD. A WORM drive has a laser head that burns pits into the polymer disk surface. These pits, which indicate zeros and ones depending on the system, are read by another beam of laser light. Desktop CD-WORM recorders, as the in-house recording solution, are also available now with a price point where government agencies can afford to create and distribute a few CD disks in-house. However, there are limitations to the recording approach that is currently in use. Because of the relative lack of stability of the dye and substrate system, for instance, a user can not write over previously recorded portions of a disk. Furthermore, WORM recording must be made in a single pass (or single-session mode) in order for the information to be recognized by current players. For example, if you record 200MB of data on a disk and later decide that you need to add another 100MB of information - a so-called "multisession" recording - a standard CD-ROM player will not recognize all the data. If users are considering a CD-ROM recorder for applications such as archival backup and CD-ROM publishing, the user should also understand that CD-ROM recorders are not standard DOS storage devices. For these purposes, appropriate software must be selected to carry out the job.

WORM's fundamental disadvantage also is its principal advantage - once burned, a WORM disk is unchangeable. This makes it perfect for storing big files that need not, or should not, be changed.

109. Rewritable Optical Systems. Clearly, it also would be useful to be able to store data optically while retaining the option of rewriting it when necessary. Two types of rewritable systems were devised for the purpose. The leading rewritable CD technology today, magneto-optical or MO, combines a laser beam with magnetization to write and then read data. A second type of rewritable drive employs a phase-change technique to encode the ones and zeros.

For users, the trade-off between MO and phase-change rewritable systems are subtle but significant. Because phase-change requires only one pass to encode data, it is faster. However, MO disks are more stable, allowing up to 1 million rewrites compared with about 10,000 rewrites for phase-change disks.

110. Multifunction Writable Optical Drives. If the data merely needs to be recorded and filed in an efficient and temper-proof manner, a WORM drive could do the job. If some of the data needed updating occasionally, even frequently, users may want to turn to a rewritable optical

system. To get the best of both worlds, government organizations in industrial countries are experimenting with multifunction optical drives that combine WORM and rewritable functions in a single unit. Multifunction drives have the erase and write-over features of rewritable drives along with certain specialized functions of WORM drives. Though they may never entirely supplant either category of drives, they are earning popularity with users who value flexibility and savings: one drive does the work of two.

Multifunction optical technology began, for all purposes, in 1982 when compact disk audio systems hit the mass consumer market. Thereafter, large amounts of digital information stored on compact disks read-only memory (CD-ROM) disks became increasingly readily available. At least in theory, data from virtually any medium can be written or "mastered" onto compact disk and read by any computer with a CD-ROM drive.

Until recently, only a handful of drive makers sold multifunction drives, more or less as sidelines to their WORM and rewritable lines. But the market has grown tremendously since 1994. There are now more than 50 mature multifunction drive systems available on the market, most of which come equipped with software drivers and SCSI attachments at prices that rival those of standalone rewritable or WORM systems in 1993.

The optical platters, now mostly in 3-1/2- and 5-1/2-inch form factors, are impermeable hard plastic, removable and easily stored, and with a shelf life estimated at 30 to 50 years. These drives give fast data access and transfer rates comparable to those of tape subsystems. Prices of optical drives have continued to drop to as low as $2 usd per megabyte stored. Best of all, the per-disk storage capacity ranges from about 128MB for low-end, 3-1/2-inch rewritable systems to 1.3 gigabytes and greater. Storage capacity to 100GB or more is possible with a jukebox or optical library arrangement of platters.

111. Optical technology will not eclipse tape subsystems or removable hard drives in the near future. When all factors are weighed, each type of storage system has advantages and drawbacks. Some of the drawbacks include WORM technology's inability to change a master file once it has been written. Also, rewritable drives are just as susceptible as magnetic hard disks to viruses and other data corruption. Multifunction drives cost more than rewritables or WORMs, and there is no ironclad guarantee that different makers' drives can read either rewritable or WORM formats.

Multifunction optical drives provide a number of benefits, including:

- Virtually unlimited write/rewrite cycles without negative effects on the optical disk.

- High storage capacity of 128MB to 10GB or more.

- Virtually limitless capacity in jukebox format.

- Portable, easily removable, and replaceable disks.

- Negligible risk of head crashes.

When selecting multifunction drive, the following aspects should be carefully evaluated:

(a) *Equipment*. As a SCSI device, a multifunction optical drive requires a SCSI host adapter card in users' computers, SCSI cabling, a device terminator and SCSI device driver software. Most multifunction drive makers build these into the base price of the unit.

(b) *Compatibility*. Though some drives are tailored to specific platform, all are compatible with any platform with a SCSI port-if the correct driver software is installed.

(c) *Capacity*. Multifunction units handling 3-1/2- and 5-1/2-inch platters are the most popular. The smaller disks store 128MB to 256MB while capacity on newer disks is starting to grow. The large disks hold 650MB to as much as 1.3GB when both sides are used.

(d) *Access/seek time*. This tells users how quickly a drive can move its read/write head to a particular disk sector to fetch data. Average access time for a 3-1/2-inch multifunction drive is 33 to 40 milliseconds. A 5-1/2-inch disk can take 40 to 60ms or more, because it is larger and holds more data. (Hard-drives have access time of 5 - 10 milliseconds.)

(e) *Data throughput rate*. DTR ranges from 500K/sec at the lower end to 10M/sec or more. A DTR of 1M/sec to 2M/sec is typical and adequate for most users' needs.

(f) *Buffers*. As with standard hard drives, a data buffer is desirable to store data temporarily until your CPU can process it. Some drives offer as much as 4M of buffering.

(g) *Setup and installation*. Specific driver software for your unit is better than generic software. Look for driver software that automatically defines the interrupt and I/O channel settings.

5.5 Multimedia Technology

112. The first computers dealt only with alphanumeric information. Early microcomputers added the ability to work in a graphical mode, but typically only at a lower resolution that was not sufficient for text. Programs such as the early version of Lotus-123 are prime examples of applications bumping up against those limitations: the user could display text and numbers in one mode, but had to switch to another mode to see graphs. As graphical user interfaces became

popular, first on Macintosh in 1984 and later on the PC (particularly with the introduction of Microsoft Windows in 1986 and even more so with Windows 3.0 in 1990), users began to see applications that could display both text and graphics simultaneously. In addition, more environments and applications began to offer a WYSIWYG (what you see is what you get) display of multiple typefaces, styles, and sizes. At the same time, peripherals that more practically allow the input and output of graphics as well as text, such as mice, scanners, and laser printers, began making an impact on the computer industry. The past decade brought users hyperlinking - nonlinear navigation through information - and object orientation, which makes complicated operations accessible with point-and-click ease. Once users could easily navigate information and had access to more powerful hardware, the users began to want more sophisticated applications that combine analog and digital video, computer graphics, and sound, i.e., multimedia. That is how multimedia became one of the hottest topics and main trends in the development of information technology.

113. By bringing sound, animation, and digital video to the desktop microcomputers, multimedia will dramatically change the way people think about and use computers. Multimedia applications go beyond today's typical combinations of text and graphics software by adding sound, computer graphics (especially animation), and support for analog and digital video. They run the gamut from talking reference books and documents, to databases that store video images, to applications that help users create music and other programs. Running these applications requires a multimedia microcomputer - one equipped with extras such as a fast CD-ROM drive and sound boards capable of MIDI (music instrument digital interface) or waveform audio. By today's terminology, the advanced hardware described in the previous paragraphs all qualify as multimedia offerings. CD-ROM disks that can store large amounts of computer graphics and video and sound boards are generally accepted as multimedia hardware, as are machines and upgrade facilities that contain one or more of those components.

114. The current standard for a multimedia PC (MPC) machine may require the following equipment. For even the most basic creation and playback, a microcomputer with enough power to handle large amount of graphics and sound will be needed, for example, an 80386 processor with at least 4MB of memory, or better. A graphical user interface for most applications will also be necessary. To date, many new microcomputer multimedia applications require Multimedia Windows (i.e., Microsoft Windows with multimedia Extensions 1.0). Since sound and graphics take up a lot of space, and digitized video takes up even more, a fast CD-ROM drive is needed. In addition, a decent video board or new graphics accelerators will be necessary to display graphics. For more sophisticated work, users may want a board designed to connect the microcomputer to an NTSC (national television standards committee) or PAL (phase alternate line) video source, such as a video camera or VCR. For audio, users will need at least basic digitized audio capabilities, and possibly MIDI connections for creating or editing the user's own music.

115. A number of tools can be used to create multimedia, but the most powerful of these are authoring systems. Two things can be done well by multimedia authoring programs. First, they let users build complex productions that combine text, graphics, sound, animation, and video elements. Second, but equally important, they provide a navigational framework for these

elements, usually in the form of some sort of hyperlinking system. Multimedia authoring systems currently are still large applications and require serious training, but they are becoming easier to use as time goes on. Multimedia authoring system software that is commercially available mainly comes with three different types of tasks: presentation - creating linear presentations integrating text, graphics, animation, and sound; computer-based training - assisting in the construction of a complex interactive program; and a kiosk-type application - adaptable to a public access terminal application. As multimedia becomes a part of the day-to-day work environment, these packages will play an increasingly important role.

116. Multimedia technology available today is still in its infancy. The current intention is to create a standard platform for applications and a multimedia programming interface. In the future, it is expected that sound and video will become a standard part of applications, such as word processors, spreadsheet, and graphics programs. Users will be able to insert animations into a word processing program and put voice annotations into a spreadsheet or a E-Mail massage. Finally, computer users will find that high-resolution graphics and video, animation, and sound capabilities are a part of all machines and all applications, and multimedia will just be a part of a standard platform.

117. Multimedia, the use of voice and images (video and graphics), is finding its way into application portfolios as organizations re-engineer their business processes. Imaging allows an organization to convert paper files into computer images that can be searched, sorted, and retrieved and is a relatively inexpensive way to process documents while they are in an active cycle. Imaging is being used by insurance companies and banks to support their paper-oriented processes. Other industries are now using the technology to automate the paper process across LANs and WANs.

Imaging can use standard micros and run on standard networks. Industry standards are already in place and the price of imaging is coming down, both for installation and per-transaction (retrieval) cost. But there is a down side. Multimedia applications require large amounts of storage and high-bandwidth for transmission, and the application development tools are just now emerging. The justification of multimedia lies beyond just seeing and hearing video and voice. Multimedia's benefit is that it provides access to information that is available in video or voice form.

The use of multimedia technology in public administration obviously has great potential, simply because public administration and management deals with tremendous amounts of signatures, photographs, images, graphics, sounds, and motions, in addition to text and data. But, for developing countries, the limits of national telecommunications network bandwidth may be a problem.

CHAPTER 6

DEVELOPMENTS IN SOFTWARE TECHNOLOGY FOR MICROCOMPUTERS

6.1 Operating Systems

118. Interposed between a computer system's built-in primitive instructions and the application software that interprets user commands into computer activities is the operating system. An operating system is the lowest level of computer software with which the user directly interacts. The function of the operating system is to process user commands and supervise the internal activities of the computer.

At present, the predominant operating system used with the IBM PC family and its clones are various versions of Microsoft Disk Operating System, usually referred to as MS-DOS (if supplied by Microsoft) or PC DOS (if supplied by IBM). With over 50 million users, DOS has become an industrial standard. MS-DOS was developed in the late 1970s and has been under continues modification and improvement until the present. DOS 5.0 was the first DOS update by Microsoft programmers since DOS 3.3 in 1987 and also the first DOS version that could take any significant advantage of the extended memory available on 80286, 80386, and 80486 computers. The DOS 5.0 kernel had been restructured and streamlined so that less RAM (random access memory) is needed than its predecessor. The DOS 6.0, released in early 1993, can double computer hard disk capacity, manage memory, back up files, and protect against viruses. The latest version of MS-DOS is the DOS 6.22, which was released in early 1994 and includes new commands and programs that make using PCs easier and more efficient. The major technical problems with DOS are the direct access memory limitation of 640 KB and no facility for multi-tasking (running more than one program on the system at one time).

119. In 1987, IBM and Microsoft announced a replacement operating system for MS-DOS, known as "OS/2". This operating system was to provide full software access to the capabilities of the Intel 80286 family of microprocessors used in IBM's PS/2 microcomputers and allow upward migration of MS-DOS applications software to OS/2, plus support multitasking. However, IBM and Microsoft split and went their separate ways.

Microsoft introduced Windows 3.0 in May 1990, which does not replace DOS but extends it into the realm of multitasking, windowing, and graphics. Window 3.0 fundamentally changed the way people think about desktop computing. This DOS-based operating environment had been in productive use since its release. Windows 3.1, released in late 1992, did not substantially change the core features of its predecessor but resulted in dramatic gains in performance and reliability. Since then, developers have produced a huge and impressive collection of applications, utilities, and driver devices for use under Windows 3.1, not only in major application areas such as word processing and spreadsheet programs but also in critical utilities such as tape drive support, backup programs, system diagnostic tools, and system automation tools.

Windows NT is the first 32-bit windows operating system and a powerful high-end desktop operating system that features powerful networking support. Unlike Windows 3.1 which sits on the top of DOS, Windows NT completely replaces the DOS operating system. By removing the memory-addressing bottleneck that has plagued DOS for years, Windows NT provides a variety of new features, including preemptive multitasking, multithreading, multiprocessor support, operating platform portability, networking, and improved security and data protection. Windows NT demands a lot of hardware for its advanced operations. The system requires at least an 80386 or 486 CPU, and cannot be installed on an 286-based computer. Microsoft recommends at least 16MB of RAM, although NT can run in 8MB. Hard disk storage requirements are large. NT requires 30MB of free hard disk space to install system files, plus space for swap files; in all, 70MB of storage space is required. Completely reengineered and leaving its DOS roots behind, Windows NT has become the leading contender for the next generation operating system market.

The newest version of Windows NT, Windows NT Workstation 3.5, was released in 1994. Windows NT 3.5 runs in 12MB of RAM, as compared to the 16MB required by Version 3.1. The operating systems works well with most Windows and DOS software, although there are exceptions: notably things like screen savers and MS-DOS programs that demand direct access to system resources. NT also delivers on its promise of connectivity. The package ships with client software for Microsoft NT server, Novell Inc.'s NetWare and TCP/IP. Any or all of these can be set up during the installation process, which is almost completely automatic. The NT installer identifies the network card, determines the hardware settings and then asks for configuration before installing the network drivers. Once installed, NT operates seamlessly in a network environment. The client can work seamlessly with different servers. NT's reach goes beyond networked file servers: It also supports limited peer networking. Users can exchange directories and files available with their colleagues on the network and share other attached services, such as printing. Hence an NT workstation could act as a print server for several workstations, for example. Unfortunately, Microsoft has limited the number of peer connections to 10. In addition, the full 32-bit Windows NT applications, including the new version of Microsoft Word and Excel, run significantly faster than their 16-bit counterparts.

Windows 95, the most significant upgrade to the Windows interface since Version 3.0 came out in 1990, is going to be released in the second half of 1995. Windows 95 is a 32-bit, multitasking, multithreaded operating system that allows users to run 32-bit applications. It can control multiple programs at once, and each program can have multiple concurrent threads, or independently executing subcomponents. The major changes implemented in Windows 95 include: the user interface, underlying architecture, and networking features.

Windows 95 brings to users the advantages of an object-oriented interface, including a true desktop and icons, drag-and-drop copy and delete, nestable folders, and easily accessible property dialogues. The file system supports long file names (as long as 255 characters) and is well integrated with the folder/desktop metaphor. The system can scan all or part of a disk for files matching specified criteria, including embedded words and phrases. The most significant architecture innovation is that DOS and Windows are now combined as one operating system. Windows 95 offers a 32-bit applications programming interface (API) which could result in faster execution of 16-bit and 32-bit applications. Unlike Windows NT, Windows 95 does include a DOS component - effectively MS-DOS 7 - to ensure backward compatibility. Windows 95 comes as a client for both NetWare and Windows networks and includes the NetBEUI, IPX/SPX, and TCP/IP protocol stacks. Windows 95 also comes with the software to act as a server on a Windows network, providing peer-to-peer networking services.

Windows 95 includes a number of features that have been in the standalone utilities, such as disk scanning, remote-node software, and a disk compression utility. But, some utilities that were part of DOS 6.0, such as an antivirus utility, are not a part of Windows 95.

A Windows 95 system, according to Microsoft, requires at least a 386DX processor with 4MB RAM, but a 33-MHz 486 with 8MB RAM is recommended. In general, 16MB of RAM is necessary, particularly if user plans to run multiple applications. Windows 95 takes up 40MB of hard disk space for installation, some 15MB more than Windows 3.1. For larger applications, a provision of at least 250MB hard disk should be made.

It is expected that Microsoft will merge the Windows NT and 95 operating systems in the future.

120. After several years of stagnation, OS/2 2.0 was finally released in March 1992. While OS/2 2.0 was touted as the first 32-bit operating system designed entirely for Intel-based PCs, the initial release was actually a mixture of 16-bit and 32-bit modules. The operating system kernel and file system support were 32-bit but the Presentation Manager GUI (graphic user interface) and the Workplace Shell (the primary user interface) were still 16-bit programs. Its upgrade, OS/2 2.1, was introduced in 1993. The changes from the last version are mostly incremental, including Windows 3.1 compatibility (enhanced mode), multimedia support, better control over DOS and WIN-OS/2 sessions, and support for a broader range of peripherals. System requirements for OS/2 2.1 are almost the identical to those of Version 2.0's: a 386SX-based PC or

better is required, with a minimum of 4MB RAM. The operating system itself takes up 3MB to 5MB more disk space than the version 2.0, depending on user's options; about 35MB for a full installation. At least 8MB of RAM are recommended to avoid system slowdowns.

OS/2 version 3.0, dubbed OS/2 Warp, was released in October 1994 and also known as a 32-bit, preemptive multitasking, multithreading, and an object-oriented desktop operating system. The Bonuspak's utilities include IBM Works (an integrated entry-level integrated software package) and the Internet Access Kit, which is the most complete set of Internet tools yet shipped with a PC operating system. Hardware requirements include Intel 80386 microprocessor; 4MB of memory; 35 to 50MB of disk space, plus upto 30MB for BonusPak applications; DOS and Windows required to run DOS and Windows applications. In February 1995, IBM shipped OS/2 Warp 3 Full Pack, which includes the Win-OS/2 libraries. These give users the ability to run Windows software without having to own licensed copy of Microsoft Windows. OS/2 Warp is positioned as a "here today" alternative to Microsoft's Windows 95. IBM is now focusing on several new versions of OS/2 that each offer a dose of networking features. The first new OS/2 Warp version, Warp Connect, will include the most important network drivers and utilities, such as peer-to-peer networking, a remote access client, and a Lotus Notes Express client.

121. Apple Computer has used a number of different operating systems with the Apple II family of computers. They include several versions of Apple DOS and ProDOS. Apple's operating systems are keyboard command driven and suffer from problems of user friendliness similar to those of MS-DOS. Apple's Macintosh line uses a proprietary operating system, known as "Macintosh System", such as Macintosh System 6 and System 7. This operating system is the first one to allow the user the choice of accessing the operating system's functions and utilities with the traditional command line or a mouse pointing device in conjunction with screen pictographic representations (icons) of the desired activity. This graphic approach to command selection and execution has greatly simplified user access to the operating system. Recently, A/UX has been developed as Apple's implementation of the industry-standard UNIX operating system. With A/UX, a user can get a UNIX open-systems solution and all the advantages of Macintosh. Macintosh with A/UX can simultaneously run Macintosh, UNIX, MS-DOS, X Window System (an industry standard protocol of displaying high resolution images from many types of computers), and Motif Applications - each appearing in a separate Macintosh Window.

As an effort to provide open systems desktop users with a low-cost Macintosh solutions, Apple Computer released its Macintosh Application Environment (MAE) as Apple's first cross-platform software. The MAE includes the System 7.1 Finder, the Macintosh graphical user interface, and the Macintosh desktop; and provides compatibility with off-the-shelf Macintosh System 6 and System 7 applications as well as innovative features that integrate the UNIX and Macintosh environment. The MAE works with the industry-standard X Window System running on UNIX workstations so that users will benefit from the convenience of using the Macintosh interface to manipulate and navigate the UNIX file system and to take advantage of enhanced graphical hardware functionality, color support, and networking features.

122. UNIX was originally developed at Bell Laboratories in 1969 for internal use. It

provided for multiuser, multiterminal applications as well as for concurrent processing of different applications on the same system. In UNIX, the operating system itself supports many operations that were traditionally confined to applications programs such as word processing and editing, screen formatting, terminal-to-terminal communications, and even type-setting. The housekeeping functions of UNIX alone make it more like an integrated applications package than a straightforward operating system. Also, everything fits together well. This, however, is what makes the system difficult for novice users to master.

UNIX stands between large, complex mainframe operating systems and small, primitive microcomputer operating systems. Traditional mainframe operating systems have attempted to meet almost all user needs. These systems are highly optimized for particular hardware architectures. They have been developed by thousands of programmers over many years. As a result, these systems have many features built in which are not present as a standard part of UNIX. On the other hand, these systems tend to be complex and unwieldy in comparison to UNIX, and they are tied to individual proprietary machine architectures. In the microcomputer world, UNIX systems compete with other generic systems such as MS-DOS. Here UNIX has a more advanced set of features, such as multiuser support, while MS-DOS is much simpler in conception and resource requirements, which makes it more suitable for the lowest price mass-market microcomputers. MS-DOS is portable to machines that share the Intel machine architecture. UNIX is portable across architectures, which allows it to run on all of the major microprocessor chips, as well as on minis and mainframes.

The evolution of UNIX was divided into several distinct "flavours" for different hardware platforms. The Xenix, from Microsoft Corp., became the first 32-bit operating system for machines based on Intel microprocessor. Berkely UNIX, developed by the University of California at Berkeley, has been very popular on many high-powered minicomputer platforms. UNIX 2.0, the predecessor of the currently popular System V UNIX from AT&T, received the most attention and is today's standard for UNIX systems based on Intel chips. With the advances Intel made, the future of UNIX on non-Intel platforms may rest with Intel. The tons of software one can purchase for an Intel-based system - including the UNIX operating system and UNIX applications - may make Intel the best value in the UNIX arena of the future.

IBM has implemented its own version of UNIX - AIX, which is used on IBM workstations. An emulator will allow AIX to run 80x86-based DOS and Windows applications. The PowerOpen is the PowerOpen Association's specification and based on AIX. An optional MAS (Macintosh Applications Services) architecture will let PowerOpen run 680x0- or MPC601-based Mac applications. "Solaris" is the flavour of UNIX from SunSoft, a subsidiary of Sun Microsystems, which has its own GUI (graphic user interface) and will be ported to the MPC601 with Motorola's assistance. Solaris that allows UNIX systems to run 80x86-based DOS and Windows applications will be available as a option.

The foremost and most convincing reason for users to consider using UNIX is that the operating system has built-in multitasking capabilities. Although Windows NT and OS/2 both have this ability, UNIX's multiuser capabilities still is better than theirs. This feature means that a 386 or better PC can support as many as 120 users simultaneously, in much the same manner that a minicomputer can. And, all of the processing takes place in a PC on a single CPU. Another strength of the UNIX system is its unparalleled portability, because it runs on many different platforms.

The most important trend in the UNIX arena - one essential for UNIX to become a mainstream operating system - is the evolution of UNIX's GUI environment. With a number of sophisticated GUI-based UNIX systems on the brink of release, users will soon be able to reap the benefit of a true 32-bit multitasking operating system without sacrificing the creature comforts of a GUI or leaving users' favourite DOS and Windows applications behind. But, it is not clear what will be the standard GUI.

However, users must be aware that UNIX is not an operating system for everyone and every application. Many of the advanced features of the UNIX operating system are too difficult to learn. Moreover, the minimum system requirements that the most advanced products demand may make a move to UNIX quite expensive. Most of the UNIX products need at least 8MB of RAM and as much as 100MB of disk space just to get the operating system and GUI up and running. At least a 386DX-based PC is needed to get by and, in many cases, a 486 is recommended to handle the UNIX operating system. Another shortcoming of UNIX is that it is not as application-rich as DOS and Windows. Therefore, only for those organizations looking for a true multitasking, multiuser operating system with superb connectivity, multiplatform support, and mission-critical stability, is the commitment to UNIX a viable option.

123. 32-bit Applications. Handling data in chunks of 32 bits allows operating systems to use hardware more efficiently. 32-bit applications can be faster than 16-bit ones thanks to higher data throughput. The latest 32-bit operating systems have the following features:

(a) *Preemptive multitasking*. Multitasking means more than one application can run at once. Preemptive multitasking creates, in effect, CPU time sharing so that applications can share the CPU cycles available.

(b) *Multithreading*. The ability for the system to execute multiple tasks simultaneously. A thread is the smallest unit of independently executable application program code. An application may have multiple threads. 32-bit operating systems multitask at the thread level, allowing users to have multiple tasks processed simultaneously.

(c) *Protected mode operation*. In the past, if an application failed, the operating system would often crash, primarily because 16-bit operating systems ran in the same address space as the applications. 32-bit operating systems tale advantage of the protected mode capability built into PC hardware, allowing the operating system to run separate from the applications. What this means is that if an application crashes, the operating system is protected from that error and continues to function and execute other applications.

(d) *Flat model memory*. 32-bit operating systems also manage memory more efficiently. Memory is managed using a so-called "flat" model, which is a single unified address space. With flat memory, application developers can spend more time writing application functionality, as opposed to managing different levels of memory, as required for DOS applications.

(e) *Security*. One of the other big benefits many of governments customers cited is that 32-bit operating systems provide users with higher level of security.

Not all the popular personal productivity applications need to be re-engineered to take advantage of 32-bit environments. The following checklist for migrating to a 32-bit environment is provided for the consideration of systems developers:

(a) Do you have the right hardware? Minimum standard for running 32-bit applications on the desktop is a 25-MHz 386 microcomputer with 12MB of RAM. For better performance, most vendors recommend at least a 33-MHz 486 microcomputer with 16MB of RAM. Hard-drive requirements vary by operating system and the applications you plan on running.

(b) Do your users have a CD-ROM drive, or do they have access to a CD-ROM drive on the network? Since many of the 32-bit operating systems and applications are distributed in CD-ROM, having a CD-ROM drive available will make life easier for your users.

(c) Are your peripherals and other hardware compatible with the operating system you selected? Most 32-bit operating systems have a hardware compatibility list you can check.

(d) Which users need the power and support required of a 32-bit operating system? To determine this, ask yourself which users can not afford any downtime, or need the increased networking, security, reliability and performance.

(e) If you are developing applications, what compilers and development tools are available for the new operating system?

(f) How many commercial off-the-shelf 32-bit applications are available for the new operating system?

(g) What level of training or re-training will be required to make users comfortable with the new operating system? What is the quality of the training manuals, documentation and support available from the vendor?

124. Supermicros use multiuser operating systems. Commonly, this is a version of UNIX, but other operating systems, such as DEC's VMS, are available. Multiuser operating systems are

larger and much more complex than those in single-user computer systems. Because of the complexity of multiuser operating systems and their difficult user interface, specially-trained systems personnel are required to install and maintain both hardware/operating systems and any applications software.

6.2 Programming Languages

125. Programming languages convert human-readable commands into instructions that computers can execute. This is normally a two-step process. The programmer prepares a set of commands, called "source code", using a text editor program or editor built into the language. This source code is then interpreted and executed one instruction at a time, or the source code is compiled into a machine-readable object code which is then executed. Programming (preparation of computer instructions) is an acquired skill much like reading and writing, but instead of allowing communication with other humans, programming allows a programmer to communicate with a computer. Knowledge of programming is not necessary to operate a computer or to run a specific application; however, if the user wishes to instruct the computer to undertake special or unique operations, then knowledge of programming is needed. There are over 1,000 different programming languages now in use although only a dozen or so are commonly used. These can be roughly classed into three categories - sequential (nonstructured), structured, and object-oriented. Many programming languages are designed specifically to create certain types of computer applications.

126. Sequential languages are first and second generation programming languages, such as Fortran, Cobol, and Basic. Their strength lies in the relatively simple translations of stepwise processes into computer algorithms for an application. When complex applications are prepared in these languages, errors in the source code are difficult to identify and remove. This increases the programming time and reduces programmer productivity, which increases the cost of the application. Also, sequential languages are hard to use when parts of the program are prepared by different programmers.

127. Structured languages are made up of named source code modules for each function the program is to perform. The programmer prepares these modules, sometimes called "procedures", and assembles them into the required operational sequence by listing the modules. The listing and modules are then compiled to create computer-readable object codes. The advantage of structured languages lies in the flexibility of using the modules in different relationships and combinations to build complex programs from standardized parts. Two of the most common structured languages are Pascal and C. The limits of structured languages are that they still require special training and skills to use. They have too complex a command structure for anyone but the professional programmer or dedicated amateur to remember and use efficiently. These limitations, which hamper the easy use of any general purpose programming language, argue strongly for specialized languages that closely relate the field of application to the language, thereby making it simpler for a nonprofessional programmer to instruct the computer. To date, most high-level applications languages for use by nonprogrammers are found in association with specialized

applications programs, such as spreadsheet, database managers, and computer-aided design (CAD) software.

128. New versions of existing programming languages and entirely new languages are constantly under development. A new family of programming languages, called "object-oriented", has been developed and is available for microcomputer operating systems.

An object class is any thing, real or abstract, that has a specified behaviour. In object software, a class is a data structure definition, the code (functions) for operating on that data, and a list of services that can be performed on, by, or for the class. Instances of a class are called objects. The software representing the object contains the data structure and methods (procedures) that express its behaviour. Encapsulation combines data and the functions that operate on that data into a self-contained object. An object may consist of many other objects, which in turn may consist of other objects, and so on. Object-oriented design tools store the software for the objects in a repository as reusable objects, which include screens, icons, tables, coded procedures, and dialogue boxes.

The methods in an object can manipulate only the data structures of that object. This protects the object's data from corruption by other objects and simplifies design requirements because each object controls access to its own data.

An object can send a message to another object in order to use its data structures. The message causes the invoked object to behave in a specified way, which may include returning a value to the calling object. Another aspect of object technology, called polymorphism, allows single functions to behave differently, depending on the context in which they are used. For example, if the OPEN function is sent to an application object, it would start up the software and begin the application itself. If the OPEN function is sent to a file, it opens the file for access.

Another important concept of object technology is inheritance. Objects belong to hierarchical classes, such as parent and child. The child inherits the properties of the parent and may have additional properties of its own. Some classes inherit properties from more than one parent. A subclass does not necessarily inherit all the methods and data structures of its parents.

Most application and software designs require that reusable code be modified to fit the current application. Developers need to be able to override some inherited characteristics. The same message can communicate with the object even if some of the parameters contained in the message are changed. The object would adjust its actions based on the content of the message.

Object-oriented languages offer greater ability to program by establishing classes of entities and functions and by specifying relationships between entities and functions as hierarchies. These types of relationships, which tend to typify the natural environment, have been difficult to address with structured and nonstructured programming languages. Object-oriented analysis and design tools will allow software and application developers to design and build software from reusable components. Object technology can be used to quickly produce applications that contain easily maintained code. The most common object-oriented, general-purpose microcomputer programming language is Smalltalk. C++ is an upward-compatible extension of C with facilities for object-oriented programming. The use of C++ is now spreading quickly and new tools for C++ program development are being brought rapidly into the market place.

129. Development of microcomputers with large memory capacity and high processor speed has led to the introduction of fourth generation programming languages for microcomputers and specialized languages for artificial intelligence research and development. Fourth generation languages are used for the development of very large and complex computer applications. They incorporate the concept of the operating system, structured and object-oriented general-purpose applications languages, and the software support tools for the programmer into one large programming environment. Several fourth generation programming languages are available for microcomputers, the most common being ADA, developed for the complex programming tasks of the United States Department of Defense.

130. Two major trends mark programming languages - the development of specialized languages for different types of applications and the emergence of a programming environment to support applications development with general-purpose languages. As microcomputer applications become more specialized and varied, general-purpose languages seem to be less and less suited for divergent programming tasks. Specialized languages that reflect the operations required for a specific type of application, i.e., text handling, simulation, and artificial intelligence, have become more important. As far as programming environment is concerned, the development of a programmer's tool box, such as natural language input, may greatly ease problems inherent in programming in non-English languages and may reduce the specialized skills and training required to provide instruction to a computer. For the professional programmer, programming environments increase productivity and the complexity of programming tasks.

6.3 Applications Software

131. With regard to applications software, the biggest initial impact of stand-alone microcomputers came in four areas closely related to the automation of business and professional office functions. They were: word processing - the production, storage, and retrieval of correspondence and documents; spreadsheet - the automation of the ledger sheet and its manipulation; database management - the organization and presentation of interrelated data; and communication - interfacing the personal computer to other computer systems using telecommunications. The application software packages most in use are as follows.

132. ***Word Processing***. Word Processing is the most common application of microcomputers and is usually the first application to gain widespread acceptance in either a government organization or a private firm. The first word processor to gain popular use was WordStar, which was introduced in 1980 for the CP/M operating system. The number of microcomputer-based word processors has proliferated, and there are currently more than 100 available commercially. Development of word processing software has concentrated on improving

the ease of use, enhancing the number of editorial and text preparation functions, and increasing the speed of operation. The development of the laser printer and screen graphics has made possible the total preparation of documents, including graphics design, layout, typesetting, and printing. The last four operations, conventionally functions of professional typesetters and printers, have been incorporated into software called desktop publishing software. The evolution from word processing to document processing has finally led to the formulation of document production systems.

Word processors have been heading towards automation for a while: formatting user's documents, helping user build macro connections to other applications, and make most boring tasks effortless. WordPerfect and Windows Word are now the most popular software packages for word processing. Microsoft Word 6.0 for Windows automates writing and text formatting better than other word processors; its balance of row power and precise detail is unmatched; and its "Wizards" automates tedious tasks such as creating faxes, calenders, and reports. In addition, the product has a keyboard shortcut for just about any functions user would care to name, and its macro language, WordBasic, offers programming power unsurpassed by that of any rival. Wordperfect 6.1 for Windows adds support for Microsoft Corp.'s OLE 2.0, and uses OLE (Object Linking and Embedding) to integrate the word processor with other applications included in the PerfectOffice 3.0 Suite. This new product introduces PerfectSense, a new linguistic engine that understands words in context, and rewrites sentences using the grammar checker, Grammatik 6. The release also add several new Experts, automated task tools similar to Microsoft's Wizards, including a templates and a make It Fit expert that helps users shrink or expand documents to fit the given amount of space.

Word processing changes the way correspondence and documents are prepared and routed in an organization. As a minimum, the traditional paper channel is augmented by a magnetic channel, where documents are transferred from machine to machine on magnetic media (disks, streaming tape, etc). In governmental organizations with strict document control involving registries, word processing can subvert the system by making physical control of the document difficult. Hence, document control procedures must be modified to incorporate word processing, and procedures for handling documents in magnetic formats must be established.

133. ***Spreadsheets***. Spreadsheets are automated ledger sheets. They are equivalent to word processing but handle numbers rather than words. Spreadsheets were invented and first implemented on microcomputers in the early 1980s. They have revolutionized many applications involving the analysis of numeric data. Early spreadsheets allowed the end user to input data from the keyboard into an electronic ledger sheet that could automatically add, subtract, multiply, and divide columns and rows of numbers. Current versions of spreadsheets allow the implementation of a large number of mathematical and logical operations, incorporate many data management functions such as data sort and search, can be programmed to automatically carry out many data structuring and analysis functions, and graphically display data. Current versions of most spreadsheets are complex software packages, and their many functions must be well understood to be successfully employed. Complex analytical models and data sets must be carefully programmed and checked to guarantee that no error has contaminated the result. Therefore, the users of

spreadsheets must be well trained and aware of how the software works. In addition, error-checking of both data and model is a major limiting aspect of spreadsheets, since no method to identify non-logical data inputs or commands exists. Although most current spreadsheets software can read files from other spreadsheets, it is advisable to standardize on a single spreadsheets software throughout an organization.

Ease of use, scenario management, object orientation, and a better connection to the database are among the features that power a new generation of spreadsheets. With the introduction of extended-memory spreadsheets, Windows spreadsheets, and three-dimensional spreadsheets, the utility of this software should continue to grow. Integration of word processing, spreadsheets and data management functions into a single software packages makes the software easier to store data, extract a subset related to a specific problem, analyze the data, and incorporate the output information into a report.

The Spreadsheets market shrunk recently, with few vendors offering few products. But the ones that remain are easier to use and offer more data-manipulation features and database query tools than ever. Microsoft Excel, Version 5.0 offers lot of features. The depth and intelligence of the product show that Microsoft has figured out what spreadsheets users do all day and lightened their burdens. Its TipWizard tirelessly points out easier, more efficient ways to do user's customary tasks, while the Pivot-Table Wizard is a rich reporting and analysis tool that let users aggregate their data in a right way to see the relationships that matter.

134. ***Database Management System (DBMS)***. Database Management System (DBMS) is the third type of applications software to gain widespread use in microcomputers. DBMS software is used to manage data and to establish relations within large sets of data which are stored in more than one computer file. At the simplest level, a DBMS assists the end user to create forms for input of data to a file, to organize data for specific tasks, and to output data in user-defined reports. Where more than one file of data exist, DBMSs are used to establish relations between files and to access files to generate consolidated reports. DBMSs make it easier for end users and/or programmers to carry out data management functions associated with computing. Benefits of DBMSs include: organization of data requirements into a simplified structured data model; efficient data input and storage; improved data integrity and security; and easier, more flexible access to data by the end user.

Because of the large number of DBMS systems available commercially, it is often difficult for end users to choose a system that both meets their needs and is simple to use. This is made even more complex, because DBMSs to date are not end-user computing tools in the same sense as word processors. They are intermediate, high-level applications environments that make data management easier, but they require a more complete knowledge of computing than is necessary to operate a word processor. Another problem recognized is that it is unlikely that the same person who inputs the data (clerical or technical) would conduct the analysis or draft the reports. This means in stand-alone, single computer environments, either the machine with the DBMS software installed must be accessible to all elements of the staff working on a special project, or the database must be transferred from machine to machine. Both of those options involve problems of maintaining data integrity and ease of access. Local area networks are a solution to this problem.

DBMSs continue to evolve and are headed towards standardization for all major, current types of computer systems (micro, mini, and mainframe computers). One example of this is the widespread adoption of IBM's Standard Query Language (SQL) that allows end-users standardized access to the database. Also, commercial microcomputer DBMS companies have recognized the need to integrate word processing, spreadsheet and DBMS functions and have released products incorporating all three primary microcomputer applications. Nonprogrammable databases are another arena being rapidly developed now. These products currently are still well suited for simple tasks such as printing mailing labels and creating mail-merged letters, but many offer more advanced features such as security and connectivity to SQL databases, all without any programming. GUI support of Windows-based products in nonprogrammable databases has raised ease-of-use to new heights. For most applications, the full power of DBMS software is not realized unless organizations have access to larger, multiuser computers or LANs which tie together stand-alone microcomputers.

DBMS software packages have made lot progresses in recent years. "Lotus Approach for Windows, Release 3.0" is a kind of end-user databases that redefines the notation of what constitutes ease of use. Its clear tabbed interface let users navigate the product with ease, and its Assistant - Lotus's take on Wizards - are present in abundance to help users turn out forms and reports in record time. It is no developer's power tool, but it will get users up and running with basic applications, queries, and complex reports faster than other DBMS products. Microsoft Access, Version 2.0 is another end-user database and the most sophisticated developer's database on the current market, but the users are not necessarily to be a sophisticated developer to work with it. In fact, Access is the leader in engine-based data-integrity features. In addition, Sybase/Watcom SQL is also a good low-end DBMS.

135. ***Object-oriented databases***. As the next generation of applications incorporates increased use of unstructured data, such as text, compound documents, bit-mapped images, and graphics, relational technology begins to fall short.

Unstructured data does not fit neatly into tables. Data cannot always be represented as entities, attributes, and relations. Relational databases require data to be broken into separate tables for efficient retrieval. For example, an order might be broken into header information, which is stored in one table, and detail for each order item stored in another table. To review an order in its entirety, these two tables must be joined before data can be pulled from each one.

Object-oriented database technology is evolving rapidly. One of the major stumbling blocks is the retraining required to change from a procedural, row/record-oriented paradigm to an object paradigm. Despite the long learning curve, most industry analysts predict that object-oriented databases will replace relational databases just as relational databases have replaced hierarchical databases. At present, however, no object-oriented databases management systems are commercially successful.

136. ***Repositories***. When DBMSs were first evaluated by organizations, a great selling feature was the data dictionary, which provided standardization for the data and consistency for the programs that used the data. Repositories are an extension of the services provided by data dictionaries.

A repository is a collection (or warehouse) of objects, in object-oriented terminology; or definitions, in computer-aided software engineering (CASE) terminology. It stores common building blocks for applications and facilitates understanding and consistency of data and processes. An organization uses many tools to build applications: CASE software, 4GLs, DBMSs, and application development software. Since a repository is a warehouse, it should support the efforts of all development tools. However, today that is not the case. For example, it is difficult to find a CASE tool whose repository specifications can be used by another development tool.

IBM, with AD/Cycle, and Digital, with CDD/Repository, have tried to provide a common metadata model for repositories from multiple vendors. Neither product has been very successful in the marketplace. However, as more tools provide repository support and integration, applications will be easier to develop and maintain. New applications will be quickly built based on proven methods used in existing applications. The meaning of data will be consistent for all users on all nodes.

137. ***Office Graphics***. Just as word processor revolutionized documents, presentation graphics software has transformed the creation of visuals. When graphics packages first appeared, they were targeted to artists who turned out slides and overhead transparencies. As the programs became easier, they became accessible to the managers who generated the content and did the actual presenting. It can be expected that graphics software will become more and more popular in the governments of developing countries.

Use has soared as presentation software matured from its costly and somewhat clumsy beginnings in the 1980s. Graphic software has now become routine for users to make their own charts, graphs, and other visuals with the help of spreadsheet and scanned documents. With modern packages that have links between applications, these visuals can be reused, changing the content of one while simultaneously updating another. The extensive use of the office graphic software leverages the cost-efficiency of a wide range of internal and external communication activities.

Once presenters commit themselves to electronic delivery, they find it easy to make the transition to multimedia sound, animation and video, if they can get hold of the right equipment. With the thousands of 486 computers now being introduced to the governments of developing countries and the dramatic drop in sound board prices, it probably will not be very long before officers and professionals in developing countries have multimedia features. At the same time, presentations with all types of graphics could become more frequent and less formal, often just small staff meetings or one-to-one briefing. Some users may also call on their presentation software for project management and planning tasks. Using the built-in utilities for outlining, formatting and charting, users can bypass their spreadsheet and word processors to design briefings and management reports with far stronger visual impact.

The graphic software that is best for a government agency depends on the type of presentation to be done. Some packages are better at high-profile speaker support, others make superior meeting tools. There are packages that focus heavily on ease and auto-design features for beginners. Others presuppose a firm grasp of design and layout. As always, it is important to form a clear idea of users' needs before making selection.

The core features of graphics software fall into three areas: Content creation, integration and delivery. Products that fail to handle all three can not truly be called presentation graphics packages. Some products for multimedia integration, for example, lack basic outlining and sliding making utilities. They might be a best choice for multimedia screen-shows, but they will not deliver basic speaker notes and handouts.

The main features of office graphics software include: master slides and templates, charting and graphing, animation, painting and drawing, clip-art media, spell checkers, outlines (one of the common ways of structuring information of documents, reports and presentations), slide sorter (another way of organizing and reordering the information in a presentation), hyperlinks (short programming routines that let a screen-show presenter jump to any slide in any order at any time).

Some products provide OLE/DDE (Object Linking and Embedding and Dynamic Data Exchange) capability, which is essential if users plan to work with Windows multimedia. OLE/DDE import and export protocols let users embed an object - any media type - into a presentation from another program or link that object to the presentation. Embedding creates a complete version of the object in the presentation file; linking merely references the file in its other location and finds it at the time the file is called.

Another feature of graphics software to look for is good help for the novice. In the early days of presentation software, the learning issue was not as critical, because the users - artists and graphics professionals - were expected to put in the time to master the products. Now, with an entirely new generation of novice and casual users designing presentations, it is important that programs be as self-directing as possible.

Overall, it is not the number but the quality and applicability of features that matter users. The better a program is at importing different file types, the more access users will have to visuals and sounds. At the least, a program should import a range of spreadsheet and word processor file types, as well as all the major graphics formats. Ultimately, the most important thing in choosing and working with a presentation package is not power or size or features. It is improving users organization's communication with as little extra time and effort as possible. A presentation software package should be judged by how much it raises users productivity. The well-known office graphics software products include: Harvard Graphics 3.0, PowerPoint 4.0, Freelance Graphics 2.01, Stanford Graphics 3.0, and Wordperfect Presentations 2.0.

138. ***Integrated Software Packages***. Integrated Software Packages have blossomed into a

unique and powerful user-tool in recent years. Today, integrated software packages offer the promise of having "big name" functionality in a small package that saves disk space and yet is compatible with the larger programs. And the price is right: packages are available in the United States market for under $100 or $200 US dollars in most cases, far below the total cost of a set of comparable stand-alone applications.

The first generations of integrated software had strengths in one or two areas and may have had others tacked on. Today's programs, however, offer the kind of flexibility that is found in many stand-alone applications - and even some that a user might not think necessary. For example, some of the products run on both Windows and Macintosh programs and user can update a spreadsheet containing inventory figures for a given region. The programs will then automatically update a copy of that spreadsheet data, which exists as a table inside a word processing file. "Tight Integration" is one of the goals on which Integrated Software Package publishers are making efforts. Tight integration means that the program's components work together with a common interface, and, creating software new users can work with easily while the more experienced will not be bored by the program's interface.

As personal computers have become more powerful and graphical interfaces have become a de facto standard for many users, the nature of what constitutes an integrated software program has changed as well. Users who work with MS-DOS still have substantial offerings from which they can choose: Spinnaker Software, Microsoft, Borland, Enable, Lotus and WordPerfect are among the leading firms that offer an integrated program for MS-DOS systems. But the shift to Windows is clearly on. Many producers are concentrating on making their Windows programs more capable in a coming multimedia age when voice will count as much as text in integrated software.

Perhaps the greatest appeal of today's integrated software is the robust capabilities of its individual modules. While the word processors contained in these programs are constantly improving, the spreadsheet components are also becoming more and more powerful. These programs, commonly a subset of more powerful number-crunchers, such as Microsoft Excel or Claris' Resolve, deliver the kind of graphical formatting and numeric functionality that the big programs do. At present, the top firms offering integrated software for both the Macintosh and Windows have spreadsheet that include 100 different numerical functions and a what-you-see-is-what-you-get, or WYSIWYG, layout.

Overall, database modules for the top integrated packages are flat-file programs that build on the spreadsheet. Although it is easy to dismiss a flat-file database as being too simple for some tasks, for organizing mailing lists, inventories and other such files, its characteristics of ease-of-use make these programs still attractive and useful. Some of the packages, such as "Enable" and "Open Access IV" offer relational database modules, which can be programmed for more complex manipulation of information.

In order to provide a full range of services to users, most of the integrated products on the market offer some form of drawing or painting programs. Using up to 16 million colours under Windows or on the Macintosh, these components can be utilized to create presentations and charts, or to illustrate word processing documents. Many of these programs offer the graphics tools as separate components; others, such as Microsoft Works for Windows 3.0, offer drawing tools as a function under other applications.

Another area in which integrated software packages contribute is communications. On the Macintosh platform, most of the integrated packages offer a module that will make modem use easier; only Microsoft Works for Windows currently tries to improve on the "Terminal" program that comes standard with Microsoft Windows.

Integrated software will be further developed to satisfy the needs of users. The question is how much can be added without making the software too complicated. A smart implementation of features is extremely important. They need to be easily used, discoverable, if user can not find a function which is not relevant, and highly useful, and to have a complete cross-platform compatible solution.

More than a score of integrated software packages - from simple to complex - is currently available for MS-DOS, Windows and Macintosh users, such as ClariesWorks for Macintosh 2.0, ClariesWorks for Windows 1.0, Microsoft WORKS 3.0, Wordperfect WORKS 1.0, etc. Most of these have a common set of elements: word processing, spreadsheet, database, and communications functions. Many also include graphics tool drawing and painting on screen, while others offer relational databases and more powerful spreadsheet modules.

Generally speaking, integrated software is becoming the personal office for small business users, who are often comprised of individuals working by themselves, as opposed to those in offices who are increasingly found in workgroups. At a personal or small office, people on their own often need a set of applications and little in the way of file share and joint scheduling, unlike the workgroup users who need to be able to pass files around and coordinate schedules. In this sense, integrated software packages are very suitable to the computerization of small offices or local governments of developing countries, and for them, today's integrated software offers a quick and relatively easy way to do data/information processing they need. By contrast, a "suite" of applications, which includes stand-alone word processing, database, spreadsheet, graphics and electronic mail, is priced and aimed at those who need to automate a larger office or enterprise.

139. ***UNIX software for the office***. As client-server computing began to spread, UNIX broke from its image as a tool for scientists and academics. Since newer UNIX operating systems run on everything from portable computers to mainframes, PC software developers have taken a second look at the UNIX office market. Today, UNIX office software has a full range of office automation capabilities, from telephone messaging to electronic imaging. Integrated software with multiple functions such as word processing, three-dimensional spreadsheet and databases, is making a strong showing in the UNIX marketplace. Suites such as ApplixWare, Uniplex onto Office and IslandOffice have thousands of government users in developed countries. Work group software, popular in PC environments, is surfacing for UNIX platform as well. In addition to Lotus development's Notes groupware, Novell's GroupWise 4.1 offers a variety of office productivity functions, as well as work flow management.

140. To communicate over phone lines, a special peripheral hardware, known as "modem", and specialized software are required. Communication software packages set computer and communication parameters, send and receive communications between computers, and can store received communications to file. FAX software works with all the most popular fax boards to give users the most extensive PC faxing capabilities, including sending faxes, receiving faxes, OCR (Optical Character Recognition) faxes which can transform ordinary faxes into intelligent documents, and compressing faxes for easy, affordable archiving. Communications software ties together the two key technologies of the information age - computers and communications.

Public administration in developing countries has made very little use of the communications aspects of micro-, mini-, and mainframe computer applications. There are a number of reasons for this, but the main inhibitors appear to be both technical and organizational. The technical limits seem to be the generally poor quality of telephone lines and lack of reliable telephone service. Organizationally, national posts and telegraphs have been slow to provide the necessary connection facilities to allow the use of modems, and most appear to have less knowledge and understanding of the importance of data transmission and little interest in internal computer networks. Fortunately, growing use of data transmission by all sectors of the national economy has resulted in gradual improvement in data communication services in many developing countries. Access by government agencies to computer-compatible telephone lines and other equipment has increased as the mutual dependence of computers and communications has received wider acknowledgement.

141. Although rapid development of microcomputer hardware in the 1980s and early 1990s has not been equalled by the development of applications software, a number of new commercial applications packages have been introduced. They include software packages for: fonts and font managers, printing, desktop publishing, graphics and design, graphics utilities, charting, presentations, OCR (Optical Character Recognition), project management, CAD/CAE (computer-added design and computer-added engineering), multimedia and video, multimedia and CD-ROM (compact disk - read only memory), statistics and mathematics, finance and accounting, debt management, integrated planning and economic modelling, utilities, modems/fax, and various business software to name but a few.

6.4 Workgroup Computing and Groupware

142. In a broad sense, groupware is software that can improve the collaboration and communication among people working in groups. Groupware was created to enhance collaboration, communication and interpersonal productivity so as to increase the productivity or functionality of person-to-person processes. Whether the product is e-mail, workflow or conferencing, groupware is providing solutions to specific business problems.

Groupware removes geographical and organizational barriers that exist in a group. Workgroup computing, which uses groupware software, is a natural evolution from personal computing. It acknowledges that employees work in groups. As organizations group workstations into networks, individuals can easily communicate with others in their group. Groupware facilitates and formalizes that communication.

Groupware is not a new idea. Many of the technologies that compose groupware have been around for 20 years. Despite the availability of these technologies, however, groupware never took off in the 1970s and 1980s because the network infrastructure needed to support it was not in place. However, the necessary infrastructure exists now, and both public and private sectors are using groupware to restructure themselves for quality business performance or global competition. Groupware experts believe that most of the software in the year of 2000 will be groupware.

143. Groupware applications depend on an E-mail system to route messages, and rely on client/server architecture and distributed environments to provide the necessary division of data and labour. Groupware, however, goes far beyond E-mail communication, which is mostly one-to-one. For example, a project leader prepares a status memo which details areas of the project that are behind schedule. Under the E-mail paradigm, the project leader sends a copy to every member of the team. They each respond. But unless each member sends a response to all the other members, there is no peer-to-peer communication. If the response is copied (via E-mail) to all the other members, the network is tied up sending the same document to many people, and disk space is used to store redundant copies of each member's memo and the project leader's memo. Under the groupware paradigm, the project leader sends the memo to the group's database, where each member can access it, read it, and respond to it. Each member can read the other members' responses and, if necessary, respond. A log of the documents, which contains sender identification and the links for the responses, is maintained for future reference.

A groupware product can replace face-to-face meetings with computer-based conferences. Telephone conversations can be replaced with real-time computer-based discussions. In addition, spreadsheet, images, graphics, and other data can be included as part of a conference message. Groupware keeps all data (typically text or bit images) in a shared storehouse that can be organized from a number of different perspectives. Groupware software also supports private communication.

Just as the groupware market is emerging, different classification schemes are being used to size the market and position products. A the present, there are at least five categories of groupware products in development:

- E-mail/messaging, including calendaring and scheduling;

- Group document handling, including workflow, document and image management and group editing;

- Group decision systems, including audio and video conferencing, group decision support systems and shared-screen products;

- Workgroup utilities and development tools, including GUI development tools and groupware maintenance and development tools; and

- Shared-database products, including Notes, Oracle Office and shared-memory products.

144. In LAN-based E-mail systems, the server maintains the directory, or address book, of users' addresses. The directory may also include user information, such as preferred word processor and spreadsheet. This allows the E-mail software to translate messages to the user's preferred format. The server also stores and routes the actual message files.

The two major LAN mail products are Microsoft's Mail 3.0 and Lotus's cc:Mail. Each uses a different architecture to support the OSI standards for electronic mail transport (X.400) and directory services (X.500). Microsoft uses its own system-level Messaging Application Programming Interface (MAPI), which allows diverse applications to be mail-enabled.

Lotus (and Apple, Borland, and Novell) supports Vendor Independent Massaging (VIM) application programming interface (API), which is at the program-level interface and is not tied to any operating system. VIM is in its infancy and the four trustees have announced it will be included in future releases of their products (cc:Mail and Notes; System 7; Object Exchange architecture; and NetWare Global Massaging and NetWare Message Handling System, respectively). IBM has announced that it will support VIM in its office product strategy.

Microsoft Mail, which runs under DOS, Windows, or Macintosh, supports Windows clients, which can work with any mail server across the enterprise network. Messages are encoded for storage and transit. Microsoft's Object Linking and Embedding technology can be used to incorporate graphics or data into a mail message. Microsoft also offers Mail Gateways that permit Microsoft Mail networks to link transparently to other mail networks, such as MCI Mail, SMTP, FAX, 3+Mail, Novell's Message Handling System, and IBM's Professional Office System (PROFS) and SNADS. A gateway is also provided for Apple's AppleTalk networks.

"cc:Mail" from Lotus consists of a front-end application and a back-end services provider. cc:Mail runs under DOS, Windows, OS/2, and Macintosh Third-party application software can be launched from within text and E-mail documents. Facsimiles (FAXs) can be viewed as incoming mail messages.

In some organizations, E-mail is also being used to download application revisions, as well as software upgrades. Recognizing this need for more controlled software distribution, Lotus is developing a product, code-named Lynx, that will manage the distribution of software revisions and upgrades.

When evaluating LAN-based E-mail packages, organizations have to take into account the features users are already using, such as calendaring, and decide if they should be available on the LAN-based system. Another issue is whether LAN-based systems can link to host systems, such as IBM's PROFS or Digital's ALL-IN-l. This would allow mail messages generated by the

LAN-based system to be easily transmitted to the host-based E-mail system.

Mail-enabling products are being developed with message handling functions, which make sending mail as easy as saving a file. It is not farfetched to expect a word processing package (running in unattended mode) to request current data from a spreadsheet package on another node in the network, incorporate the requested data into a template document, and send the resulting document to appropriate personnel.

Developments in this area will integrate voice mail into workflow processes. Messaging-enabled workflow applications use messages as agents to carry out tasks, which are programmed into the application.

Lotus Notes from Lotus Development Corp., one of the major players in workgroup computing, uses a distributed and automatically replicated database to give multiple users access to the shared files. It accepts a variety of data types and supports DDE (Dynamic Data Exchange), OLE (Object Linking and Embedding), and the DataLens interface to RDBMSs. Lotus Notes users can circulate documents, incorporating changes as they go. Multiple users can work on one or more documents simultaneously. Notes automatically control the flow of the information. A Notes API (Applications Program Interface) allows Notes to be incorporated with and accessed by other applications. Each Lotus Notes database is stored on multiple Notes servers on the network. The database contains documents that can be categorized and linked according to users' needs. Filters can also be used to facilitate faster location of specific documents. Notes is document-oriented and supports compound documents (many kinds of information from many sources). It can handle structured data as well as unstructured data. It supports distributed databases and has built-in robust security. Business users can build their own applications based on an organizational Notes system.

145. The main groupware products in the current market, in accordance with their functions, are introduced as follows:

- *Electronic mail and massaging*. Sample products are: cc:Mail (Lotus), Microsoft Mail (Microsoft), DaVinci Mail (DaVinci), Beyond Mail (Beyond), MHS (Novell), Futurus Team (Futurus), FirstClass (SoftArc)

- *Calendaring and scheduling*. Sample products are: Meeting Maker (On Technologies), Network Scheduler 3 (Powercore), Time and Place/2 (IBM), Microsoft Project, Microsoft Schedule +

- *Group decision support systems*. Sample products are: GroupSystems V (Ventana), VisionQuest (Collaborative Technology Corp.), Council (CoVision)

- *Group editing*. Sample products are: Face-to-Face (Crosswise), Mark-Up (Mainstay Software)

- *Workflow*. Sample products are: ATI (Action Technologies), WorkMan (Reach

Technologies), JetForm (Jetform), FloMark (IBM)

- *Document image management*. Sample products are: FileNet (FileNet), Plexus (Recognition Technologies)

- *Workgroup utilities*. Sample products are: Workgroup for Windows (Microsoft)

- *Shared-memory products*. Sample products are: Lotus Notes (lotus), Oracle Office (Oracle), WordPerfect Office (WordPerfect), LinkWorks (Digital Equipment)

- *Shared-screen products*. Sample products are: ShowMe 2.0 (Sun Solutions), Aspects (Group Technologies)

- *Groupware development tools*. Sample products are: Notes (lotus), Oracle Office (Oracle), CoEX (TwinSun)

- *Groupware services*. Service listing include: planning and implementation, application development, training and maintenance, organizational consulting and business re-engineering, business process redesign, meeting facilitation.

146. The Groupware Environment. Groupware lies on a network infrastructure which includes PCs, PC operating systems, cabling, network operating systems, administration utilities and, if necessary, the phone lines for a Wide Area Network. Groupware is part of the networked applications environment. However, not all networked applications are groupware. Access to a corporate database through a network may not be groupware. However, interactive or discussion databases may be part of a groupware application.

Often, groupware applications are workgroup-oriented and not enterprise-oriented. The issues involved in scaling up these applications for government agencies or a government as a whole are not trivial and frequently require the cooperation of competitive vendors, the establishment of standards, and maturation of the supporting infrastructure. Groupware rests at the top of a big wave that includes technologies such as: client/server, multimedia, document and image management, networked applications and distributed/mobile/remote computing.

There are many challenges to providing groupware services. Many advocates become discouraged because even though the technology is adequate for the organization, many organizations do not want to change the way they work. This is because groupware requires not only software and customization but also, even more importantly, organizational restructuring and change management. In particular, the absence of top management support and the lack of appropriately addressed business problems often result in the greatest problems in implementing groupware.

147. Workgroup computing facilitates a change in corporate culture and the way people do business. The written word becomes more important than the spoken word. It softens the natural

hierarchy of groups because managers and executives are readily accessible via the computer links. All members must participate through groupware for the benefits to be realized. Benefits are mostly intangible (shorter, more-efficient meetings) but some tangible benefits can be attributed to travel cost savings.

There are two major challenges to groupware: technical and organizational. On the technical side, besides a mature and well-operational network environment, main issues concerned are: support for cross-platform conversions; lack of interoperability between groupware software; degradation of network speed; limited links to other software; application independence; and a new set of user dynamics. On the organizational side, the key factors are: getting top management involved in the implementation of groupware; planning for the changes of the corporate culture caused by groupware; and re-engineering current business processes to take advantage of the potentials of modern information technology. Of the two major challenges, the organizational challenges are more difficult to meet. Technical solutions can almost always be reached through persistence. However, even if groupware technology is proficient, the groupware implementation will not be successful if the corporate culture does not support it.

CHAPTER 7

NETWORK COMPUTING

7.1 Benefits of Network Computing

148. In the 1960s, business computing revolved around the mainframe, which performed batch processing tasks. Users submitted stacks of punched cards and waited for the printed results. Time-shared approaches gave more people access to mainframes in the 1970s, and minicomputers gave some people a less structured computer environment. Data communications technology linked the computers together, but the mainframe was always the master in an unquestioned master/slave relationship. The microprocessor brought a wave of personal computers and workstations, which freed users from their dependence on expensive and overburdened mainframes and minicomputers. The microcomputers and workstations were sometimes connected via networks for the purposes of exchanging data/information and sharing resources such as printers and disk storage. When smaller computers were networked with mainframes, however, the master/slave relationship still ruled.

149. The latest revolution in microcomputer-based network computing gathers the benefits of all previous advances into a cohesive unit. No matter what type of computing resource a user needs, network computing makes it available immediately. In its simplest form, a network computing system consists of computers connected to each other and to users via a network. However, the rich potential offered by today's network computing systems rests on the ability to access resources no matter what vendor they come from, no matter where they reside physically - as though a vast array of computers and software applications were on the user's desk. Yet the user can tap that array of resources in simple, intuitive ways. The computer industry has had to refine an

enormous number of concepts to achieve this simplicity. While some details will continue to fall into place for years to come, the structure of network computing has become clear. And, the power of network computing is now available.

150. Benefits from network computing are obvious.

For the users, they have all the benefits of a highly user-friendly personal computer with the global advantages of having easy access to other machines and users on the network, without knowing where any of the files, applications, or other users are located physically. Many users are not aware of the complexities that make this simple cooperation possible.

For network administrators, a network computing system is a cost-effective system that allows administrators to provide management services and to back-up data routinely, wherever it resides on the network, and secure data against unauthorized access and/or modification. The network administrators can control what is in the system to end the proliferation of incompatible hardware and software.

For applications developers, a network computing approach based on industry standards is attractive to software developers because it provides a solid foundation on which to build applications. Developers can feel confident that the environment for which they create their products will be around for a long time. Further, their products should be easily portable from one type of server to another, giving developers a broader base of customers.

For government organizations, a network computing system is the most versatile approach yet devised, due to its ability to accommodate hardware and software from different vendors. Based on industry standards, this heterogeneous hardware and software can interoperate as though designed by one vendor. Management is then free to obtain hardware and software from the most cost-effective source. Additionally, management can expand a network computing system as needed by adding more servers and other resources, including optimized servers for tasks such as database management or communications. There is no need to eliminate existing resources as new ones are added, except for reasons of economy. The system is therefore extensible, yet protects investments in hardware, software, data, and user training.

151. LANs (Local Area Networks) are combinations of hardware and software, allowing microcomputers to share mass storage devices (fixed disks), peripherals, and data by linking microcomputers together in communications networks. LANs were the obvious outgrowth of the rapid expansion of microcomputers in business and government during the 1980s and early 1990s. LAN hardware consists of a configuration framework, or topology, which establishes the relationship among the microcomputers and the cabling interconnecting the hardware in the LAN, the connections or taps from the microcomputers to the cabling, the special adapter boards (installed in each microcomputer) which send and receive data from the network, and a file server. The file server is a microcomputer, usually with large, fixed-disk capacity, that manages the network communications and stores data available to the other workstations (microcomputers) on the LAN. Although the hardware sounds complex, LANs offer relatively easy and inexpensive

ways to upgrade from stand-alone microcomputing to a data-sharing environment.

There is no doubt that LANs will be a major growth path for computing in developing countries. Recognizing the new direction for computerization and information systems development is critical for the decision makers of developing countries. Of course, it is a large jump from a collection of stand-alone microcomputers to a LAN. Problems do exist, both technical and organizational. On the technical side, introduction of both computer and communications technologies into the government information systems' matrix makes the technology transfer problem more complex. On the organizational side, LANs are complex systems that require management on an institutional scale. This means more administrative support, management time, and financial resources will have to be committed to information technology than was the case with stand-alone microcomputers.

As networks evolve toward the ideal of providing high-speed access to any kind of information, at any time, in any location, the role of microcomputer-based LANs has been evolving to keep pace. Four major trends in developing countries will be evident: LANs are becoming larger, more capable, and more complex; more mission-critical applications are migrating to microcomputer-based LANs; the cost of managing these LANs is increasing; and the demand for multimedia is beginning to be a factor in network design. Under this circumstance, a unified strategy that ensures the four major challenges are being met becomes more and more important. The unified strategy must take into account the following factors: to formulate a stackable architecture which will be easy to extend to meet new demands for performance and capacity; to conform to relevant industry standards; and, to manage complexity and reduce cost.

7.2 LAN Topologies

152. At the end of the 1970s, larger hierarchical networks were based on hosts and terminals. Systems network architecture (SNA), announced in 1974, was IBM's original approach for networking based on a simple tree-oriented, single-host network connected to terminals through a front-end communications controller. As microcomputers became more and more powerful and popular in the second half of the 1980s, the requirements for networking PCs grew very rapidly. LAN technology has experienced very fast development since then.

A network is a means to allow for the sharing of system-wide resources among users. Typically these resources are programs, printers and data/information. Networks provide other capabilities as well, such as the ability for convenient E-Mail (Electronic Mail), group scheduling, workgroup management, gateways and bridges into other computer environments and hardware multitasking. LAN topologies are the pattern formed by LAN's cabling structure.

LANs are short-distance networks (usually with a range of less than two kilometers) typically used within a building or building complex for high-speed data transfer between computers, terminals, and shared peripheral devices. Every workstation on the LAN can communicate with every other workstation or node.

There are two major types of microcomputer networks. The first is a peer-to-peer network. In this scheme, each user on the network has (potential) access to any other users resources. Thus user A can use user B's hard disk drive and printer, and user B can use user A's hard disk drive and printer as well. Peer-to-peer networks are relatively easy to implement and use, provided the number of users is small and the performance needs are relatively minimal. The second type of network is a client-server based network. In this design, one or more microcomputers are set up as a file server or network server. Under a DOS environment, file-server based network systems are normally a lot more powerful and have increased capability compared to peer-to-peer designs. In a peer-to-peer system, the network exists as a guest, or task, on a DOS machine. Therefore, all of DOS limitations apply, like volume sizes, file structures, lack of security, lack of multi-tasking design, etc. In a client-server based network design, the file server runs on software which is, in fact, an operating system - network operating system. Network operating systems take over the entire machine and typically use proprietary disk formatting schemes, file structures and file access methods. This is why advanced features can be implemented within the operating system.

A microcomputers based network consists of a network interface card (NIC) connected to a network cable that links the microcomputers and any file servers to form a network. The network can have a variety of configurations, called topologies. Three major topologies have been defined: Star, ring, and linear bus.

153. *Star*. Star networks directly connect remote nodes to a central intelligent controller node, or a file server as the center of the star, forming a star pattern. The typical configuration framework of star topology is a central-distribution hub connecting multiple remote nodes, including mainframe, minicomputer, PCs, printers, and monitors, as user want. Star networks are easily expanded by wiring more nodes directly to the central node, usually located in wiring closet. Sometimes smaller central nodes are linked to a larger central node in a hierarchical fashion. As with the other topologies, the star configuration uses all types of cabling with twisted pair being the predominant choice. Network nodes have little intelligence and depend entirely on the central node or controller, which polls each node periodically for network access. Many traditional network systems, such as SNA, are based on this topology. Actually, no true star topologies are being produced today.

154. *Ring*. The second topology, ring, has a configuration that connects each workstation, minicomputer, mainframe, and printers, to cabling that forms a complete ring. IBM's Token Ring network provides an example of a currently manufactured network that use a ring topology. When data is transmitted, it is sent from node to node in one direction. Networks using a true ring configuration have cables routed between the nodes in a daisy-chained point-to-point manner. Other rings have a cable layout resembling a star pattern, in which the cables are routed from a wiring closest to a node, then back to the closest wiring and out to the next node. This configuration is known as a star-wired ring. Whenever a ring needs to be expanded, it can be done by breaking the ring and inserting a new node.

All types of cabling can be used to form a ring network, including coaxial, twisted pair, and fibre optics. The two most popular ring networks are the IBM token ring, which uses twisted pair cabling, and the FDDI token ring, which uses fibre optic cables. Network nodes that are part of a token ring network usually gain access to the network in an orderly, one-at-a-time fashion, similar to the way runners take turns running a relay race. A runner passes a baton to the next runner when it is his or her turn to run. In a token ring network, each node passes an electronic token between nodes when it is its turn to transmit. This methodology guarantees every node equal access to the network.

155. *Linear Bus*. The third topology, linear bus, uses a single cable laid out along the length of the network. Each workstation is either directly connected to the bus or is connected to it with a drop cable. The most common linear bus implementation is Ethernet.

The bus cable is centrally routed through an area with smaller cables routed from the main bus to the actual network nodes. These smaller cables are referred to as drop cables. Nodes also may be added by tapping directly into the bus. Networks using the bus topology may be configured as a linear bus, a star bus, or a tree bus, depending on the transmission technology employed. All types of cabling can be used to form a bus, but coaxial cable is predominantly used. Each node listens to the cable and waits to transmit its data when the cable is quiet or idle. Data that is transmitted by one node is simultaneously received by all other nodes on the bus. Data is ignored by all except the node to which it was addressed.

7.3 LAN Implementations: Three Major Standard LANs

156. Today, the LAN world essentially has three major de facto standards, each roughly corresponding to one of the three topologies. Ethernet uses the linear bus; Token Ring uses the ring, ARCnet uses the star - actually a string of stars. ARCnet provides medium performance and low cost networking to many business environments. It also gives users an ideal LAN starting platform and is the entry level system usually recommended. Ethernet has an international standard that provides excellent performance and interconnectability for networks using dissimilar platforms and operating systems. Ethernet, a mature and well respected networking standard, has the largest installed base of network nodes in the world. Ethernet is not only important for microcomputers based LANs, but also in the minicomputer and mainframe computer worlds. In the world of the UNIX operating system computer, virtually all networks are Ethernet based. Ethernet also provides the basis for DEC's DECnet LAN, the major interface used for TCP/IP (Transmission Control Protocol/ Internal Protocol) LANs. Token Ring was developed by IBM as the centrepiece of its PC networking strategy. Token Ring is relatively expensive for the performance offered and, until recently, very proprietary to IBM. Token Ring provides IBM's solution for the larger connectivity picture as well, when PC LANs must be connected to IBM mini- and mainframe computers.

157. Broadband and baseband signalling techniques. Broadband uses a radio frequency signal on a bus cable (coaxial cable or fibre optics). Generally, data transmission systems divide the frequency spectrum in half: the lower half of the frequencies is devoted to the transmit side and

the upper half of the frequencies is devoted to the receive side. Devices are connected to the broadband bus cable through bus interface units. These interface units serve to modulate and demodulate on and off the bus cable. All bus interface units have their radio frequency transmit and receive signals set within a specific range so that they transmit on the same frequency and receive on another frequency.

Ethernet on a broadband cable system is defined by the IEEE 802.3 10Base36 standard. Many large organizations and college campuses use broadband LANs because they provide good network coverage that can reach every office in every building.

Broadband uses FDM (Frequency-Division Modulation) to carry many channels on the same cable. This makes it is possible to transmit data, video, and voice over the same cable simultaneously. Broadband technology has a higher initial cost but supports a variety of communication services. One broadband LAN can support several 10-mbps Ethernet channels (IEEE 802.3 10Base36) along with other LAN protocols, such as token bus (IEEE 802.4 or MAP - Manufacturing Automation Protocol), on the same cable. The actual distances that can be covered are limited by the propagation delays of the cable signals rather than by the cable technology itself. The 10Base36 system can cover an area within a radius of 1900 m.

Broadband systems have several points of failure that are typically backed up with hot spares. For mission-critical operations, redundant cables systems are used. One major drawback is the cost of system maintenance, because broadband cable systems use many active devices, such as amplifiers and frequency translators, that require periodic adjustments. They need annual tune-ups to prevent normal signal degradation. Broadband network service must be done by qualified technicians using special expensive equipment.

Baseband systems are much less complicated and much less flexible. Baseband uses a single frequency pulse signal rather than the multiple signals of a broadband system. Digital data is encoded in a square waveform with baseband rather than broadband's radio frequency signalling. Baseband's square frequency wave represents a digital data bit encoding of a serial bit stream. Baseband systems need to be concerned with capacitance, resistance, and noise in the medium, rather than attenuation and signal reconditioning.

158. IEEE 802.3: CSMA/CD (Carrier Sense Multiple Access with Collision Detection). CSMA/CD is a decentralized media access technique. Every node has equal access to the media, and the media access algorithms are in every network interface. Each node listens for a carrier on the network. For baseband systems, that translates into detecting the presence of a single digital square waveform. For broadband systems, this requires listening to the reverse, inbound send side of the bus cable for a signal. If no carriers are detected, then the node will transmit. Otherwise, the network interface will compute a random back-off time to wait before reattempting to transmit. If the transmitting node detects a collision, then that node sends a jam window of a set of bits to ensure that the other transmitting nodes detect the collision and perform a back-off. The sending node will compute an exponential back-off duration to wait for retransmissions - the more collisions occurring on a segment, the lower the bandwidth utilization. This indeterministic

transmission scheme precludes being able to calculate when nodes will be able to transmit.

In 1980, DEC, Xerox, and Intel developed the first CSMA/CD specification, called Ethernet, a data communications network standard for 10 mbps high-speed LAN communications. DEC remains a leading supplier of Ethernet products and has promoted Ethernet as an effective LAN solution. Messages over the Ethernet cable are broadcast, allowing each station to receive all messages transmitted on the cable but accepting and acting on only those messages addressed to it. Stations wishing to transmit listen for traffic on the cable and wait to transmit until the cable is not busy. When two or more stations transmit simultaneously, a collision occurs. All stations can detect such collisions and delay any further transmissions (including retransmissions) for a random interval. Except at near maximum loading, collisions and contention on the LAN produce little overhead.

The CSMA/CD Ethernet bus has been widely used to implement LANs since the emergence of baseband network technology in the late 1970s. Typically, a cable is installed to service one or two floors of a building or a group of buildings. The cable is routed throughout the immediate areas via building corridors. Distribution drops are then run from the nearest corridor to the adjacent offices. This topology and media is the least expensive of the cabling systems to implement but has some real limitations in network reliability and management. The cable media most commonly used is thick Ethernet (l0Base5), which usually runs between buildings or building floors. It can cover a linear distance of 500 meters and support 100 transceiver connections without repeaters. The smaller and cheaper RG-59 cable (10Base2 or Thinnet) can also be used, but the segment length is limited to 185 meters and it can only support 29 transceiver connections. Repeaters can be used to link two cable segments together, but no more than two repeaters can be in series. Fibre-optic repeaters are used to link two remote segments separated by up to 3000 meters. The bandwidth of the Ethernet bus is limited to 10 mbps, which can cause slow response times and restrict network expansion.

Network distribution systems based on a linear bus have been used because they offered certain advantages over competing tree- and star-based systems in terms of initial installation and network equipment cost. Ethernet cable is easily installed by laying cable in overhead ceilings. One coaxial cable can be snaked through a building and provide access to areas that are within 50 meters of the coaxial cable. Additional network connections can be added at any time. Ethernet segments require no active electronic components except the transceivers, which are required for every connection. The cable segment can be expanded easily by adding cable to either end or by splicing a new section of cable into the middle of the segment.

Ethernet linear bus topology has disadvantages to be considered before implementing. Because all network drops are attached to a single segment, stations are dependent on the integrity of the cable segment. If the coaxial segment fails, then all drops on that segment will also fail due to bad connectors, poor system grounding, and bad cable taps (transceiver connections). Troubleshooting large cable segments is time consuming and requires trained technicians. The best defense against network downtime is documenting the cable's route and purchasing cable test equipment to aid in quickly diagnosing problems.

159. The star bus topology is another popular Ethernet backbone LAN system for several reasons. First, there is a variety of media choices available, such as coaxial cable (10Base5 or 10Base2), twisted-pair cable (10BaseT), and fibre-optic cable. Second, because the only active component is the hub of the star, it is cost effective. Third, a wide area can be covered with cable legs (segments) run from a central distribution hub to areas located around the site. Each leg is a linear bus segment supporting up to 100 transceiver connections. The topology can service an area within a radius of 500 meters from the hub using standard thick Ethernet (10Base5) cable media. Some hubs support fibre-optic cables that extend the radius to 1500 meters. Multiple hubs can be linked to form clusters of stars, but careful attention must be paid to the maximum end-to-end distances to avoid violating the Ethernet specifications. To improve reliability, a second hub can be used to drive a redundant set of cables.

Typically, the hub acts as an inexpensive ($100 to $400 US dollars per port depending on the media) multiport repeater with a total bandwidth limitation of 10 mbps. The bandwidth of a star topology can be enhanced by using multiport routers as the hub rather than multiport repeaters. These routers treat each cable leg as a separate 10-mbps segment and intelligently pass data between all of the segments connected to the router. Multiport routers are available with internal bandwidth exceeding 100 mbps.

160. The 10BaseT standard using twisted-pair wiring was completed in June 1990 and has become the most popular office-wiring scheme. It supports both shielded twisted pair (STP) and unshielded twisted pair (UTP) cabling for distances up to 100 M. UTP, often referred to as telephone cable, contains two insulated wires twisted around each other. When the wires have a metallic covering, such as an aluminum polyester tape, the cable becomes STP. Ethernet on twisted pair was the final step in acceptance of twisted-pair wiring as the universal wiring system for the office.

161. Fibre-optic cable is frequently used because of its noise immunity and ability to cover large distances (3000 km), but today only proprietary systems are available. IEEE has developed a fibre-optic standard known as 10BaseF. Frequently, network designers use a fibre-optic cable star configuration to support Ethernet, with plans to switch to FDDI in the future. Later, when FDDI equipment is more cost effective, the fibre-optic cable can be used for a FDDI network. Careful planning must be used to install fibre optic cable that will be compatible with both Systems.

162. IEEE 802.4: Token Bus. Token passing is implemented in both global bus (broadcast) systems and logical ring networks. In the token bus, each node listens to everything that happens on the network. A unique message frame represents an explicit token. This token is sent in a predetermined manner throughout the network. In both token bus and token ring systems, each node knows its successor and predecessor node. Transmitting stations receive the token from their predecessor, perform a transmission if necessary, and send the token on to the successor. These deterministic media access schemes allow for known intervals between receiving tokens and the opportunity to transmit data. When nodes with nothing to transmit receive the token, they merely send it on to the successor node. Nodes may also be prioritized by giving different token holding

times.

In comparison, token passing (token bus and token ring) algorithms are much more elaborate, and the hardware is much more difficult to implement than CSMA/CD. Token-passing media-access techniques are deterministic, with known, predictable delays between message transmission opportunities. In light of this predictable nature, token passing access is well suited for large factory automation applications. Token bus data transmission rates range from l mbps to 10 mbps. General Motors Corporation helped pioneer the development of the system in the mid 1980s. Token bus is used to support manufacturing automation protocol (MAP), but it can also be used as a corporate backbone network. The token passing technique is well suited for factory automation because it provides access to the network every few milliseconds. This is extremely important in an automated factory requiring deterministic response times.

163. IEEE 802.5: Token Ring. IBM's token ring network is a baseband star-wired ring network that uses the token-passing access method. In the token ring, every node sequentially receives messages and regenerates them. The token is passed from node to node in this sequential manner. It runs at 4 mbps or 16 mbps and can use a variety of twisted-pair and fibre-optic cabling products. The 16-mbps version is designed for departmental backbones and the 4 mbps version for workgroup LAN interconnections. The token-ring standard on which it is based is IEEE 802.5.

In the IBM token-ring network, up to eight devices are attached to a multistation access unit (MAU), which is the hub of the star portion of the topology. The ring portion is created electrically within the MAU. MAUs can be linked so that up to 260 devices can be on a single network.

164. IEEE 802.8: FDDI. FDDI is a 100-mbps counter rotating token-passing twin-ring that enables users to send more information over network distances of 100 km. FDDI products are highly reliable, easy to install, and primarily support fibre-optic circuits; however, they are also quite expensive. The high cost is due in part to a dual-fibre ring costing twice as much as a single ring for interface optics and electronics. The more complex timing and the logic for token passing and optical bypass also add to the cost.

FDDI's counterrotating token-passing twin ring accommodates synchronous and asynchronous data transmission. The FDDI ring is designed for an overall bit error rate of less than 10^{-9}. It can support up to two km of fibre between stations and a total cable distance of 100 km around the ring with 500 attachments. Even though FDDI was originally designed to operate over optical fibre, it has been successfully tested to operate at short distances (less than 100 m) over shielded twisted-pair wire.

Generally, a new product that is ten times faster than the product it replaces will cost three or four times more than its predecessor. FDDI has an even higher premium; it is ten times faster than Ethernet but can cost 25 to 40 times more at the interface level. Many may find that price increase unacceptable, except workstations and servers that need the extra bandwidth. FDDI routers cost approximately $30,000 US dollars, bridges cost about $25,000 US dollars, and FDDI concentrators range $15,000 to $20,000 US dollars.

FDDI accommodates synchronous and asynchronous data transmission, as well as is synchronous channels for real-time digitized voice and compressed video. The FDDI ring is designed for an overall bit error rate of less than 10^{-9}. The network can support up to two km of fibre between stations and a total cable distance of 100 km around the ring with 500 attachments. The intrinsic topology of FDDI is a counterrotating token-passing ring.

FDDI standards directly address the need for reliability. This need arises because a backbone system transports many user sessions, and its loss would be a serious outage. FDDI incorporates three reliability enhancing methods. First, a failed or unpowered station is bypassed by an automatic optical bypass switch. Second, wiring concentrators are used in a star wiring strategy to simplify fault isolation and correction. Third, two rings are used to interconnect stations so that failure of a repeater or cable link results in the automatic reconfiguration of the network.

165. Asynchronous Transfer Mode (ATM) Asynchronous Transfer Mode (cell relay) is an emerging common transport for LANs and WANs. ATM offers several advantages over other competing technologies. Multimedia support of LAN, WAN, voice, video, and data due to its fixed-size 53-byte cells accomodating both connectionless and connection-oriented traffic is a major plus. ATM also provides flexible transmission rates from 51 mbps to 1.2 gbps. Network management is simplified by enabling users to deploy a common transport technology in LAN, WAN, and voice environment. However, high prices, missing standards, interoperability problems and the lack of network management features continue to hamper its widespread market acceptance.

7.4 Client/Server Architecture

166. Client/server technology is the result of the advances in hardware and the newest evolution of software products and has been called the computing paradigm of the 1990s. It has become a popular strategy for organizations trying to minimize costs while improving data and information service. The emphasis of client/server computing is not hardware. The technology that makes client/server computing possible is the software.

The goals of client/server computing are to allow every network node to be accessible, as needed by an application, and to allow all software components to work together. When these two conditions are met, the benefits of client/server computing, such as cost savings, increased productivity, flexibility, and resource utilization, can be realized. These goals can be achieved in part by adhering to industry standards and creating open systems. However, some of the components of client/server computing have multiple standards to choose from, others have none.

Client/server applications rarely confine themselves to their own LAN. In addition, clients in the same network can use different software. Servers in the network can use different operating systems and server database software. When client/server applications need to go outside their own network, the environment must be able to communicate with the accessed environment, accept data, and then transport it back to its own environment.

There are many types of client/server applications, ranging from simple to complex, each with their own requirements for the individual components of the architecture. Organizations starting with the simplistic must plan for future growth when deciding how to configure their architecture.

167. What is client/server computing? Client/server computing uses local processing power - the power of the desktop platform. A simple definition of client/server computing is that server software accepts requests for data from client software and returns the results to the client. To make it sound more technical: most of the application processing is done on a programmable desktop computer, which obtains application services (such as database services) from another computer in a master/slave configuration.

Client/server computing allows applications to be segmented into tasks. Each task can be run on a different platform, under a different operating system, and with a different network protocol. Each task can be developed and maintained separately, accelerating applications development. Data can be placed closer to the user. Users can access their data with a comfortable interface and tools for manipulating that data into meaningful information. Suddenly users are able to do more for themselves, rely less on a centralized information system for assistance, and receive quick turnaround time for applications requested of information system. The end result is more efficient use of existing equipment and more productive workers.

Application processing performed on more than one machine in a network may be either distributed computing or cooperative processing. Distributed computing partitions the data between two or more computers, which may be geographically dispersed. The user has transparent access to the data. Cooperative processing splits an application's functions (processing) between two or more computers in a peer-to-peer relationship. Most client/server network structures are based on distributed access, not distributed computing. Client/server architecture uses a master/slave configuration where processing may be performed by both the master and the slave.

The use of open systems (hardware, software, operating systems, databases, and networks) enhances client/server computing. By adhering to standards, open hardware and software can provide interoperability and portability. Open systems offer IS greater flexibility in linking divergent technologies.

168. Benefits of Client/Server Computing are as follows.

Cost Savings. The magnitude of savings that can be realized by migrating host-based applications to a client/server environment. Mainframe environments are costly to maintain - the hardware, software, and staff required to maintain and develop applications are very expensive. Fewer staff are required to maintain client/server platforms and maintenance contracts (if there are any) are moderate in cost.

Client/server technology allows organizations to protect current investments by using existing equipment and protect future investments by using scalable, expandable products.

Client/server-based applications can be developed in less time than mainframe-based applications. Since front-end and back-end processes are separate, they can be developed and maintained separately. Client/server applications are usually developed on the client machine, freeing up mainframe resources for processing. Security and business rules are written as stored procedures within the server database software, stored separately from the applications programs, and maintained separately. Once these common business rules and procedures are programmed into the server software (coded and verified once), developers can focus on solving application-specific business problems.

Increased Productivity. Both users and developers are more productive using client/server tools. Users are more involved in the development process and in control of the application, once it is operational. They have transparent access to the data they need to do their jobs and have a standard, easy-to-use interface to that data. Developers can be more productive as well by using client/server development tools. Applications may be designed, implemented, and tested in a client/server environment much faster than in a mainframe environment. Not because they are simpler - most of them are not - but because the development environment and the tools themselves are easier to use and automate many of the development steps.

The development platform is the desktop machine. All phases of application development - designing (in some cases), coding, testing, executing, and maintaining - can be performed from the desktop machine. The finished product can be ported to a more appropriate environment, if necessary. The desktop environment offers the developer a GUI interface, local autonomy, and subsecond response. The platform is also appropriate for building iterative prototypes of the application.

Flexibility and Scalability. By segmenting the application tasks, an organization can easily migrate to new technologies or enhance existing technologies with little or no interruption. An application does not have to be redesigned to use new interface software or be moved to a new platform. An upgrade to a server should have little impact on the applications themselves.

Client/server computing is modular. Organizations can easily upgrade components or migrate to a newer technology without changing the specifications of the application. Users have more control over how they work with their applications and their data.

Resource Utilization. A basic tenet of client/server computing is effective use of computing power. In a balanced client/server network, the processing power at every node in the network is efficiently used. By focusing client machines on user interfaces and application processing, and servers on data storage and retrieval, computing resources are leveraged - reaping obvious cost benefits.

The first client/server implementation in an organization may not require new equipment.

One of the important features of client/server computing is being able to link existing hardware and applications. It allows an organization to use the equipment they already have more effectively. Network bottlenecks can be reduced further by separation of duties. Local processing can focus on supporting the user, remote processing aimed at number crunching.

Centralized Control. Client/server computing allows today's information systems facilities to combine the best of both centralized and decentralized architectures. The decentralized portion of the computer system consists of the processing done on the client and is the responsibility of the business end user. The centralized portion of the system consists of the processing performed on the server and is the responsibility of information systems professionals, as are the links to the server. The server maintains an intelligent database with rules and security checks coded into the server. The end result is that information systems get centralized control over the data and users focus on their business requirements.

The rules governing the management of all the organization's data are located at one source and controlled from that source - the server. All access to data goes through that source, and, therefore, must pass through the stored business rules and security checks. Any controls that are the responsibility of the local facility can be implemented as rules on the local server. Backup and recovery procedures are centralized. To ensure that the server is always operating, procedures, such as installing an uninterruptible power supply, adding a shadow system, mirror data, and using fault-tolerant processing, can be put in place.

Open Systems. For client/server computing to be effective, multiple environments must be supported. When applications are rightsized, it is important that there be connectivity among the components of the platform. There must be support for multiple hardware vendors, multiple GUI platforms, multiple operating systems, multiple DBMSs, multiple communication protocols, and multiple LAN operating systems. Management of the network can become the weak link in the configuration. Tools that allow the systems administrator to manage the network (configuration, console, problems, modification) and monitor its performance must be developed or purchased.

169. Components of Client/Server Architecture. Client/server applications have three elements: a client, a server, and a network. Each of the elements has a hardware component and several software components.

The Client Hardware. The client hardware is the desktop machine that runs client software. It could be a microcomputer or a workstation. The client software formulates data requests and passes the requests to the network software. And, accepts the results from the server and passes the results back to the client software. There is also an operating system running on the client hardware, which may or may not be the same as the server's operating system. There is also communications software running on the client hardware. The client-based network software handles the transmissions of requests and receives the results of the requests. However, individual network operating systems do not support all available client and server operating systems.

The client may also be executing runtime support for applications generated with client/server development tools. Using the development tool, the application logic is specified and partially executable code is generated. The generated code is executed by the client's runtime version of the software. In some cases, a client is actually a server acting as a client (then the server is called an agent) by requesting data from another server.

The Server Hardware. A server is the machine that runs data management software that has been designed for server functionality. Compared to a desktop micro, server hardware has larger memory capacity; increased storage capabilities; increased processing power, including, in some cases, parallel processors; improved cycle times; and improved reliability with built-in reliability features, such as an uninterruptible power supply, fault tolerance, and disk mirroring. A server has operating system software, data management software, and a portion of the network software. The operating system has to interact reliably with network software and be robust enough to handle server technology. The data management software responds to requests for data retrieval, updates, and storage.

The Network Hardware. The network hardware is the cabling, the communication cards, and the devices that link the server and the clients. Connections must allow servers to access other servers and for users (clients) to access data on any network node. The connection devices, such as routers and wire hubs, are beginning to incorporate network software, which frees up server processing. The most common communications-related services to be migrated to hubs are messaging and routing capabilities.

The communication and data flow over the network is managed and maintained by network software. The network operating system manages the network-related input/output processes of the server. Each network operating system has its own protocol, which is a set of rules that define the formats, order of the data exchange, and any actions that are to be taken on the transmission or receipt of data.

7.5 Network Operating Systems

170. The heart of a network is the network operating system (NOS). The network operating system supervises communications between microcomputers, manages shared programs and data resources on the file server, and allows access to the network. The network operating system is installed on the server machines but a portion of it runs on each connected client machine as well. Each network operating system has its own protocol.

For microcomputer-based LANs, the most popular network operating system is NetWare, which controls two-thirds of the network operating system market and is manufactured by Novell. 3Plus Open, manufactured by 3COM, used to be the second most popular network operating system. Microsoft's LAN Manager joined the group of client/server network operating systems in August 1990, which requires OS/2 on the server. IBM also makes networking software to run with its Token Ring cards. The other major microcomputer LAN network operating system is Vines, manufactured by Banyan, which runs as a task under the UNIX operating system. Vines has been a convenient way of implementing Wide Area Networks (WANs), which encompass more than what a locally cabled LAN can conveniently connect. Other network systems warrant mention because of their significance within narrow market niches. The first DECnet, was developed by Digital Equipment Corp. (DEC) as an Ethernet-based network system for tying DEC minicomputers together and for allowing devices, such as terminal servers, to be handled over high speed Ethernet cabling. The TOPS network from SUN was one of the first to allow IBM-PC compatible and Apple Macintosh computers to share files on the same network.

171. The trend in networked environments is toward integrating support for multiple computer platforms and for multiple LAN topologies under one network operating system. This support is not only limited to computers that rely on the DOS or Macintosh operating system, but also support for Windows NT, OS/2, and a variety of UNIXs. For example, the VINES server-based network operating system support ARCnet, Ethernet, Token Ring, and LocalTalk and uses TCP/IP, AppleTalk, Named Pipes, and NetBIOS. It supports unlimited DOS, Windows, Macintosh, and OS/2 users and 20GB per server of disk space. It can track unlimited network files and has integrated routing, asynchronous communication services, directory services, and gateway services. It has network management software and an SNMP (Simple Network Management Protocol) agent. Novell NetWare 3.11, a 32-bit server-based network operating system, supports DOS, Macintosh, OS/2, and UNIX clients and IPX/SPX (Internetwork Packet eXchange/Sequential Packet eXchange), AppleTalk, TCP/IP, and OSI protocols. It supports 32 tera bytes of disk storage, 4GB file size, and 100,000 open files. Server management, routing, communications, physical-layer management, and gateway services are available, so is an SNMP agent. LAN Manager, a server-based network operating system, supports ARCnet, Ethernet, and Token Ring and uses TCP/IP, DECnet, AppleTalk, Named Pipes, and NetBIOS. It supports unlimited DOS, Windows, Macintosh, and OS/2 users and disk space, as well as async communications and domain naming services. It also has network management software and an SNMP (Simple Network Management Protocol) agent.

The release of Windows NT Advanced Server (NTAS) version 3.1 marked Microsoft Corp's most recent attempt at asserting itself in the LAN server market. And, after missing the mark with its earlier networking software LAN Manager for OS/2, Microsoft has produced an operating system replete with networking services that is sure to contend with the likes of Novell, Inc.'s Netware, IBM's OS/2 LAN Server and Banyan Systems' VINES. Windows NTAS can address a maximum of 4GB of RAM and files upto 1,700GB in size. It also supports most of the popular network adapters and printers. Windows NTAS is bundled with support for Macintosh, TCP/IP (Transmission Control Protocol/Internet Protocol), Netware and Internetwork Package Exchange (IPX), as well as fault tolerance and remote procedure call capabilities. In addition, it offers a workable, global directory service. There are four areas where Windows NTAS demonstrated particular strength - its integration with the Windows NT operating system, its straightforward installation procedure, its use of trusted domains to provide a global directory service, and its relatively low cost.

With Windows NTAS, all of the network configuration is done through the operating system's control panel, and GUI(Graphical User Interface)- based tools allow network managers to monitor network and file server performance, as well as examine system event logs. Windows NTAS offers a simple procedure for a potentially clumsy process, with its ability to autodetect many common network adapters. In addition, network managers can take advantage of the simple point-and-click interface to configure Windows NTAS for their environment.

172. Network operating system interoperability. Network operating system interoperability remains an issue to be addressed if centralized government-wide networking services are to be provided and different LAN operating systems in government agencies need to be connected and talk to each other.

Enterprise Network Services (ENS) is Banyan's answer to bridge the gap between NOSes by bringing other network operating systems resources under the VINES umbrella. Announced first for the NetWare environment, ENS for NetWare is touted as a NetWare add-on, giving NetWare users access to all VINES services, including Banyan's StreetTalk directory service with which user log on to the network once and have access to two different environments transparently. Banyan also intends to bring ENS solution to other environment such as LAN Server (IBM) and LAN Manager (Microsoft). Banyan is, however, the sole network operating system vendor providing interoperability to other network operating systems through the server rather than the client.

At present, other vendors are focusing on providing interoperability through client workstations instead of at the server level. Microsoft is taking steps to provide interoperability with NetWare services, but is focusing on the client side rather than the server side. Microsoft includes LAN Manager/NetWare Connectivity in every LAN Manager box, which basically consists of a Novell Internetwork Packet Exchange (IPX) protocol stack that the administrator loads on every LAN manager workstation. The workstation can then maintain multiple logins to multiple servers. Once users have logged on to both servers, they can access all files and services provided through the LAN Manager server and can access files resident on the NetWare server. But users still have to know how to log on to the NetWare server and must know NetWare commands to navigate the network. LAN Manager, however, also provides server-based connectivity to AppleTalk nets as well as UNIX connections through the Transmission Control Protocol/Internet Protocol (TCP/IP). With server-based protocol support, clients can access LAN Manager services as if they were resident on their local net. In addition, because IBM's LAN Server evolved from LAN Manager, clients within each environment are able to transparently access services within the other environment. Due to the emergence of Windows NT Advanced Server (NTAS), LAN Manager capabilities expected to be incorporated into NTAS and LAN Manager will fade away. NTAS is expected to provide the same general connectivity capabilities as LAN Manager in terms of network operating system integration. NTAS will come bundled with LAN Manager/NetWare Connectivity feature, just as LAN Manager does, and will also provide the same server-based AppleTalk and TCP/IP connectivity. These abilities, however, will not be inherent in NT itself. Therefore, if users are looking to implement an NT-based network and if network operating system interoperability is at stake, Windows NTAS is the choice.

As with Microsoft's LAN Manager, IBM provides server-level connectivity for Macintosh clients, letting those clients access LAN Server services as if they were Macintosh services. However, beyond Macintosh support, IBM is relying solely on the dual-redirector method of network operating system interoperability without providing some of the out-of-the-box hooks that Microsoft does. LAN Server/NetWare dual-redirectors will provide file access but will not provide access to the network operating system-based services such as security, network management or directory services if they are available. And, once again, the user has to log on to and get around in two environments. IBM intends to bring out a new version of LAN Server that will provide the same directory service-based connectivity to NetWare as Banyan provides but will do so through the implementation of Open Software Foundation, Inc.'s Distributed Computing Environment (DCE).

Because of its dominant share of the market, Novell sits back and waits for other vendors to connect to NetWare instead of making the effort to provide that connectivity itself. Novell, like other vendors, provides Macintosh and TCP/IP connectivity on the server, but is still pushing the concept of enterprise services with NetWare 4.0. So far the company has interoperability at the client level and it is working to broaden that so servers.

Client-based interoperability is a short-term solution that burdens end users with having to learn multiple network operating system environments. Another shortcoming of client interoperability is that users have to know which network operating system a resource resides on in order to access it. Server-based interoperability is preferred because it gives users access to multiple brands of servers from within their native network operating system environment. With protocols supported on the servers rather than on clients, users do nothing different; they simply log on to the network as usual, and access to other nets is provided transparently, without having to log on to a different server and without having to know that resources are on a different server.

7.6 Wireless LAN

173. Wireless LANs connect computer devices within an office or building by radio or light waves. Wireless hubs and bridges can weave wired and wireless LANs into a government-wide network.

Wireless holds strong appeal for two distinct groups of users within government. Wireless can extend conventional Ethernet or token-ring LANs instantly where cables would be difficult or impossible to lay. A wireless hub or bridge can connect hundreds of users across a street or river, without costly tunnelling. The other group is mobil users, such as police and military officers, who can log into their wired LANs via low-powered radio adapters, without modems or cellular phones.

Radio frequency (RF) and infrared (IR) transmission dominate the wireless LAN market. Spread-spectrum RF can signal across a wide bandwidth, whereas narrow-band microwave RF works in a more limited spectrum. IR covers diffuse and line-of-sight technologies. To choose the right one which balances cost against security needs, transmission range and usage inside or outside a building are the factors to be considered. Spread-spectrum signals need not be transmitted or received in a straight line, meaning they can get around walls and other impediments. Their modulation makes them resistant to radio, TV or microwave interference. Single-frequency, narrow-band RF systems allow throughput close to that of wired Ethernets. Unlike spread-spectrum, single-frequency RF has no encoding system - the signal occupies the entire carrier frequency. The data signal is up for grabs unless a separate encryption box or software is installed. Infrared signalling is an efficient and hassle-free way to set up 10- to 20-foot, point-to-point connections. Invisible pulses of light travel from one transceiver to another, along the line of sight or by diffusion of the light beam over a wider area. IR signalling systems are fairly cheap and easy to build, and faster at 115 KB/sec than most modems over short distance. The problem of IR systems is that infrared signals can not go through or around walls.

Slow transmission rates and the high cost of radio LAN adapters have limited the emergence of wireless LANs. Except in specific environments, such as noisy factory floors with high interference, sensitive hospitals, and high security governments facilities, wireless LANs have been avoided. Recent LAN announcements suggest that radio technology is becoming more affordable ($1,000 US dollars per network connection) and providing higher-speed connections (1-10 mbps). Wireless LANs could provide the next big connectivity breakthrough. Radio-equipped PCs spread data transmissions beneath the noise level of licensed frequencies. Spread spectrum transmissions can help eliminate eavesdropping or interference from electric motors and factory machinery, all without affecting the sensitive equipment found in hospitals, airports, and laboratories.

Wireless radio connects LAN workstations within the radius of an omnidirectional antenna. PC radio LAN adapters send and receive transmissions from a broadcast server using CSMA/CD access techniques. Signal strength, LAN configuration, and network identification protocols prevent signal mix-ups among multiple server networks.

Transmission rates of 2 mbps directed to distances of several hundred meters are achieved in open factory floors. Office environments with partitions and conventional construction transmit at distances of 100 - 150 feet. Using standard Ethernet or token-ring cabling on the backbone, wireless LANs provide effective office distribution connectivity. Furthermore, wireless LAN vendors currently support all major LAN network operating systems, such as NetWare, LAN Manager, and VINES.

Microwave systems have been around commercially much longer than spread-spectrum RF and IR lightwave systems. Microwave came about as a "bypass" alternative to local telephone services. It is fast, efficient and loaded with bandwidth for virtually any type of voice, data or video signal. As is evident by the number of microwave dishes atop city buildings in developed countries, it is popular as a site-to-site wide area network connector.

174. However, Wireless LANs will not supplant wired systems in the near future for the following reasons:

(a) Hitherto wireless LANs are still very slow. Wired Ethernet's standard throughput is

10 MB/sec while a tenth of that can be expected from a wireless system.

(b) Most wireless LANs have a transmission range limited to about three hundreds meters within a building and 1.6 to 3.2 kilometers outside for spread-spectrum radio systems.

(c) Standards are a real headache for both wireless manufacturers and purchasers. Interoperability lags far behind product development. Buying one vendors products will lock the user into that vendor's suite indefinitely.

(d) Despite the convenience, wireless per-node cost is high. A single node runs $ 700 to $ 1400 US dollars in the United States market, depending on type and range, and far more if you count the cost of a multiuser wireless hub or LAN-to-LAN bridge.

7.7 Internetworking and WAN

175. The most significant trend in the computing world is the growth of distributed processing, a technique that puts computing power closer to users rather than in large, central mainframes. LAN interconnection strategies promote development of truly distributed networks, thus taking advantage of the remarkable increase in power and reduction in cost offered by PC technology. LAN interconnection eases the sharing of information between departments and networked nodes. Users log on to the network rather than onto one system, and the LAN directs them to the mainframes, minicomputers, or other LANs. In addition, LAN interconnection applications running on PCs in a network environment can deliver many of the benefits offered by mainframe computing, for example, security, integrity, and availability.

LAN interconnection used to be placed in the hands of large system vendors such as DEC or IBM. Single-vendor proprietary solutions have become unpopular for LAN interconnection because of the considerable risk of dependence on one provider. Competitive advantages from accelerated technological innovation, product and price differentiation, and lessened dependence on vendors make standards-based LAN architectures preferable to proprietary interconnection strategies. Standards-based architectures are developed by multiple vendors using an open network design framework where any vendor's computer system can freely share data with any other computer system on that network.

Today, many different LAN network providers offer creative, open, standards-based LAN interconnection solutions. The current market offers mature products at competitive prices. Technological advances have simplified LANs so that highly-skilled expertise is not required to achieve connectivity. Turnkey systems have put LANs into the hands of both the small business and large corporation.

176. WANs (Wide Area Networks) are used to connect buildings, building complexes, and cities over distances greater than just a few miles. Today's WANs often integrate voice, data, and

video traffic to take advantage of the economic advantages of high-capacity transport facilities. The network design process is easily applied in the broad context of integrated services. This structured engineering process of network optimization is applicable to not only data transmission systems but also voice, video, and integrated services.

Typically, a WAN connects LAN sights located throughout the country or even the world. There are four distinct components in a LAN-WAN internetwork: the LAN itself, the LAN internetworking communications hardware, the WAN access communications hardware, and the WAN transport facilities (private and public). Standardized LANs are widely accepted, with Ethernet, token bus, token ring, and fibre distributed data interface (FDDI) being the most prevalent types as described in previous sections.

177. Internetworking communications hardware. There are four different types of networking devices that can be used to connect multiple LANs together: repeaters, bridges, routers, and gateways. Each of these systems operates at a different OSI (Open Systems Interconnect) layer and differs greatly from the other units in complexity, functionality, performance, and cost. The repeater, the cheapest among the four, sends all network signals from one LAN onto an adjacent network segment. Its primary use is to extend the physical distance of a network. A bridge links two or more LAN segments to form a new single and large LAN. The router provides a means of connecting multiple, independent networks together. Networks that are connected through routers maintain their individuality from a management and protocol perspective. The gateway is a device that can translate between different types of protocol. It is common to see gateways combined with bridge or router functionality. However, gateways, providing much more functionality than a repeater, bridge, or router, generally process information at a much slower rate. A large internetwork (multiple LANs connected together) may often involve a mix of the above products.

178. WAN access devices are used by customers to access WAN transport services. At the customer premises one typically finds modems, multiplexers, channel banks, channel service units (CSUs), and data service units (DSUs). Modems are devices used to modulate and demodulate digital signals to and from analog transmission facilities. Typically analog circuits are more troublesome to install and maintain than digital circuits. Analog modems support data rates of up to 24.4 kbps without compression. This speed is often too slow for large-scale LAN-WAN internetworking, but it can provide a cost-effective solution for a small number of PCs or workstations. Digital transmission services offer a wide range of data rates: DDS (Digital Data Service) operating from 2.4 kbps to 64 kbps, T1 providing 1.544 mbps, and T3 running at 44.736 mbps or 28 T1 signals, for example. A CSU terminates digital circuits in a manner similar to that used by modems in analog environments. DSUs work with CSUs to transform digital signals into the standard digital format used by business equipment such as data terminals and fax machines. Channel banks are multiplexers that combine many voice or data signals into one high-speed link and control the flow of these signals over this link.

WAN transport facilities can be either private or public. There are a number of ways to build a network using common-carrier public service offerings. Public services are generally divided into two categories: circuit switching and packet switching.

Circuit switching provides a temporary dedicated pathway or circuit between two users; it is established when a call is originated and terminates when a call is completed. The pathway is not shared with any other public network users. Users have exclusive use of that pathway or circuit throughout the duration of the call. Examples of circuit-switched public services are dial-up lines, switched 56K, and integrated services digital networks (ISDNs). ISDN can also utilize packet switching and private dedicated transport facilities.

Public packet switching is a data transmission technique in which data packets are sent over a circuit shared by multiple users. Each packet contains data, a destination address, and an origin identifier. As the packets are transmitted, switches read the address and route it to the intended destination. Users receive only those packets meant for them, even though the pathway contains packets for many users. The term virtual circuit (VC) is used in conjunction with this technique, because the user sees the pathway as being dedicated, when in fact it is shared. Packet switching works well for LAN-WAN internetworks, which often have burst traffic patterns. Examples of packet-oriented networks include packet-switching X.25 networks, frame relay with fast packet switching, cell relay, asynchronous transfer mode (ATM), and switched multimegabit data services (SMDS).

Private networks provide permanent, dedicated pathways for the transmission of data. These types of telecommunications services are used with LAN/WAN internetworks with fairly consistent traffic patterns. Private WAN transport services not based on common carriers include those using satellites and microwaves. Private leased lines are common-carrier services obtained from private-line providers. In the United States, for example, interexchange providers, such as AT&T, MCI, and US Sprint, publicize their services and rates in tariffs. Examples of private-line facilities are analog leased lines, digital data services (DDS), new hubless digital services (NHD), fractional T1 (FT1), T1, fractional T3 (FT3), T3, and synchronous optical network (SONET). Although the availability of digital facilities has expanded greatly, there are still some locations served only by analog voice-grade services (VGS). DDS provides low-speed digital transport services with NHD facilities offering an attractive alternative to the high cost of DDS for local intraLATA services.

T1, FT1, T3, and FT3 all offer dedicated high-speed transport services at relatively low rates. These types of services provide the greatest flexibility for using available bandwidth for LAN-WAN internetworking. SONET was conceived as a way to provide a standard interface for extra-high-speed transport facilities.

179. A network computing system must be based on industry and international standards, which permit the hardware and software from different vendors to work together. Networking must operate in different physical environments, moving data within offices and around the world; moving data at a rate suitable to the application at hand; connecting proprietary products and standard ones; and supporting activities at different hierarchical levels within a network computer system. All these functions can not be carried out without a set of standardized rules, by which two or more devices agree on data/information and code structures required for successful and error-free

communications. This interoperability has been achieved in today's network computing systems. For example, Ethernet is the standard for the low-level data link layer. Some vendors also support the ARCnet, the Token Ring, Token Bus and FDDI (Fibre Distributed Data Interface - fibre optic link). Protocols for this media (as well as wide-area media) range from a variety of currently popular TCP/IP-related solutions to OSI (Open Systems Interconnect) protocols. The world of networking standards is ruled by the International Standards Organization's OSI seven-layer model. That is the ideal for which network computing strives. In the real world, there is an almost overwhelming variety of networking approaches due to specialized requirements and proprietary solutions. A realistic network computing system must support all widely used networking strategies.

PART III:

METHODOLOGIES OF SYSTEMS DEVELOPMENT

CHAPTER 8

REENGINEERING AND BUSINESS PROCESS REDESIGN

8.1 Reengineering

180. A government agency is organized to perform its functions. A function is a managerial control unit with responsibility for and authority over a series of related activities involving one or more entities and performed for the direct or indirect purpose of fulfilling one or more missions or objectives of the agency. Specific functional responsibility and authority may rest with an individual, a group of individuals, groups of individuals, one or more areas of the agency, or within the agency itself. Functional performance of a government agency must be identifiable, definable, and measurable.

Generally, a function can be equated to a management control point, with one manager representing one function. Thus functional decomposition of a government agency follows the management reporting structure (which may or may not follow the organizational lines), and a function is whatever a manager is responsible for. Functions correspond to managerial authority and responsibility, which can only be delegated from above. Hence, the functional model of an agency could be represented by a simple hierarchy.

A business process is a sequence of related activities, or it may be a sequence of related tasks which make up an activity. These activities or tasks are usually independent, and there is a well-defined flow from one activity to another or from one task to another. Business process definition and description identify activity and task dependencies. Business processes usually identify major units of bounded, repetitive work, and they are more easily modeled in horizontal form than in vertical form. Therefore, business processes are groups of business activities organized around data or process dependencies. For a well organized government agency, there must be a well-defined flow from one activity to another or from one task to another.

An activity is a set of tasks organized and proceduralized to accomplish a specific goal. Tasks are usually discrete, part of an overall process performed in support of a function, highly structured, and task-oriented. Activities are usually data-driven, triggered by transactions or requests for data; they are the active portions of functions, tend to be repetitive and formalized, and are composed of many tasks. Activities are almost always portrayed horizontally.

Business function-process-activities are the chains to recognize and model any government agency, in terms of business systems analysis of government agencies. A well organized government agency should have a set of well defined function-process-activities chains, or systems.

181. Government information systems are designed to support, or computerize business processes of the government agencies so that they will be able to perform their functions effectively and productively. However, the real power of information technology is not that it can make the original, or the old, business processes work better but that it enables government agencies to break old rules and outdated assumptions and create new ways of doing the job. That is reengineering. Other names include business process redesign, business redesign, process redesign, business reengineering, etc.

An example from IBM Credit can explain how reengineering works in practice. IBM Credit finances the computer equipment purchased by IBM customers. Before reengineering, customer requests for financing had to go through several departments and levels of decision making, often taking many days to process. The application and approval process includes request form, background checking of the customer, modifying the terms of the agreement, determining the appropriate interest rate, and issuing a quote letter. Sales representatives of IBM were frustrated over the slow response time in processing customer requests for financing, and complained about customers cancelling orders or finding alternative financing with other companies.

The reengineering process then took place. When IBM looked closely at the old management scheme, they found that most of it was little more than clerical: finding a credit rating in a database, plugging numbers into a standard model, pulling boiler plate clauses from a standard file. These tasks fall well within the capability of a single individual when he or she is supported by an easy-to-use computer system that provides access to all the data and tools the specialist would use. IBM management eliminated five separate offices and handed over the task of handling a customer's request for financing to a single "case worker" called a "deal structurer." One generalist, armed with a computer, now handles the entire process. IBM Credit thus reduced the time it took to process a request for financing from seven days to less than four hours, using less labour in the process.

Another example using information technology to reengineer business process is the TradeNet developed by the Government of Singapore. The system links government agencies, traders, transport companies, shipping lines, freight forwarders, banks and airlines. An on-line information transfer allows trade and customs clearance to be completed within 15 minutes, rather than the two days taken previously. Through use of one common electronic document which can be submitted round the clock, TradeNet provides "one-stop" and "non-stop" service to shippers and traders. The Government estimates the TradeNet saves traders about $ 1 billion US dollars annually through reduced delays and fewer needs for personnel to process paper.

Obviously, one of the keys for successfully reengineering business processes is to understand what fundamental changes the modern information technology have brought to the world and how these changes will transform the ways people do their business.

182. One of the basic changes is the accessibility and availability of information. Without computerized databases, information may appear in only one location at one time. With shared databases, however, information can appear simultaneously in as many places as it needed and can be shared by as many people as need it. In the past ten years, people have gone from isolated personal computing to work group computing to organization computing. By the means of network computing, i.e., LANs and WANs, people do not have to be in the same location; a business process team can be spread around the city, around the country, or around the world. Moreover, the business process team can include "outsiders" such as people from other government agencies who are closely related to the business process. Connected properly, the virtual team can work together for the common good of all the players.

Instant access to information means that the control and coordination of activities can be exercised quickly and at lower levels of command that are "closer to the action." The introduction of computer-based technologies allows information to be processed horizontally rather than vertically, in effect collapsing the traditional organizational pyramid in favour of networks operating along a common plane. By eliminating the slow climb up and down the old-fashioned decision making pyramid, information can be processed at a speed commensurate with the capabilities of the new computer equipment.

183. The old rule is that the managers make all decisions. With the assistance of the desktop computers and decision-support tools, decision-making now can be everybody's job. Today's desktop tools provide the means for quickly moving among applications, constructing complex documents, accessing data from different sources and communicating with others in a work group. And, these means are becoming more productive. Now, any employee, if authorized, at any location within the organization can access all of the information being generated and directed through the organization. Organizations that are reengineering their business processes often eliminate or reduce mid-level management layers that frequently serve as data funnels. Now it is up to front-line employee to make decisions based on the information at hand. It has become necessary for the end user to do for himself what previously had to be done by a trained information systems professional: access data in a meaningful way.

184. Many business processes of administration and management must choose between centralization and decentralization. Applications of computer communications systems have

changed this rule. Effective and efficient communications are becoming more critical to supporting new streamlined business processes and styles. Electronic mail, bulletin boards, electronic conferences, etc., make business able to simultaneously reap the benefits of centralization and decentralization. This is the reason why mail/information-enabled applications are becoming so popular. These applications can send and receive messages and documents in common e-mail formats, without interrupting the user's workflow, and, these applications make it easier to team up with others to process, store and forward information in multiple formats, including data, documents, drawings, photographs, audio and video. Modern information technology lets decisions made at the closest place to the related matters but still retains central control of most information.

185. Offices used to be an indispensable need for people to receive, store, retrieve and transmit information. But, wireless data communications and mobil computing have changed this rule. People now can send and receive information wherever they are. From portable computers to personal digital assistants, people can take their computing power with them. Rapidly evolving communications technologies such as wireless modems and credit card-sized network adapters mean that people can literally communicate with anyone, anywhere, at any time. For better or worse, the workday does not have to be end when people leave their offices. This opens new possibilities for field personnel, homebound workers, travelling executives and officers.

186. It has been long recognized that only experts can perform complex work. With the development of artificial intelligence and expert systems, a generalist now can do the work of an expert. In particular, knowledge bases become very important to successful reengineering. Knowledge bases are stores of information that are outside people's own domain. These data bases contain tremendous amounts of information that can be culled to meet very specific needs. Knowledge bases can be tapped on-line or via CD-ROM. They can be free or a for-fee service. The type of information could be virtually unlimited, from public data/information to marketing data and consumer information. Making full use of this wealth of knowledge, a generalist could become very knowledgeable.

187. Successful business processes take team-work, and information technology is the vehicle for enabling that team-work. There is a whole category of applications that are designed for collaborative computing. This category, known as groupware, includes applications that encourage people to share ideas and build on what has been done already. The applications include group information managers, such as "Notes" developed by Lotus Development Corp., electronic brainstorming and meeting products, such as "Team Focus" developed by IBM, project managers, group schedulers and more. Groupware supports the concept of employees as teammates, where everyone contributes and benefits from other's contributions.

Client/server technology also restructures the business flow processing, partly by placing it closer to the work node. By building a totally automated information system for the business process, organizations eliminate the delays and errors created when data is manually manipulated. The use of electronic data interchange (EDI) is an example of a modification in business flow processing.

188. Information technology enables reengineering of organizations only if the management of the organization has embraced the idea of change. Reengineering represents a high-level application of modern information technology and provides a way that an organization can benefit as much as possible from the modern information technology. To apply reengineering technique to a government agency, two aspects of knowledge are imperative:

(i) Understanding the methodology of business processes analysis, i.e., establishing the business model of the government agency; and

(ii) Understanding the changes brought by modern information technology and how these changes are influencing the way people do business. Given that information technology is being developed very rapidly, the changes brought by the technology are dynamic. Keeping an eye on the state of the art of information technology is necessary.

Three major steps are essential for a successful reengineering program: reviewing the existing business processes, identifying the opportunities for change; and redesigning the business processes.

189. Reengineering is a term used to describe how organizations can achieve radical improvement over a short period. However, such reengineering is not a straightforward or easy undertaking. It requires vision, willpower, and a comprehensive approach to change that includes these elements:

- Leadership and commitment from the top management of the organization throughout the entire reengineering process, which can guide the change and lead the implementation;

- An external orientation seeking why and how to improve existing business processes;

- Sound methods for reengineering the work process to meet strategic objectives and performance goals of the organization;

- The appropriate use of modern information technology to enable breakthrough performance;

- Effective change management to adjust the organization's people and culture to new ways of working; and

- Continuous improvement methods to sustain and increase the dramatic gains achieved during reengineering.

In practice, reengineering has been a difficult undertaking. The difficulties start with the task of documenting the systems currently in place. Actually, the important work of evaluating the current state of the organization's systems and business processes is not high-tech work. It requires time and dedication, both of which are often in short supply. It also requires the formation and growth of a community of interest within the organization.

8.2 Methodology for Business Process Redesign

190. The core of reengineering an organization is to review and redesign its business process. The purposes for doing so are:

- To obtain a streamlined business process which adapt to the environment provided by modern information technology and are able to benefit from it; and

- To develop a streamlined information flow for the organization, which could only be based on a streamlined business flow.

Without a streamlined business flow, there will never be a streamlined information flow, nor a rationally designed information system.

The methodology of Business Process Redesign (BPR) is used for streamlining activities affecting the business flow and information flow of an organization. This methodology aims to transform the business process and streamline the business flow of an organization by using a combination of the techniques and tools of modern industrial engineering, operations research, management theory and systems analysis. Its results are the achievement of breakthroughs in the organization's quality, responsiveness, flexibility and efficiency. For example, process flow analysis is a problem identification technique that has its roots in industrial engineering. It has been successfully used for several decades in various engineering disciplines to study the general flow of processes that cross several business, shop floors or engineering departments in the organization.

Without reviewing and redesigning the business process, any efforts toward reengineering will like a "castles in the air", and will not thoroughly solve the problems currently existing in the organization. Moreover, only if the business processes of an organization are redesigned and streamlined, can its day-to-day operation be rationally normalized and systemized.

191. Implementing a BPR project requires great effort. The main steps included in a BPR process are as follows:

(a) Organizing a steering committee and a project team, which will be responsible for the entire BPR process;

(b) Current Business Process definition and measurement, including documentation of current business process flows and steps as well as information flows;

(c) Identifying Change opportunities, through a series of brainstorming workshops and presentations to the Steering Committee and all people related;

(d) Defining the new Business Process and information flow for the organization as well as documenting the organizational changes necessary for implementation;

(e) Government approval of the recommendations on the new Business Process of the organization;

(f) Implementation of changes identified in BPR.

The implementation of a major BPR project may take two or more years. Including input from all the appropriate people is one of the critical success factors. Commitment from the top management to see the project through is crucial, and involvement of other officers and managers can hardly be neglected. If the process involves other government agencies and external institutions, there will need to be close coordination with them. The success of the implementation will depend on the quality of the analysis and planning performed prior to the BPR project. Where possible, a pilot operation of the redesign business process should be set up and evaluated. Debugging is always easier when only a limited part of the organization's activities have been committed. The results of the business process change should be measured against the goals established during the analysis phase and be periodically reported for at least the first few years of the implementation. If necessary, measurement devices can be built into the new business process to provide continuous measurement and form a base for further evolution.

192. A Steering Committee for BPR (Business Process Redesign) should be established. The committee should be chaired by the top management of the agency and should include senior representatives from departments/division/units of the agency. The Steering Committee's responsibilities include the following:

(a) Providing management direction to the BPR project team;

(b) Ensuring that adequate resources are availed to the BPR project;

(c) Suggesting, evaluating and assessing the implications of proposed changes to the Business Process of the agency;

(d) Making final recommendations on the Business Process Redesign of the agency to the government authority;

(e) Guiding the implementation of the changes and new business process.

A BPR project team should be established as well to conduct the substantive work for the business process redesign. In general, the project team should be made up of a project team leader from the business process, representatives from each organization currently conducting a part of the business process to be studied, associated information systems professionals and, if necessary, outside consultants adding a neutral opinion to the mix. This team will perform detailed analysis, design the changes or new systems and identify any new or modified implementations of information systems to support the redesigned business process. The team will be substantially dedicated to the BPR project throughout the analysis and recommendation phase. This team will also form the cadre for guiding the implementation phase in the future.

193. The project team will work with high-level government officers to establish which process are targeted for redesign and to set improvement priorities consistent with the mandate and overall strategy of the agency. Improvement goals may be stated in terms of quality improvement, effectiveness, productivity, cost, or other measures desired by the management.

The project team will then conduct a preliminary analysis of which particular business process of the agency should be redesigned. The team will investigate the current business process definition and measurement so as to identify problem processes, make diagnoses, and find solutions.

The first step of the project team is to study government documents and regulations with respect to the agency, its mandate and functions, and how these functions are related to current organizational structure and business process. Current business process and information flows should be documented after the study.

The project team should then interview government officials, both internal and external, who perform or are in associated with the subprocess, and from their descriptions, note each step in every sub-process, the documents and data used, the sources of information, the disposition of results, and interactions with other officials or sub-process needed to perform the task. The project team must correlate the results obtained from the views of the officers and clients of the agency with the views of the top managers to obtain a consolidated picture of the primary threats to the agency's functions and performance. Special attention should be given to the analysis of overlap and interdependence of organization units as well as potential inadequacy and redundancy of activities in the business process.

Based on these activities, the project team will be able to document the business process and activities; document information flows: what information is used or created/modified in each step of the business process. For better understanding of the officers of the agency, a graphic annotated flowchart of business process and activities should be created.

The analysis on the current business process will:

- Measure the outputs of current business process;
- Provide a clue to the causes and effects of current problems;
- Identify specific activities or sub-processes requiring improvement and help; and

- Propose to improvement goals and improvement priorities.

The project team can take advantage of information technology tools developed for computer-aided software engineering (CASE) to document the business process. Computer-based project management tools may also be used to analyze the current business process.

194. Identifying change opportunities is the critical step for redesigning the business process. The project team will have a fairly good idea which information technology will play a significant role in enabling changes to the business process.

Knowledge about the technology must be shared so that those involved will be able to participate properly in planning business process changes. Targeted individuals include members of the steering committee, nontechnical members of the project team, and managers and senior employees involved in the process to be designed. The latter group needs the information so that it can contribute ideas and validate conclusions. It is not, however, necessary to teach every manager or employee the details of the technology. Instead, they must be taught the basic functions they can perform by combining computers and data communications. It is important that they understand how applications replace labour-intensive work, ensure the reliable storage and retrieval of information, enable changes in the sequence with which work is performed, provide additional information needed to manage the business process or even reduce the amount of information necessary to manage a business process. Applications examples and brief descriptions of appropriate technologies and their capabilities can be used to develop a short course for the steering committee and for supervisory personnel and key employees in the business process.

Armed with the knowledge of enabling technology, the project team, business process managers, and key senior employees are ready to become more intimately involved in changing the way things work. A series of brainstorming workshops would be held to draw on the wisdom of the masses and absorb all useful ideas. The primary purpose of the workshops series is to verify the description of the current business process and obtain ideas to change the process. The presentations for the workshop, prepared by the BPR team, will include:

- The objectives of the BPR project;
- The reasons for the project;
- The methods used in the BPR analysis up to this point;
- A diagrammed description of the current business process of the agency;
- A diagnosis of the causes of current problems and their effects; and
- The expected results of the workshop.

After the participants verify that the flow of the current business process has been accurately represented and after they have annotated any comments, the project team members should open the discussion by suggesting process changes to workshop participants. The idea here is to brainstorm. No suggestion, however outrageous, should be rejected immediately. The team should encourage ideas that challenge existing organization structures, sequences of work, geographic locations of work, the existing approval process and unwritten assumptions that underlie the current process.

The BPR project team should document the workshop conclusions and hold a final review session in which it validates those conclusions.

The BPR project team should then prepare a workshop for the Steering Committee, with the following presentations, in addition to the materials prepared for the previous workshops:

(a) The changes to the business process recommended by the initial workshops;

(b) Comments on the feasibility of the suggested changes; and

(c) Comments on the expected benefits of the suggested changes.

In its workshop with the steering committee members, the project team presents and discusses the composite material developed to date. Steering committee members and the BPR team will likely have additional suggestions for changes. Out of this series of workshops should come preliminary recommendations for changing the business process so that it fits the agency's objectives and internal environment. A draft report: "Recommendations on Redesigning the Business Process of the Agency", which defines the new business process and information flow for the agency, will be worked out, including the document on the organizational changes necessary for implementation. The report and relevant documents will be submitted to and reviewed and approved by the steering committee. A final report will be submitted to the government authority for final approval.

195. Following the final approval of the report, a series of activities will be carried out by the project team. The changes to the final report: "Recommendations on Redesigning the Business Process of the Agency" need to be specified. First of all, Departments/Units/Divisions contributing to new Business Process should be defined, in accordance with the final report. The organizational structure adapting to the redesigned Business Process of the agency, taking into account the existing structures, should be determined. Organizational charts and their relevant descriptive information need to be prepared. The functions, responsibilities, accountability, delegations of authority, number of staff, and linkages with other Institutions/Departments/Units/Divisions will be clearly defined. For each Department/Unit/Division contributing to the new business process, its information input, output, and responsibilities of data collection and production will be illuminated and modeled.

To support these new flows and organizational changes, the project team recommends changes in technology, such as replacing systems or applications or acquiring new systems altogether. With the assistance of all relevant information systems staff members, the team provides costs and pinpoints trade-offs among possible implementation path. It also delineates how the new processes will affect other processes throughout the organization. It calculates how long the redesign will take and what risks are involved. Finally, the team outlines the benefits, recommends a course of action and delineate an action plan.

A report on "Recommendations for Organizational Adjustments of the Agency", in which the results derived from the activities specified above, will be drafted and submitted to the steering committee for reviewing and approval. Incorporated the committee members' comments or changes, a final proposal, which will establish a new paradigm for the business process, will be submitted to the government authority by the steering committee.

196. Indispensable regulations, norms, working standards, and operational manuals, as well as suggestions to organizational adjustments need to be identified and worked out so as to embody in practice the redesigned business process of the agency and normalize and systemize the new business processes. A series of workshops on the drafts prepared by the project team should be held for discussing and gathering comments. Various timely finalized new regulations, norms, working standards, and operational manuals for the new business process should then be submitted to the steering committee or appropriate authorities for review and approval.

To make the BPR process succeed, the objectives of the BPR must be audacious. The management objectives must set targets that stretch the imagination beyond the confines of the present organization, the accepted ways of doing things and the current process sequence. Only by striving for grand results can an agency achieve a breakthrough in its administration and management.

CHAPTER 9

METHODOLOGY OF STRUCTURED INFORMATION SYSTEMS DEVELOPMENT

9.1 Information Systems Engineering

197. The design of effective, efficient government information systems is based on many factors, including understanding the user's requirements and being able to determine the most effective methods to satisfy them. The former requires detail expertise of users' business. It means that the availability of managers and users with an expert knowledge of their business is an essential requirement. The latter requires the involvement of information systems analysts who have expertise of the-state-of-the-art of information technology. Therefore, the result of information systems design is a design partnership: the users provide business design; the information systems analysts provide computer and communications design.

This is easy to say, but in practice very difficult to do. Information systems design, as with business processes analysis, is at best an inexact science, one that is highly dependent upon clear, precise, accurate communications of information and ideas between user, analyst, and designer. The methodologies of information systems engineering, which summarize experiences and lessons of previous systems development, either successful or failing, must be followed if successful information systems development is expected.

198. In order to accomplish any given set of tasks effectively, one must have a work plan or procedure. Without it, activities are performed in a haphazard manner and with little, if any, coordination. The results are that various intermediate products rarely fit together into a cohesive whole, and worse yet, the finished product rarely meets the initial specifications. In some cases,

because of the lack of a work plan, there are no initial specifications. The detailed work plans for information systems development are called methodologies. In fact, a methodology is a system of principles, practices, and procedures applied to a specific branch of knowledge. Methodologies provide the framework and the sets of procedures within which the myriad of development tasks can be performed. Most methodologies cover the entire span of development activities, from project initiation through post-implementation review.

199. Information systems engineering leads to gains in the productivity and quality of systems development. Some significant issues relating to information systems development and addressed by information systems engineering are described as follows.

Data administration and information resource management. Information systems engineering attaches great importance to data administration and information resource management and is a powerful vehicle to establish data administration and information resource management functions in an organization. Data administration is a function that defines standards, stewardship, and control of information in an organization. Information resource management has a similar purpose to data administration, but also includes the planning, organizing, and control of data and process models and designs, defining configurations of hardware and software, and training of the people required to support the information systems of the organization.

Productivity and system quality. Increased productivity with poor quality will not achieve the desired result - productivity and quality must be improved together. Information systems engineering stresses and assures quality by capturing business requirements before creating solutions. The rigor in the techniques and phases of the methodology ensure that this initial quality is carried through the implementation. Although it certainly costs an organization precious resources to establish and maintain the information resource management functions, the increase in productivity of systems development using information systems engineering more than compensates for this investment.

Change management and evolution. Information systems engineering provides a mechanism to manage change in an organization. The addition, deletion or revision of a business rule requires evaluation from a broad perspective of the data and process model. This might lead to modifications in many systems. Changes in technology or systems requirements require modifications to system designs and implemented systems as well. By separating technology-independent aspects of change management from technology-dependent implementations, systems maintenance is an evolutionary process that allows an organization to control its own destiny.

Migrating to alternative architecture. Once technology-independent data and process models have been developed for a functional area, they provide the basis for system design and implementation. In some cases the target environment for implementation of a particular functional area may have already been specified. In many situations, however, the data and business models become the baseline to evaluate alternative technologies. This allows an organization to select the optimum configurations of hardware and software, based on the budget they have available, to meet their needs. It may be that more than one target environment will be required to satisfy the business needs depicted by the data and process models. Rather than merely interfacing these different environments, however, they can be fully integrated, so taking advantage of the key features of each environment.

Reengineering and reverse engineering. Reengineering emphasizes streamlining business processes of an organization to take full advantage of modern information technology, takes a top-down approach to building data and business models, and yields high-quality results in a short period of time, while also ensuring user understanding. For organizations with current systems that are not well-documented, a bottom-up approach, reverse engineering, might be necessary. Information systems engineering uses business normalization and reverse engineering principles to extract database designs from data structures and program code, and develops technology-independent data and process models that are able to adapt to different technology-dependent platforms. This process of reverse engineering is feasible for those organizations that are not subject to business change because of regulatory or other constraints.

Object-oriented development. The emergence of object-oriented analysis, design and programming has led to a review of the traditional information systems development methodologies. By means of information systems engineering, the distinct sequencing of data and business process ensures that objects important to the business are identified, defined well, and linked to the strategic management statements that govern their existence. Therefore, the characteristics of object-oriented systems and databases are fundamental characteristics of information systems engineering.

Information systems engineering enables an organization to maximize the advantages gained from emergent technologies. The benefits realized range from new insights into the strategic business vision of the organization, to detailed planning and optimization of new technologies. Both short- and long-term benefits are attained. Once established, the returns from implementing information systems engineering ensure not only productivity and quality but also long-term success of the organization.

For this reason, this chapter gives a brief introduction to the methodology of structured information systems development, which is one of the important techniques of information systems engineering and is very useful, in particular, for large and complex information systems development. As the size of the project decreases, some development phases might be combined.

200. Assuming that a government information system project proceeds in a normal and orderly fashion, it can be expected to follow the following general phases: *project initiation*; *requirements analysis*, including business analysis, evaluation of existing system components, problem identification, and feasibility analysis of alternative approaches; *logical design*, including redesign of business flow, streamlining information flow, and the design of system architecture; *physical design*, including specifications of hardware, software and communication facilities, network design and wiring, and system security; *implementation*, including establishment of databases, data entry, and applications software development; *operation*, including merging the system into the normal business environment, data updating, and system maintenance; and *post-*

implementation evaluation.

There may exist many different ways to phase an information systems development life cycle. However, they all can be simplified into three main stages: analysis, design, and implementation. These three are bracketed by project initiation and project review. Additionally, all these activities include the administrative tasks of planning, scheduling, and control.

9.2 Preliminary Analysis

201. Project initiation is carried out through a preliminary analysis. The preliminary analysis forms the first and perhaps the most critical phase of the development project. In many cases, it is the project itself since the information developed in this phase may show that no further work is necessary, feasible, or desirable. In all cases, the results of the analysis phase determine: if there is a problem to be addressed; if there is a feasible solution to the problem; and if developing a solution to the problem is cost-beneficial to the user and to the government agency as a whole.

The primary objective of the preliminary analysis is to decide whether or not a project should be initiated to develop an information system requested by the users. Even at this early stage, the results of the preliminary study will determine if there are sufficient anticipated benefits to justify continuing the project into the next development phase.

A detailed view of the preliminary analysis would address the following:

- The current problems to be eliminated from the user environment and the exploitation of current and future business opportunities

- The definition of the system mission and the translation of user business needs into a clear set of project business objectives

- The setting of delimiters for the area of study of the project

- The identification of possible project constraints and risks

- The initial search for potential system implementation solutions

- The elaboration of a preliminary cost-benefit analysis

While identifying the current problems, much attention usually is given to how information technology could be used to improve effectiveness, efficiency, and productivity and quality of the government agency. However, this is far from enough. Strong emphasis should be placed on examining the current business processes of the organization. The new information system could be integrated into the existing business environment only if the efficiency of the current business processes is justified. Otherwise, redesigning the business processes must be considered.

202. The problems and/or opportunities identified or described by the users should be prioritized by order of importance. This ranking is necessary to differentiate between those issues that are very important and those that, although useful to address, are not essential to the project at hand. One possible way of categorizing them would be as follows:

- *Essential*: Requirements without which the user could not properly operate in the business environment.

- *Adaptable*: Requirements that, if need be, can be partly modified to allow alternative modes of operation.

- *Nice to have*: Requirements that the user is willing to document but that can be excluded from the system list of requirements, if they prove to be too costly to satisfy.

The definition of the project objectives is produced in relation to the problems and/or opportunities that were identified during the analysis of the current situation. The project objectives should be stated in a concise, measurable, and attainable format.

203. The output of the phase is the PRELIMINARY ANALYSIS REPORT, which contains:

- the definition of the problems;
- the terms of reference;
- the objectives and expected outputs;
- a preliminary work plan;
- anticipated benefits and cost-benefit analysis; and
- the budget and required resources.

As a matter of fact, a formal feasibility study should be conducted during this phase. Through the study, an agreement on the scope of the project should be obtained between the management of the user organization and the project team. Included with the report are justifications for the project, clearly defined boundaries for the development, and a work plan outline indicating how the development should be completed.

9.3 Requirements Analysis

204. Requirements analysis attempts to discover what is desired and actually needed by the users, clarify the products that will try to satisfy a complex set of desires, and discover who constitute a major part of the requirements process. Obviously, requirements analysis is crucial to

successful development of a government information system because if the system developers do not know what the users need, or do not communicate with the users adequately, the system's functions and performance can not be correctly defined. Any information system which fails to meet the real needs of the end-users will not last long.

Determining requirements begins with a thorough analysis of current business flows and organizational structures of relevance to the proposed system. Through data collection and interviewing the users of the system to be developed, the analysis tries to answer the questions specified in the following paragraph.

205. The most important way to conduct a requirements analysis is to interview the users, in particular the persons essential in the business process and end-users of the system. For different levels of government information systems described in previous chapters, different levels of users need to be selected for interviewing. When interviewing the users, the key issues are to learn all about the user's business, understand the user's terminology, and ask all the right questions. The logical sequence of the interview is:

(a) First, find out about the flow of information in the organization. Start with the outputs: What is the information needed to run the business? How must the data flow among departments and individuals? Determine the frequency, timing, and accuracy.

(b) Second, the inputs are then driven by the outputs: What information is required to produce each of the outputs? What information is available, when, where? What new information will have to be gathered?

206. The aim of requirement analysis to be conducted after interviewing with the multiple levels of users is to document the existing user functions, processes, activities, and data. The activities for the analysis phase are as follows: current function analysis; development of the current functional model; current process and activity analysis; development of the current process model; current data source and use analysis; current data analysis; and development of the current data model. Following the analysis, the appropriate approach to meet the user requirements may be recommended: developing a custom designed system; implementing a vender supplied package with or without modification; and reengineering the existing computer system. The design of any new system must be predicated upon an understanding of the old system. Even for a completely new system, making full use of existing resources must be carefully considered.

The validation of the requirements analysis is important enough to warrant separate treatment. The completed analytic documentation must be validated to ensure that all parties agree that the conditions as presented in the documentation accurately represent the environment, and that the documents generated contain statements that are complete, accurate, unambiguous, and testable.

207. The requirements analysis should result in a REQUIREMENTS DOCUMENT (RD), which states the user's problems and the general solutions required. The language should be

oriented to the user's business, and avoid computer lingo. The requirements document is sometimes used as a request for proposal (RFP) when the user tenders the project to outside contractors. However, a user written requirements document is usually inadequate for estimating and development because the user may be unaware of what a computer-based system can do, and so the requirements document is often vague. A user may not even perceive his or her own needs correctly for the reason that the user is not up-to-date with computer and communication technologies. Other problems are from communication. A non-technical person cannot be expected to learn computer lingo in order to explain his requirements to the computer analyst. Therefore, it is up to the project team to notice and solve the above problems. Many system analysts' experiences have shown that it is worthwhile for the project team to spend some time working with the user to help him/her write a good requirements document.

The main contents of a requirements document should include the following sections:

(a) Introduction: State the problems that need to be fixed, the history, examples of the problem situation, motivation to fix it, etc.;

(b) Project goals: A simple statement of why the system development is being proposed. Major constraints of personnel, time, and money can be mentioned;

(c) Major functions: Simple statements about how the system will function, based on the project goals;

(d) General outputs: A simple description of information required from the system. Details on every item of information (not necessarily screens or reports) required. The system analyst should suggest what reports will best provide the required information;

(e) General information inputs required: Go through the list of output items above, and see what input data is necessary to produce the outputs. This is an important time to ensure that all of the required data is available at the proper time;

(f) Performance: How many transactions are to be processed, how much data must be stored, how frequently must reports be produced, etc. State in terms of averages and maxima (in a peak day or hour);

(h) Growth: Try to calculate the increase in business and stipulate the number of years that the system is expected to function. Express the growth as a percentage or as actual numbers. The additional functions in the subsequent phases can also be described;

(i) Operation and environment: Where the computer will reside, how the LAN will be wired, where the interactive terminals are, if any. Who will use it. Any unusual circumstances such as a hostile environment (intentional or accidental), or endurance requirements. There may be a need for portability, or for special safety or physical security measures;

(j) Compatibility and interface: State if inter-computer communication is required, any existing equipment that has to be incorporated or if distributed access is required. If the system must go on an existing computer, or must be programmed in a specific language, document this fact here;

(k) Reliability and availability: Quote mean time between failures (MTBF) figures, mean time to repair (MTTR) and percentage up-time required. All manufacturers publish these figures for their hardware;

(l) Human interface: Outline the computer experience required of the user. State how the system is to handle the brand new user;

(m) Organizational impact: Which departments will be affected and how their work must be changed. How the new system is to interface to some existing or new manual systems;

(n) Maintenance and support: Warranties required: how long, to what extent, how it will be delivered; and

(o) Documentation and training: List the general documents and/or courses that would be required. For example, documents for users, operators, and maintainers.

208. User participation. It is mandatory to obtain active participation from the users during this phase. This is, beyond a shadow of a doubt, a very critical success factor. For instance, the business needs and objectives of the project cannot be properly developed without the users' firm commitment to assist in the initial process to define them. This is the only way to ensure that the requested system will be precisely aligned with the business goals of their departments and of the entire organization. Hence, users must actively participate and articulate their own needs. In fact, this statement remains true for all the deliverables that are produced during the preliminary analysis and requirements analysis phases. This emphasis on user involvement should be seen as conducive to the success of the project. The system that will be developed will be as effective in supporting the users' functional areas as the users will be in participating in the development of the system's requirements, especially during the critical stages of the analysis process. With the advent of user-oriented development techniques such as prototyping, more and more information systems will be developed successfully by a team of users and systems analysts who work closely together during the entire project.

The most successful projects are often those which are placed under the formal responsibility of the users. Although the system may be developed by computer and communications professionals, the ultimate responsibility of the project lies in the hands of knowledgeable and capable user representatives who are officially held accountable for the new system.

209. User training. It is important to familiarize the users who will directly participate into the project with the requirement definition techniques that will be used. This will help bridge the communications gap that might exist between the users and the systems developers. Courses should be designed specifically to help remove the cloud of mystery surrounding the development of an information system. In general, these courses describe the system development process in simple terms that are easy to understand from a user point of view. During these seminars, the specialized (and often esoteric) information systems concepts and vocabulary used by information systems developers are also explained, along with a brief description of the various graphical tools and techniques that are applied during the business process and data modelling tasks. Given the investment that will be poured into the development of a large information system, not to mention the fact that such a system will likely last between 10 to 15 years, a one- to five-day course for users is a small price to pay for attempting to deliver a high-quality system that aims to truly meet user needs.

9.4 System Design

210. The purpose of the system design is to define the internal architecture of the information system being developed. For a large, complex application, the design issues associated with the performance, usability, and maintainability characteristics of the system are of paramount importance. Consequently, the physical data and process models should be engineered in such a way as to offer as much flexibility as possible while taking into account the physical constraints that might be imposed by the technology selected to implement the system. Any deviation from the original requirements in the functional process and data models that might be necessary to accommodate specific system operational criteria should be properly documented and thoroughly discussed with the users. The strategies for testing of the system, data conversion, end-user training, and installation of the system should also carefully designed.

211. On the basis of user requirements analysis, the functions of the system to be developed can be defined. While defining the functions, system developers must capture all and only functions, and understand evident, hidden, and frill functions. Evident functions are those to be performed in a manner that is as visible, or evident, to the users as possible. Hidden functions are to be as imperceptible to the user as possible. Frill functions are those that the user would like, but not if they cost anything, either directly or in compromises with other functions. Classifying the functions list into hidden and evident functions helps to identify overlooked possibilities because it focuses on how some of the most essential functions of a system are taken for granted.

The definition of the functions should be performed collaboratively with the users, i.e., through brainstorming, developing an initial list of potential functions; classifying each function as evident, hidden, or frill. Using this classification, try to uncover unmentioned hidden functions, perhaps by brainstorming to augment the function list. In making the classification, look for functions with wording that implies some constraint on solutions and transform the wording to become problem statements, rather than solution statements; and, finally, create a list for the frill functions.

212. There are several issues which are also important and must be elaborated in a logical system design. They are identifying constraints and risks of the system development, defining preference, and limiting expectations to the system being developed.

Identifying constraints and risks existing in the system development is an important issue. The business and technical constraints and risks pertain to those conditions that are considered outside the direct influence or control of the project team members. At the same time, however, they might have a direct impact on the scope of the project, its schedule, and the proposed implementation solution alternatives. Constraints or risks that might affect the project include the following: organizational stability in terms of policies, functions and structures, government regulations, budget limitation, political consideration, schedule consideration, legal consideration, environment consideration, operational limitations, data availability, hardware/software/networking considerations, personnel considerations, technical limitations, new technology never trailed before, etc. In order for the final design solution to be acceptable, every constraint or risk must be satisfied. Therefore, a constraint or a risk must be defined in terms that will enable participants to determine objectively whether or not it has been satisfied in the finished product.

Defining preference is another job in the system analysis phase. A preference is a desirable but optional condition placed on an attribute. Any final design solution that satisfies every constraint is an acceptable solution, but some acceptable solutions might be preferable to others. Preferences enable the designer to compare acceptable solutions and choose the better ones. It is better to make preferences measurable; preferences are used by designers to guide them in satisfying their clients. Therefore, preferences would not be of much use unless each is defined in terms that will enable designers to determine to what degree the preference has been satisfied.

Limiting expectations to the system to be developed is important as well. If the developers think of the design process as a way of providing for all expectations and avoiding disappointment, he/she will never be successful if he/she can not control expectations. To raise and document expectations and limitations, a list of specific expectations from representative users should be generated first. The system developers must work with the list to understand and generalize each expectation and then negotiate to limit expectations to a reasonable level, leaving open possibilities for future modifications of the system, but definitely ruling out anything that can not reasonably be expected. When setting a limit, the source of the limitation should be documented, because today's limitation becomes tomorrow's opportunity.

213. Logical system design identifies the logical relationships of essential elements within and without the system, i.e., the business process flows that the system to be developed will support, and the information flows that will be processed by the system being developed. Business process flows represent the business model of the organization, and information flows depict the data/information model of the organization. Business model and data/information model are both technology-independent and address the system architecture at the logic level. Logical system

design will also identify the functions performed by the new or improved system and specify what the new or improved system will do to support the business process flows of the organization.

The product of logical system design is FUNCTIONAL SPECIFICATIONS of the system being developed, which consists of the following items:

(a) System overview: scope of the system; major components; business process flow of the organization; information flow; interfaces with other existing systems or agencies;

(b) Major objectives and functions;

(c) Special system requirements;

(d) Project outputs and activities;

(e) Other deliverables: documentation, and training;

(f) User and project team interfaces, and user's responsibilities; and

(g) Terms, conditions and assumptions.

The logical design should be a non-technical document accessible to system professionals and users alike. Once the user-manager is confident that the new system will meet the organization's needs and approves the logical design, the physical design of the system can begin.

214. Physical design determines the system architecture at the physical level, which is technology-dependent and develops system model. The physical design of an information system includes the specifications for how the logical design will be implemented. This involves such things as specifications of all manual and computerized procedures, system architecture and network topology, computer hardware and software selection, design of the physical data files required, specifications of all necessary programs and/or procedures, and the system's physical security. This process is a fairly technical one and requires user participation, especially in detailing the manual data processing procedures.

The completed physical system design should be documented at two levels. A design overview should be written that includes a description of the system and applications subsystems, inter-relationships of the subsystems, system architecture, its procedures of operation or data capture, its auditing procedure, a description of its databases and a sample of all input/output documents or formats, and the measures of system security. It should also spell out in detail the relation and interfaces of the present system to other information systems within the organization's environment. This design overview should be approved by the management of the government agency before the detailed technical specifications are spelled out.

In addition to design overview, there should be detailed specifications for data dictionary, files, databases, input/output documents, display screens, programs and procedures, wiring system, and user training programmes.

215. The product of physical system design is the DESIGN SPECIFICATIONS of the system. Its main components are as follows:

(a) System overview: application subsystems; system architecture; databases; internal and external relationships; integrating existing systems into new system, etc.

(b) Hardware/software/communication facilities: acquisitions and installation strategy;

(c) Design priorities and attributes: user friendliness, response, cost, time, etc.

(d) Design diagrams and module dictionary conventions, module naming conventions;

(e) Parameter passing and data dictionaries;

(f) Error handling;

(g) Structured programming standards and programming tools;

(h) Top level design;

(i) Medium level design;

(j) Module dictionaries;

(k) File and table definitions, database backup/recovery/reorganization strategy;

(l) System security strategy;

(m) Development of training strategy; and

(n) Acceptance.

9.5 System Implementation

216. The primary purpose of the implementation phase is to deliver a fully operational system to the users. Based on the system design specifications that were produced during the previous phases, the software programs are coded, tested, and gradually integrated into a complete system. The manual and administrative procedures of the system are finalized and also tested in conjunction with the automated portion of the system. The user and system documentation

manuals are completed and the staff is appropriately trained. The data in the old files are located into the new file/database structures of the system. The proper hardware/software/networking equipment and facilities are installed at the user sites, and the system and its supporting materials are transferred into the production environment. If necessary, the system is fine-tuned during the first month following its installation in production.

The users must participate in the testing of the applications software, programs, procedures and databases so as to better understand the system. Techniques such as computer-aided software engineering (CASE) can be used to ensure quality. Special attention should be given to documentation. Training programs for users at different levels and materials related to the new system should be developed as part of the implementation process. These should include: the preparation of notices and seminars for conveying general information about the system; class outlines and materials for providing detailed training in systems concepts and procedures; on-the-job or in-service training programme for those who would be assigned daily work with the new system.

217. An acceptance test is necessary before putting the new system into operation. All of the promised functions and deliverables should be demonstrated in the acceptance test. The system is complete as a whole project when:

(a) The new system is set up and running smoothly;

(b) Conversion or cutover from any older systems is complete. Cutover should be done in phases if possible;

(c) The end users are trained and comfortable with the new system;

(d) A post project review is held and all items that can benefit future projects are documented; and

(e) The responsibility and method of ongoing maintenance is defined.

There is always a need to change a system in order to improve it, add new features, or fix any problems still left after the system acceptance or warranty is over. Most of the time, the user's business will change with time and so will his requirements. These changes or enhancements make the system maintenance indispensable.

Conversion should be a well planned process in its own right, in which users should participate. Files and documents must be created, forms printed, and new procedures instituted.

218. A preliminary version of the different types of system manuals should be developed that are required to use, operate, and maintain the system in production. At the early stage of the implementation phase, these manuals can be developed in a draft manner. However, they should contain enough information to support the users and eventually the system operations staff during

the user acceptance and production acceptance testing cycle.

The system user's guide should always be written in a language that is easy to understand from a user's point of view. Technical jargon should be avoided. The users do not need to know how the system works internally but, rather, how to interface with its automated component properly and efficiently.

The system maintenance guide describes the high-level functions and facilities that are carried out by the software application, primarily focusing on a technical perspective. It contains general program narratives and describes the important technical characteristics of the system (i.e., its internal architecture). It is primarily aimed at supporting the maintenance team's efforts. However, it does not necessarily describe in detail the program specifications. The detailed information associated with a program could be in a separate guide.

The system operation guide provides a description of the detailed documentation required by the data/information center personnel to operate the system in production. Typically, the type of information that should be described for each production job within a specific processing cycle (daily, weekly, monthly, yearly) includes job preparation, job execution, and job output distribution.

219. A system training package should be prepared during the implementation phase. The training materials can be developed in a draft form at the early stage of this phase. Nevertheless, it should contain enough information to support the initial training of the user team participants who will conduct the user acceptance tests. The detailed system training strategy in light of all the information that has been produced so far on the new system should be reviewed. And, the drafted system training package should be walked through to verify that it is accurate and meets the stated training objectives.

The formal training materials should finally be prepared so that the users and system operation and maintenance personnel can be trained on how to use, operate, and support the system in the most effective manner, prior to its implementation in the production environment. The training materials could include student handout, slides, overhead transparencies, and so forth. This materials should be designed in a top-down manner, describing the system from the very general down to the very specific. In some instances, it will be necessary to tailor some specific components of the training package to suit the specific needs of the targeted audience.

220. Once the system is in operation, a post-implementation evaluation should be conducted. The purpose of doing so is to determine how well the system meets its design objectives. The overall performance and level of operability of the entire system should be judged from the viewpoint of: response time of the on-line programs, execution time of the batch programs, execution time of the software utility runs, security facilities, installed computer equipment, computer operating instructions and job control instructions, user/system documentation in general, system communications network, and the like, or through any indicators related to the original objectives. The evaluation may be performed by the project team or by internal systems auditors.

System post-implementation optimization can be performed based on the evaluation. The specific areas where the original system requirements have not been fully attained should be identified. The project team should also determine the causes of the problems and apply the appropriate remedies. A complete set of the system documents and the production system optimization should also be included in the optimization task.

221. Resistance to change. The rate of transfer of any new technology within a large organization is often dramatically slow. Many reasons are suggested to explain why it is so slow. The following paragraphs discuss some of the reasons.

Fear of technology. In many instances, the resistance to change from the high-level or senior officers of the organization because they have no or little knowledge of new technology and are afraid that they would lose their preponderance in the old management systems over those officers who know the new technology better than they do. This becomes a critical issue if the people who fear the new technology or change are those who have the power to enhance the computerization and information systems development process. Only the determination and pressure from higher authorities can improve the situation.

Creative habits. Once people become accustomed to a given way to do things, they have a natural tendency to resist new approaches unless they are pressured to do so. It is understandable because it is human nature to feel comfortable with things already known. However, if this behaviour is not properly controlled, it can generate into a serious attitude problem where people stay anchored in the past and systematically refuse to grow and learn new approaches.

Insufficient time to learn the new techniques. There is indeed a large increase in the number of sophisticated application systems that must be developed to satisfy user needs, often with limited resources and time. This naturally creates constant pressure on systems developers to deliver as many direct hours as possible to the users. The net results is less time to learn about the new tools and techniques. In some organizations, it is getting so bad that staff has no time for formal training at all.

Competing techniques. Many new techniques emerge one year after another. In some instances, they compete against each other. It is not uncommon to be faced with many techniques that in fact are quite similar but use slightly different terminologies. It is not much of a problem to opt for one as opposed to another. Rather, the problem arises when each has its own fan club. If not properly managed, the selection process for the acquisition of new tools and techniques can turn out to be not as straightforward as it should be, even though sound selection criteria were used in the process.

Environment compatibility. Many of the productivity tools introduced within the system development organization work best when they are primarily used to develop brand-new systems. However, their introduction in the maintenance world takes a longer time because they might not readily be fully compatible with the existing maintenance and operational environment.

Built-in obsolescence syndrome. New products come to the market everyday with the rapid development of information technology. Each product brings some enhancements to provide a better way of doing things when compared with other similar products. The attitude problem surfaces when the decision to bring in a new tool is delayed until next year because something better will most likely come along. A year later, the same decision is delayed for the same reason. The same scenario happens with methods. Thus, the irresolute and hesitant decision-making also contributes to the resistance to change.

This long introduction about the resistance to change shows that even though developing a new information system is not a straightforward thing, maintaining and operating an information system may need more efforts.

222. The methodology of information systems development introduced in this chapter is in principle on the basis of the system development life-cycle. There are three different types of information systems development (refer to Chapter 3). The main three stages remain the same, i.e., analysis, design, and implementation. Some of the phases within the stages, however, are different depending on which type of information systems development is being carried out.

9.6 CASE Technology

223. It was known for years that although structured development techniques were very successfully applied to the development of complex information systems, or software systems, their use still remained somehow restricted because they were very labour intensive. During the last decade the advent of CASE (computer-added software engineering) has brought a brand-new perspective to the information systems engineering scene. CASE technology promises a new era in the automation of the system development and maintenance life cycle processes through savings in both time and money. Although the expected benefits have not been fully realized, the intelligent use of CASE tools can definitely help an organization cut down development time while still delivering quality systems.

CASE aims at automating the entire system development life cycle, starting from strategic systems planning at one end of the spectrum to maintenance at the other end. Hence, it can surely help to support existing applications. In fact, two of the most rapidly growing segments of the CASE industry deal with application reengineering and reverse engineering. With these tools, maintenance people can streamline existing applications, making them easier to maintain in the long run.

224. CASE technique is a top-down structured approach. It starts at the top of the systems life-cycle, involving key managers and users in gathering the business objectives, requirements, and priorities needed for developing the system. The CASE technique fosters communication between users and developers as systems are defined from a strategic point of view. As developers prepare increasingly detailed models, they can cross-check and confirm them with the users, creating

conceptual prototypes of the complete system. After completing analysis, developers can use the CASE method to create logical and physical designs, for optimal flexibility and performance. By the use of CASE tools, documentation and systems implementation will occur in parallel, as developers build their systems and perform unit tests. Transition, including user education and training, data conversion, and system testing, based on earlier planning during analysis and design, can be carried out with CASE tools as well.

There are a multitude of CASE toolsets on the market that seek to automate the functions performed at all three levels of the organization's management information system: strategic systems planning (strategic level), information systems project management (tactical level), and Systems development, engineering and maintenance (operational level). Some try to provide a completely integrated software engineering solutions, others address a specific level of the pyramid or even a specific function inside the level. The different functional toolsets that are necessary to support the automation of the information systems development and maintenance process are as follows:

- *Strategic planning toolset* supports a strategic system plan developed in accordance with the strategic business plan of the organization.

- *Analyst toolset* supports the creation of graphics-oriented models to portray a proposed application system solution.

- *Designer toolset* supports the automation of the system design process.

- *Programmer toolset* typically supports the automation of the software programming and testing activities.

- *Maintenance toolset* supports the software maintenance process. It enables the software/maintenance engineers to keep the production systems well structured, easy to maintain, efficient, and well documented.

- *Project Management toolset* assists project leaders to plan, monitor, control, and manage the activities of the development team during the project.

- *Executive toolset* is a relatively new breed of automated tools specifically designed to support the high-level activities of the organization's executives. This workbench provides senior management with immediate access to all the information required to make strategic decisions.

- *Prototype toolset* supports the generic activities associated with special facilitated application specification techniques such as prototyping and joint application planning and design (i.e., JAD-like techniques).

- *End-user toolset* supports the user computing environment, either on a mainframe or a micro platform.

- *Software metrics toolset* is used to collect and monitor the progress made by the organization in terms of software systems productivity and quality improvement.

Each toolset can become the object of a specialized software engineering workstation. With such an approach, the automation of the system life cycle can be built up gradually with the acquisition of specific workstations that address an organization's most immediate needs. The toolsets can be integrated and form a CASE architecture in which the strategic planning and the executive toolsets are at strategic level, the project management and software metrics toolsets are at tactical level, and the other toolsets are at operational level.

225. If an organization wants to introduce CASE technology through the strategic system planning of the development cycle, then the tools identified in the upper-level category of CASE tools should be looked at. If it is desired to improve the maintenance environment first and then introduce CASE tools through the system operation, the lower-level category of CASE tools should then be considered. Between these two extremes of the life cycle spectrum, the middle level is populated with an abundance of CASE tools aimed at automating analysis, design, and programming activities of the information systems engineering process. Until a unique toolset provides an integrated solution that comprehensively covers the entire range of functional facilities, an organization must devise the best strategy possible to assemble an optimal set of tools that work well with a minimum of redundancy across the various layers of management information systems activities.

The acquisition of CASE tools can be fairly expensive. Hence, it might be necessary to justify the purchase by figuring out the expected payback. The organization should expect direct and indirect costs. Direct cost might include: CASE product acquisition (hardware, software and networking facilities), consulting fees if external consultants are used to introduce CASE into the organization, training the staff on using CASE tools, training the staff on using the software engineering methodology, customization of CASE tools to meet the standards and procedures in place, ongoing costs for acquiring and installing new releases of software. Indirect costs might include: training costs for staff to learn the use of CASE tools on their own, after formal training sessions, the time it takes for the organization to adjust to the new technology from a cultural viewpoint.

The productivity gains expected from using CASE technology should warrant the cost acquisition investments. However, the payback may not necessarily happen overnight. In some instances, the CASE start-up costs might not level off for the first two or three years. However, soft savings can happen immediately when improved quality deliverables are produced with CASE tools. Later, during the maintenance phase, this soft savings will translate into concrete savings. The information systems will be cheaper to maintain because they are better constructed.

For the developing countries with compact size or very limited resource, a set of CASE tools can be equipped within the national information/computer center so that it can be sufficiently utilized.

9.7 Project Management

226. Planning, organizing, staffing, and controlling are the four key issues to make programs/projects successful.

Successful projects must have a clean beginning - a written plan that defines what will be delivered, and how it will be accomplished. Measurable acceptance criteria ought to be written down and used to prove that the promises have been met.

During development, close monitoring should be conducted to ensure that the project stays as planned. The staff of the project team should be adequately experienced to produce the product. The right documents for the right people must be produced even in a tight situation, because management should realize that documentation is one of the most important aspects of the project. Frequent reviews are necessary to measure progress against the schedule. When a problem occurs, it should be noticed at once, and solved if possible, otherwise estimates and schedules should be redrawn, and expectations be reset as necessary.

In the end, the user's satisfaction should be the first concern of the project team. The product that the team has delivered should be as promised. The cost must be controlled so as to be "reasonably close" to the quoted estimates. There should be no hassle about acceptance. The precise and detailed method of demonstrating that the product functions are as required should be approved by the user ahead of time.

227. A good team organization, for a small or medium information system project, consists of project manager, project leader, systems analysts and software programmers. Each person on the team has a specific job. The system analysts are responsible for system analysis and logical system design. The system physical design and implementation are jointly accomplished by system analysts and programmers. The programmers program applications software and conduct database design. All technical people need close technical supervision, so the project leader provides this by leading the technical activities and solving any system problems. The major responsibility of the project leader is product quality. The project manager, to whom the project leader reports, is there to provide management leadership and handle all communications between the project team and the outside. The responsibilities of the project manager include the overall management of project resources and the successful implementation of the project objectives, outputs and activities.

For a larger project, system analysts and programmers can be divided into several teams in such a way that the individual teams can treat their portion as a subsystem or stand-alone project. The terms of reference of the team leaders need to be clearly defined and all the team leaders are to report to and be supervised by the project leader.

228. *Selection of Project Manager*. Project managers are key persons to secure the success of any information system projects, responsible for the successful design, implementation, operation and maintenance of the systems. The hardest part in information systems development is to make sure that the systems integrator understand exactly what the users want and not to speak different languages with the users. In general, users are looking for more than technical expertise from their systems integrators. Project managers should have a good understanding of the core businesses of information system users. A purely technical solution can only benefit users very little. The following aspects show what qualifications a project manager should have:

(a) Must possess a thorough knowledge of the vertical industry and preferably should have held an executive post in that line;

(b) Should be able to work with line-of-business managers to define requirements and carry out the actual implementation of information systems;

(c) Should have in-depth understanding of technical concepts and the ability to translate between business and requirements and technical development of systems;

(d) Must be a good communicator who works well with teams and has good negotiating skills; and

(e) Must be a detail-oriented person who can chart out actual time lines for the completion of a given project, track milestones and be the single point of reference for the user and systems integrator.

PART IV:

INFORMATION RESOURCE MANAGEMENT

CHAPTER 10

INFORMATION RESOURCE MANAGEMENT

10.1 The Information Asset

229. Information, which in essence is the product of the analysis and synthesis of data, is unquestionably an organization's most vital resource. It can be structured into models for planning and decision making. It can be incorporated into measurements of performance and productivity. It can be integrated into products design and marketing methods. Information, in another word, is recognized and treated as the important asset that an organization owns. With the proper utilization of it, information becomes a potent competitive force, particularly for enterprises. In today's global and competitive economy, information might, in fact, be the deciding factor in determining the winners or losers of the world. However, without a well-developed national information infrastructure and public data/information environment, in which public data and information are easily accessible and retrievable to individuals, enterprises, and any authorized users, it would be impossible to have a good information environment for any enterprises and individuals to compete in today's global economy.

Information is an ingredient vital to good management as well, particularly for governance and public administration. The sharply reduced cost of computer and communications technologies have created a very real opportunity to improve effectiveness of governance and public administration through improved use of information by management. However, this opportunity has not been easy to exploit in the past two decades, in particular, for developing countries.

230. In every organization, there is a need to assist key users to ascertain data/information

requirements, to plan for the development and exploitation and utilization of data/information resources, to plan for information systems development, and to monitor the status of both the development and the ongoing operation and maintenance of information systems in order to ensure the optimal use of the resources. In short, there is a need for someone to act as the architect of the organization's information capabilities. This is so called "Information Resources Management".

The emphasis on hardware and software is shifting towards a focus on information resources and information management. This focus is significant because it emphasizes the quality and the value of the output of computers rather than the quantity of computing power itself. This is understandable because what the users really want is not only the computing power but the distilled, summarized information that can be accessed, assimilated, and used more effectively, particularly by management.

Due to the development of distributed processing and network computing, attendant physical control of computer resources is moving into the hands of users. This new development creates the needs for an entirely new way of thinking about and managing distributed information resources in the organization.

The importance of information resource management also increases with the evolution of computer applications from transaction processing to information processing. At the early stage of computer applications, data processing (DP) systems are developed for clerks. The DP systems process the transactions of operating a business, which is, of course, important in the operational or lower level control of business activities, and computer have made possible important improvements in the productivity of these clerical workers. However, the applications, no matter how effective they are, rarely reach into the office of management. Thus the role of information resource management beyond simple transaction processing is not even considered by many management of organizations.

While basic transaction processing systems still exist, computer applications have been evolving toward supporting management decision making - at tactical and strategic levels. These applications require information managers to direct more of their resources to management assistance rather than operations and clerical support. These higher-level applications tend to require not only more advanced technologies but also more user-management involvement than those record-keeping and transaction-based systems. Accordingly, information resource management becomes increasingly important.

231. Information resources management is a significant aspect which enables information systems development to succeed. Without rationally organized data gathering, information utilization, and information management systems, the development of information systems in government agencies could possibly cause confusion. In addition, the security and confidentiality of government information will be ensured through an effective policy for information resources management.

Information resources management involves the integration of diverse disciplines, technologies, databases, and other information handling resources. There is no doubt, however, that the core of information resource management is the management of data and information. Considering the present situations of developing countries, the following aspects with respect to information resources management are briefly introduced in this chapter: data availability and collection, including data pollution and quality control issues; the management of data actions in information systems operation and maintenance; the management of hardware and software, including management strategies, anti-virus and vendor policy; and the security of data/information. The other issues that have not been addressed in this chapter include exploitation and development of information resources, commercialization of information, government information services, development of an information services industry, and so forth.

10.2 Data Availability and Collection

232. Data is the core of any information system. Data availability and collection are essential to any government information system, either developed or to be developed. Data availability must be studied before any information system project is to be launched.

Generally speaking, data availability should not be a problem with information systems at operation and management levels. Operational information systems usually deal with either batch (in a centralized mainframe architecture) or on line (in a networking environment) data processing, and data in various forms and formats are regularly sent to computer centres or network nodes and imported into the systems. Management information systems acquire data by means of the authority of an administration or management organization which the system supports. The data source institutions are required to provide data and information by the administration and/or the management, otherwise they may get into trouble. Taking project management information system as an example, project executing and implementing agencies are under obligation to provide any data/information regarding the project to the department responsible for the project management. Otherwise, the project management may consider interrupting funding for the project. In some cases, administration and management power has to be used to guarantee the data availability.

Data availability becomes, in many cases, a problem for decision-making support systems. What a decision-making support system usually provides is comprehensive and highlighted data and information that reflect the macro situation monitored by the government agency, including the information on the agency, the government, the country, and/or even the world. The data and information may come from internal and external sources, such as the management information systems of the agency, information systems of other government agencies, international available databases, and so on. In general, these data and information must be edited and analyzed so as to meet the information needs of the decision makers of the agency. Obviously, data availability of a decision-making support system depends on the information utilization capacities of the organization. Under a circumstance of inadequate information utilization capacity, data availability, consistency, and timeliness usually become a question mark.

233. It happens sometimes that relevant government agencies are reluctant to provide, or

even reject, data/information to authorized users of the government on a timely basis. There are several motives to do so. But it is mainly because in come cases data and information mean power or property.

The fundamental approach to resolving the data availability problem is through laws and government regulations, which clarify the responsibilities and accountability in data/information collection among government agencies and other institutions. Using an overall plan of data collection, data or information should be collected only once and at the first available or most convenient source, and be provided to the user agencies, even though the collecting agency itself may not need the data or information they collected. Data or information collection within one agency must take into consideration the needs of other government agencies and/or the public. Data and information collected within one government agency should be accessible or retrievable by all legal users.

Given the fact that information is a strategic asset of the government, it is better, from a long-term view point, to have a government agency which is in charge of the administration and management of the government data/information resources. Whether the collection of information by a government agency is necessary for the proper performance of the functions of the agency, including whether the information will have practical utility for the agency, the agency in charge of information resources management of the government must:

(a) Prepare an inventory of all information collection activities.

(b) Assign agencies as the primary collectors for other agencies.

(c) Determine the goals for the reduction of information collection.

(d) Monitor compliance with recommendations of the Government.

(e) Design and operate a government-wide information locator system.

(f) Report to the Government, on a regular basis, the problems to be resolved and coordinated.

234. Data pollution is a serious problem frequently existing in many information systems, especially in developing countries. There is no doubt that corrupted, inaccurate or incomplete data will negatively affect management business and decision making. The causes of data pollution problems are multi-dimensional.

Dirty original data and data entry errors are the main pollution sources. Sometimes complete and accurate data and information are not available, or errors take place during delivery, or faulty data is collected from other agencies. Hardware failure and software bugs also result in data pollution. The most important way to beat the data pollution problem is to control the quality of the data at the very beginning, i.e., at the entrance of information systems. However, the first step is for top management to simply acknowledge that this is a critical issue and that a problem does exist. The top management of government agencies must realize that data quality is of the highest priority and must be in a strong position to tackle the complex and odious task of cleaning up dirty data. Following up, some steps may be taken, such as forming a task force/committee to investigate problems, working out guidelines for quality control of data, data backup and disaster recovery, monitoring and controlling data entry, installing/upgrading database software, using specialized software to sample and analyze data, strengthening training, and replacing problem equipment, etc.

10.3 Management of Data Quality

235. Operation and maintenance of government information systems involves a series of data actions. Complete understanding of data actions, and not just the processing itself, can reduce the complexity of data management and can clarify the data required for processing and the effect of that processing on the files of the government agency.

Data actions involved in the operation of government information systems, in general, are as follows:

(a) Receive: the receive action describes the data carrier or trigger that was received, how it was received, and how it could be received.

(b) Retrieve: the retrieve action describes the actions needed to obtain prerecorded items of data that are required to perform the verification and validation activities or to provide data from the reference files of the government agency needed to complete new entity occurrence records.

(c) Archive: the recording of a previous entry for historical purposes, usually by recording the data element or set related data elements along with the dates or other indications of the time frames. When data is archived, it is usually because only one set of values is true at a time, but previous values are needed for research or other management needs.

(d) Add: add a new entry, data element, characteristic, or attribute to the files of the government agency. Unless this adds a whole new entity member, the addition of a new occurrence of an attribute of an existing entity occurrence must be preceded by an archive action.

(e) Update: the update action describes the changes or modifications which must be made to previous values of an attribute of an entity when the previous entry is of no historical value. Update is also referred to as change, modify, or replace.

(f) Verify: the verify action should follow both the update and retrieve actions.

Depending upon what action it follows, it is a verification that the incoming data is correct and is being applied to the correct records, usually by comparison with existing data that was previously retrieved, or that the change or update action is completed and has not produced a conflict with other data in the files of the government agency. Verification may be manual or automated.

(g) Delete: a previous (archived) or current entry is no longer of interest and may be removed from the files of the government agency.

Of course, different government agencies or government information systems may stress different types of data actions.

236. The management of information resources should identify all data actions caused by information systems, the sequence and the time frame of data actions, and any date or time dependencies which may exist within the systems. Standardization and normalization of all data actions will greatly benefit the management of data/information resources. For each data action, a clear description of the government agency's rules which govern how this action must be performed should be documented for operational purposes. The government agency's rules also dictate how the agency must react to each data event. There are two types of data events in practice: those that add, change, or remove data from the files (active events); and those that retrieve data from the files in response to some query (passive events). Of the two, the active data event is the more inclusive. The passive event contains only receipt (of the query), retrieval, verification, and validation actions. Thus, more attention should be concentrated on active events while working out the standards and norms of data actions.

The standards and norms for data actions should be reviewed by all operational and other affected areas to ensure that the data that must be recorded from each data event is in fact recorded, that all history is archived, and that data is not prematurely deleted. It is important also to ensure that the operational areas responsible for the handling of each data action be clearly defined.

237. Data base management merges the user's need for easy, but sophisticated, data manipulation with the technical capabilities of computer and communication systems. There are many data base management systems (DBMSs) available on the market now. The following actions are suggested for government agencies to develop a data base strategy.

Start with a data dictionary. Install a data dictionary before attempting any data base application. Government data must first be put in order. The tool to do so is the data dictionary. The dictionary puts the data in order by defining data definitions and data relationships for all data elements in the data base.

Appoint a data base administrator (DBA). A really competent full-time person will be needed to control the data dictionary. The DBA's job is to develop the organization's standards, or the government's standards if they exist, for data definitions and data relationships, to review application data bases designs for consistency in a shared environment, and to assure design integrity through control of the dictionary's contents. He or she should also guide the conversion effort, preferably in a phased approach, which is easier to control and more likely to succeed.

Plan long-range. Whatever DBMS is selected, it is not likely to be the final answer. Plan in advance to convert from one data base system to another. Because government may have hundreds of application programs and a sizable investment in them, this investment must be preserved. Thus, conversion to the DBMS is often done over several years, as systems are rewritten, rather than all at once. The goal is a single data base structure that can inter-link many individual data bases, not a single massive data base.

Involve top management. A high-level of management understanding, acceptance, and support is necessary for an undertaking of this magnitude. management needs to understand both the costs and the benefits of the DBMS. This is important because when dealing with the organization's data resources, one is dealing with the heart of management.

In summary, data base systems are generally big and complex. Data base establishment is the kernel work of information systems development. Build small data base systems in short time frames to build credibility and user confidence and to increase the chances of success.

238. Zero defect data approach. The following is a five step, zero defect data approach that can be used to improve data quality of government organizations:

Step 1. *Identify the data to be improved*. Start with a high-level assessment of where data quality has the greatest impact on the bottom line. Once areas where data quality improvement will affect the bottom line are identified, ask data base users which data gives them the most trouble. Select a manageable portion of the data base for data improvement.

Step 2. *Measure the quality of the data in the data base.* Ascertaining current quality is the key to making improvements. Get users to specify business rules about the data. Then use those rules to find records that are inaccurate, incomplete, inconsistent or outdated.

The levels of technical integrity in the data base should also be measured, such as uniqueness of primary keys, referential integrity and incomplete or missing data. Such constraints are not usually enforced as well as they should be, particularly in older data bases or flat-file systems.

Step 3. *Identify causes of poor data quality*. Armed with these measurements, identify the data quality problems in the top 20%, look at some of the defective records and identify their causes.

Causes to look for include data entry errors, data intentionally entered incorrectly because complete and accurate information was unavailable at the point of entry, faulty data obtained from outside institutions, data that was mismatched during a merging process and poorly synchronized transaction processing.

Step 4. *Improve systems to prevent data quality errors.* For each of the causes of errors identified above, develop an action plan to prevent errors from recurring. In the long run, it is better to invest more energy in fixing the causes of the data quality problems than to try to scrub data after the fact. Whenever possible, enforce data quality constraints at the data base, using triggers or stored procedures. Constraints that can not be enforced at the data base can be sometimes enforced using edits embedded within the application code, but be careful with such edits.

Look for opportunities to re-engineer systems to improve quality. Minimizing the number of processing steps between data entry and the data base because each processing step represents an opportunity for error. In a networked environment, ensure that all applications users who have access the data base are included in the quality control program.

Step 5. *Measure the improvements*. Once the improvements are implemented, continue to measure the data base to ensure that quality is improving. It is necessary to start again from the step 1 after completed the cycle above mentioned. Data quality requires a continuous improvement approach.

239. There are several data quality software packages commercially available that can help information systems managers sample and correct data. Some data quality management tools let organizations monitor and certify the accuracy, completeness and integrity of information stored in data bases. Some of rules-based systems run under Microsoft's Windows environment while some under mainframe, such as MVS, environments. These products verify file use, balance summary-level information, reconcile data items at multiple levels of detail, and automatically generate detailed reports describing exceptions in data bases. There are also OS/2-based data quality software packages which uses an expert system to help data base administrator create, manage, and enhance optimized DB2 systems.

10.4 Management of Hardware and Software

240. The management of hardware is to ensure that the necessary technical resources will be on hand when needed to provide these services. That is, resources must be matched against expected needs well in advance. Because of the long lead times in technical evolution, in equipment delivery, and in system development, hardware/software migration planning must necessarily be fairly long-range. Hardware migration planning involves matching resources against needs. There are at least four major steps in this process:

(a) *Keeping abreast of technology*. As described in previous sections, the evolution of information technology is almost a revolution, with cost/performance gains accelerating by geometric proportions. Not planning well in advance could mean having bought a multi-million dollar machine which is made obsolete in a short time. It is crucial that government officers responsible for information systems and information management have the best information available to meet the government agency's hardware needs over the next five to seven years. Information should pertain not only to equipment selection but also to acquisition options.

(b) *Forecasting government needs*. This goes back to integrated information systems planning. New computer applications must be projected, and projected volumes must be forecast for existing applications. It might be helpful to plot applications and volumes growth over the past two years and then project it for two future years. This procedure will indicate whether the trend line will accelerate or decline and will serve as an information source to management on computer center growth.

(c) *Knowing resource utilization levels*. A knowledge of current use is necessary to project the impact of added business. Vendors' systems measurement facility provides raw data such as this, but considerable analysis is necessary to convert such raw data into meaningful planning information. This conversion can be done through a formal process of capacity planning. In addition, computer performance evaluation is the new tool and technique used to effect management control over computer performance.

(d) *Keeping management involved*. The knowledge gained from technology research, information system planning, and capacity planning can be distilled, encapsulated, and presented to management in such a way that they are able to be involved in the hardware planning decision-making process. This requires summary nontechnical explanations which show what resources are needed to do what, and at what cost. Emphasis should be placed on demonstrating increased productivity and efficiency as the reason for computer upgrades, not just having the latest new technology.

In addition, reliability of computer hardware is another issue to be addressed in hardware management. Reliability of computer hardware has been increasing with technical progress. As information systems grow more complex, however, small failures can have greater impact on service levels.

241. The shortage of skilled programmers coupled with an ever increasing demand for applications programs is creating a widening gap between what is needed and what can delivered in developing countries. Narrowing the gap has become a big issue in the development of government information systems in developing countries. One of the strategies dealing with the problems of software management is the use of commercially available and third party developed software packages. The reasons to consider buying commercial software or using third party software packages are obvious: decreasing development costs, making full use of scarce resources, time

deadlines, increased package availability, and increasing demand for computerization. Some systems, of course, probably should continue to be built: for example, very specialized business service and management systems, unique operational systems which can not be satisfied with packaged software; systems that give a competitive advantage; and systems that change rapidly. Naturally, when using commercially available software or third party developed software packages, some customization work and user-interface design are still needed.

Package programs are available from a variety of sources, including software vendors, computer manufacturers, international organizations, and individual governments. When procuring a package program some steps are indispensable, such as: determine user requirements; study available packages; develop evaluation criteria; study the candidates; visit other users; and credit check the vendor; etc.

242. There are more than 60,000 different software packages available on the market now. For a similar function, there may have tens or hundreds of packages for customers to choose. This situation makes selection of software packages difficult and confusing. The following questions might be used in the development of selection criteria when investigating the acquisition of an application package.

Hardware/software/networking characteristics. On which type of hardware and operating systems does the package run? Is the software transportable across hardware? Is the package available in source language form? In which programming language was the package developed? Is the package compatible with the current networking facilities? Is the data base design structure of the package compatible with the organization's data administration standards? What are the computer region size requirements to run the package? Can the application package embrace new technologies?

Installation support. Are there special installation requirements in terms of hardware, software, and communication? What kind of technical support does the vendor support when the package is installed at the user site? How long does it take to install the package? Does the vendor provide basic recommendations on the new business policies, working patterns, roles and responsibilities that should be enforced to take full advantage of their package?

Functional Characteristics. What type of functions does the package provide? Are the functions available on-line, batch, or in real-time modes? What are the reporting facilities offered? What are the inquiry capabilities? Can the package interface with other systems? what are the interfacing characteristics of the package? Does the package support special features, such as graphical facilities or statistical facilities? Does the package provide security facilities, if yes, at which level? What are the performance limitations or constraints of the package? Does the package support word processing or spreadsheet facilities?

Vendor profile and stability. How long has the vendor been in business? Will the vendor still be in business five to ten years from now? What is the vendor's financial status? How many copies of the package have been sold so far? Does the vendor provide a wide range of application packages? Are the packages supported by an integrated data architecture?

Vendor support. What is the frequency for the delivery of a new release? Can you get an evaluation copy for a month or so to try out the software? What kind of support does the vendor provide? Does the vendor provide a hot-line service? Where is the nearest vendor location? How knowledgeable are the people providing technical support? Is the vendor response to the demands of a user group?

Vendor references. Is the vendor willing to provide reference on current users? Can these users be contacted? If yes, what are their comments and experiences on this package?

Vendor training services. What type of training does the vendor provide, at which level and for which audience? Which courses are offered, at what costs, how often, where? Does the package provide a test environment for training purposes? What type of training material is provided to the student?

Vendor Documentation. What type of document is available, under which format? Is the documentation complete, up to date, well organized, and in a standardized manner? What are the cost for new user manuals, new technical manuals?

Contractual requirements. What is the total price of the package, including direct and indirect costs? What is the expected delivery date? Are there constraints on modifications that are made to the package by the organization? What is the vendor's maintenance policy and warranty? Is there an additional cost to install the package on more than one user site? What type of training is supplied by the vendor, at what cost? What type of documentation is provided initially by the vendor, how many copies, at what cost? What type of services and support will be provided by the vendor during the installation of the package, and after?

243. Another important software strategy is the use of various tools and techniques to raise the productivity in system development. One well known technology is computer-aided software engineering (CASE), which has been introduced in Chapter 9.

244. Documentation is a very important tool for software management, for database management, and for the management of information systems development. The effective development and implementation of a documentation system is contingent, to a great extent, on the establishment of sound documentation standards. Documentation standards should be established that specify the document items that should result from each task, identify the phase-end-documents to be produced, and define the content of each document. The objectives of such standards are:

(a) To provide project managers with documents to review at significant development milestones so that they can determine if the functional requirements are being met and whether the project warrants the continued expenditure of financial resources.

(b) To record the results of tasks performed during a particular phase of development in a manner that allows coordination of later development and use/modification of the system.

(c) To ensure that documentation managers and technical writers have a guide to follow in preparing information systems documentation.

(d) To provide for uniformity of the format and content of presentation.

Controlling the dissemination of software and systems documentation is another prime consideration in document management. Each of the document types produced during the system life cycle should provide information that explains any security requirements that may exist. The procedures for gaining access to controlled documentation that is not included in a specific document should be detailed.

245. Viruses have become a serious issue to be concerned within software management. A virus is a program that has the ability to reproduce by modifying other programs to include a copy of itself. It may contain destructive codes that move into multiple programs, data files, or devices on a system and spread through multiple systems in a network. Viral codes may execute immediately or wait for a specific set of circumstances. Viruses are usually not distinct programs; they need a host program executed to activate a third code. By most accounts, in October 1988, only three DOS computer viruses were known. By October 1991, some 900 computer virus strains were identified. It was estimated that 1.6 new viruses were discovered daily during 1992.

The most frequent sources of contamination include: physical or communication contact with an infected computer; copying an unknown disk containing a carrier program; downloading a file from a bulletin board system; running an infected LAN program; booting with an infected disk; infected software from a vendor; and overt action by individuals. A number of clues can indicate that a virus has infected or attempted to infect a system, even before any damage is done. Unexplained system crashes, programs that suddenly do not seem to work properly, data files or programs mysteriously erased, disks becoming unreadable - all could be caused by a virus.

Preventing a virus infection is the best way to protect government organizations against damage. The following steps can help keep a clean system from becoming infected with a virus:

(a) *Awareness training*. All employees having access to computer systems should be required to attend a training session on the virus threat. It is crucial that employees realize how much damage a virus can infect.

(b) *Policies and procedures*. The organization should prepare a policy on virus control to address the following issues: tight control of freeware and shareware; a control process that includes running anti-virus software regularly by each department; a virus response team and methods for contacting the team; control of the infection once it is detected; and recovery from the virus, including backup and dump policies.

It should be noted that the primary cause of the spread of virus infection is through the uncontrolled use of diskettes being introduced into computer systems. Therefore, sharing software is a great risk and users should not accept software in an illegal way. In addition, the most prudent precaution is to carefully make, store, and routinely check backup copies of files and programs - all on an established schedule. Controlled access to backups guarantees integrity.

The ability to rapidly detect the presence of such viruses and exterminate them depends to a large extent on the anti-virus software an organization decides to implement. There are three types of virus fighters, often in one package: scanners, integrity checkers, and monitors; each uses a different method of examining potential virus hideouts. Those hideouts include data, system, and application files; hard disk boot sectors; the hard disk partition tables; and memory. However, if such programs are going to be used, the user should be careful that they do not cause more problems than solutions.

246. Vendor policy is an important issue for many developing countries to address. For control and efficiency purpose, it can be a sound strategy to have a government policy of centralized control over major hardware and software acquisitions, as well as certain vendor contacts and contracts. A few points in this regard briefly are as follows:

(a) *More effective vendor management*. A single contact point between vendors and a government agency (or the government as a whole) is highly desirable to prevent wasting many people's time. From a customer standpoint, a single contact point gives the user organization more "clout" with a vendor than contact through diverse users throughout the organization. In the case where vendor contact is left to individual government agencies, a list of approved vendors could be provided based on previous experiences, research, or standards for equipment selection.

(b) *Control over major spending*. Government policy can have all purchase orders go through a central purchasing department, which would ensure control over spending for equipment, software and services.

(c) *Better equipment research*. To avoid biased presentation from vendors and be aware of alternative competitive products, equipment evaluation is a hit-or-miss proposition. A centralized equipment research group can be in constant touch with the technology, the leading vendors, and new product announcements. They can do comparative product evaluations, serving as an internal research consulting group for all potential users within the government. The research could also include the vendor.

(d) *Expertise in contract work*. Some centralized expertise is essential when it comes to vendor contracts. Contract work is a highly specialized and important part of dealing with vendors. A central group can develop contract standards; assist users in negotiating contracts; review contract forms for needed provisions, protective clauses, etc.; and assist in the preparation of requests for proposals (RFP) to vendors for software development. These are all areas where experience and expertise can avoid many pitfalls, and where a highly specialized central group perform the best.

(e) *Improved vendor service and support*. A central group monitoring and recording the general service level and the response of vendors for service can provide a total corporate picture not otherwise possible.

It is necessary to design a strategy to get the most from the vendors who serve the government agencies. Considering the amount of money spent on equipment, software, contract consulting, etc., a policy of vendor control in the government can pay off handsomely.

10.5 Data/Information Security

247. There is an emerging recognition by developing countries that information resources are the most valuable category of government physical assets. In some countries, of course, assets which are not valued tend to be poorly managed.

Government spends a lot of money on the development of computerization and information systems. Government information produced through this investment in computer programs and information systems is usually stored and maintained in electronic form in government agencies' computers. In such form, it can easily be lost, stolen, damaged, or destroyed if not properly controlled. It can be read onto a diskette, a tape, and carried out of the government agency in an employee's briefcase. Or it can be transferred from one organization to another, computer to computer, in a matter of minutes. Thus, government confidential documents, strategic plans, and all sorts of sensitive information stored electronically can be easily stolen.

However, as government has become more and more dependent on their computer systems to provide their daily information, process their transactions, and maintain government documents and other records, more attention has been paid to the physical security of information management, such as computer hardware, which is actually only one of the aspects with respect to information resources security. It is very important for a government to make a full study of the security of their information resources. The overall information resources security strategy should be based on a careful analysis of the government agency and the particular hardware, software and communication facilities used at the installation.

A government policy can be issued to establish and fix the responsibility for security within the government. This will be a useful strategy to set the stage for the subsequent issuance of security standards within the government.

248. Data/information security is the number one security issue and the first concern of any government. Control over data security includes risk assessment study, access control, and security standards. The five basic security problems identified are as follows:

- Data compromise by legal users.
- Denying access to unauthorized users.
- Virus prevention.
- Communications security (encryption).
- Physical security.

Establishing an effective data-security system takes considerable effort because it must be done without sacrificing good service for the value of security. Both are important, but good security and good devices are usually conflicting objectives. The ultimate in security would be to lock up the data processing operation so that no one could get into it; the ultimate in service would be to allow everyone easy and quick access to all data in the government databases. Obviously, these aims are in conflict. The key to an effective data-security strategy is to achieve an optimum balance between good service and effective security.

249. A risk assessment study clarifies what the government wants to protect and from whom? A good way to begin is to determine who are the owners of the information resources that the government agency seeks to protect. Once the owners of the information resources have been identified, the next step is to review with each owner the sensitivity of the files, the controls already in place, and the additional controls needed. The internal system controls should be built into the system during system design while external system controls are added to strengthen security control. Highly sensitive files may require additional controls; less sensitive data may require fewer controls. Where to focus attention on security control can also be learned as a result of this study.

250. The first problem mentioned above is the one to which there is no technical solution. Data integrity is most often compromised by people with legal access to the system. In other words, employees are the source of most data disasters. In some cases, the problems are caused by simple human errors.

There are some technical steps that can be taken to prevent mistakes. A simple step is denying users the ability to delete files in critical directories, so as to save a business. Protecting against purposefully destructive behaviour, or the theft of critical data, is much harder, and is more properly the domain of employee relations, not computer security.

251. The second security problem is keeping unauthorized users out of the system: access control. Access control provides base-level access security over the government agency's production programs and production data files, regardless of the sensitivity of the various files. Program security controls are designed to ensure that unauthorized changes cannot be made in production programs. To this end, basic controls include access to production programs, changes in production program libraries, separation of responsibilities so that no one person has complete

control, dual-control procedures, and protection of back up copies. Data-file security controls are designed to ensure that unauthorized changes cannot be made in data in production files. These controls include access to on-line data files, authorization of data files usage, physical security over production data files, separation of duties, dual-control procedures, and the use of job control language and utility programs against these files.

Access control starts with a system password, on top of which can be layered a user name and user password. A user name and password generally allows the assignment of different privilege levels to directories and even individual files, including such limitations as read-only, write-only (for batch data entry, for instance), and executive only (useful for virus protection and preventing the illegal copying of software). Many systems also allow additional security to be imposed on dial-in users, a prime entry point for system attack.

252. Once the base-level data security control program has been devised, the next step is to establish the program formally, beginning with user interviews to acquaint users and owners of data files with the base-level security provided. The risk assessment study initially set the groundwork for what was sensitive and needed protection. The access control system establishes the what and how of the basic protection afforded. The user interviews determine what further protection, if any, is needed to complete the security programme. Once this program has been put in place, the final step is to document the data security program in the form of government agency security standards. These standards can specify security issues and problems, the ownership of government information resources, and the protection afforded (over those resources), including the responsibility of users/owners for the care of the information resources entrusted to them. This responsibility would also include physical security over the physical resources, e.g. microcomputers, minicomputers, and LANs etc. under their care.

253. Physical security of information resources management includes various aspects. Computer room access can be controlled by guards, coded badges to open doors, and the like. Access to the LAN server must be controlled if a LAN is established within the organization. Simply locking the door to the room in which the server is installed is a good first step. Turning off the keyboard sometimes serves as well, this leaves the mouse active. Software which prevents someone from re-booting the server from a floppy, thus bypassing all security precautions is another step to consider.

For LAN security, there are some other measures that might be helpful: for example, add expiration dates to accounts; limit concurrent user connection; establish password protection accounts; enforce periodic password changes; activate intruder detection/lockout; ensure that file servers, routers and gateways are maintained in a secure location; train users on their security responsibilities; don't overlook built-in LAN operating system security facilities; implement virus protection on file servers and workstations; establish security controls for dial-in/out capabilities; perform and test backups; implement an audit strategy to detect unauthorized activity and ensure copyright compliance.

Protection from fire is usually provided by smoke detectors, water sprinklers, CO_2

extinguisher, and halogen gas. Power protection takes the form of uninterrupted power supply (UPS), internal generators, or automatic power supply in many organizations. Computer room environments are, in general, closely controlled by temperature and humidity control devices. Backup is taken through various approaches. Remote storage of production programs and master files has been a widely accepted practice for years. All these measures can be taken as necessary.

CHAPTER 11

INTRODUCTION TO THE INTERNET

11.1 What is the Internet?

254. The effort that established the foundation of the Internet started in 1969. The project was known as ARPANET, supported by the Department of Defense's Advanced Research Project Agency of the United States. The project was aimed to build a computer network that would enable researchers around the country to share ideas, even though there was no standard computer operating system and machines generally could not communicate with each other at that time. A small group of computer scientists in the country devoted to the project and were thinking of ways to make computers more efficient by connecting them in networks. They hoped that the experimental network would create new communities of scientists separated by geography but united by technology and would make computers serve as communications devices. At that time, no one had anticipated that the network would have become such a vast international computer network of today. Now some experts believe that the Internet could be the prototype of the Global Information Infrastructure of the future while some deems it as the information superhighway of tomorrow's world.

The initial plan of the ARPANET project was to link four sites: the University of California, Los Angeles (UCLA), where the first "node" was located; the University of California, Santa Barbara; the Stanford Research Institute; and the University of Utah. There were nearly two dozen sites connected by 1971, including computers at Massachusetts Institute of Technology (MIT) and Harvard University. Three years later there were 62 and, by 1981, more than 200. The ARPANET was the first packet-switched network to connect heterogeneous computers. That is, computers of very different in size and type and speed could exchange information for the first time. The ARPANET, however, was not initially an internet because it connected hosts rather than networks.

By the early 1970s other countries wanted to join in. The ARPANET underwent many changes as it reflected developments in networking and, eventually, in internetworking that multiple networks could use, and paved the way for the Internet. In 1984, the ARPANET was split into two networks: the ARPANET for research oriented activities, and the Defense Data Network (DDN) for military operational activities. The DDN still exists as one of the Internet networks; its MILNET network provides unclassified operational support to military users. The ARPANET itself was phased out in 1990 in favour of the more advanced NSFNET backbone, a network established by National Science Foundation of the United States.

As personal computers became cheaper and easier to use in the late 1980s, anyone with a modem could get on-line. NSFNET then served as the technical backbone of the Internet. Currently, there are more than 100 countries that have some access to the Internet, at least 39,000 networks assigned unique IP (Internet Protocol) network numbers, more than one million hosts known to the domain name system, and nearly 25 million computer users worldwide.

255. The Internet, as a matter of fact, is the network of networks. It is a unique collection of networks, mainly in the United States, but also throughout the world. The computers on the Internet use compatible communications standards and share the ability to contact each other and exchange data. Users of the Internet communicate mainly via electronic mail (e-mail), via Telnet, a process that allows them to login to a remote host, and via implementations of the File Transfer Protocol (FTP), a protocol that allows them to transfer information on a remote host to their local site.

The Internet exists to facilitate the sharing of resources among participating organizations which include government agencies, educational institutions, and private corporations; to promote collaboration among researchers; and to provide a testbed for new developments in networking.

However, no one is in charge of the Internet. The Internet is a cooperating group of independently administered networks. Each component network on the Internet has its own administrative body, its own policies, and its own procedures and rules. There is no central, overseeing authority for the whole of the Internet.

However, certain government agencies have traditionally been prominent in setting policy that is followed throughout the Internet. Today important policy decisions come from the National Science Foundation (NSF) of the United States, i.e., the administrator of the National Science Foundation Network (NSFNET).

Although government agencies have traditionally controlled the Internet and still have enormous influence, today there is a large and growing "private" or "commercial" component of the Internet. This component is spearheaded by organizations whose common goal is to establish a part of the Internet that is open to everyone and supports a wider range of traffic, not traffic dedicated only to the support of research or education. This component particularly would like to see the Internet available to meet the full span of everyday business needs.

In addition to influential government agencies, a strong, mostly voluntary, coalition of technically knowledgeable individuals guide the development of the Internet. Innovations that upgrade the technical quality of the Internet are usually worked out cooperatively by the technical community working together under the auspices of a group called the Internet Architecture Board (IAB). The IAB has recently been included as part of the structure of the Internet Society (ISOC) (at which time the IAB changed its name from the Internet Activities Board). There is a hierarchy of Task Forces, Areas and Working Groups under the IAB that address technical problems and develop solutions. Eventually, solutions are agreed upon by the Internet community and the IAB recommends they be implemented. In this way, new additions to the TCP/IP suite of protocol standards are developed, tested, recommended, and implemented. Implementation of such new standards, however, depends on the cooperation and resources of each Internet site. There is no mechanism for requiring a site to implement a new standard.

256. What is a part of the Internet? To send an electronic mail does not necessarily need to be a part of the Internet. However, for the functions of searching a database, transferring a file, or using a remote application, worldwide, being a part of the Internet is meaningful. Doing all of these things and more is possible on the Internet because Internet computers (or "hosts") accommodate a set of protocols specifically designed to allow resource sharing across networks.

It is generally agreed that upon test of whether a site is an Internet site or not is whether it has "IP connectivity." One way of testing IP connectivity is to "ping" the host. "Ping" is a program that uses a required feature of the Internet Control Message Protocol (ICMP) to elicit a response from a specified host or gateway. If a host is pinged and responds, it is on the Internet.

Another common test is to see if a host will open a Telnet connection. Some Internet hosts do not implement the Telnet Protocol, however, so if this test fails, it cannot necessarily be concluded that the host is not part of the Internet. A Telnet connection allows user to connect to a remote host. That is, given site A that is on the Internet, can site B telnet to it? If so, then site B is also on the Internet.

257. What is not part of the Internet? The Internet does not include:

- Networks, even very large ones, that do use the TCP/IP protocols, but do not have a connection to the Internet that allows IP connectivity.

- Sites that are accessible only via e-mail.

- Networks built on suites of protocols other than TCP/IP if all they provide is limited access (such as e-mail) to and from the Internet.

For example, there are major wide area networks, such as **BITNET**, that allow only e-mail interaction with the Internet and are therefore not considered part of the Internet. Universal mail delivery is possible because of mail gateways that serve as "translators" between the different network protocols.

This distinction of Internet vs. non-Internet sites, however, is made only for the purposes of definition. For many people in search of access to the Internet, e-mail connectivity may be totally satisfactory.

258. Some Major Networks It might be worthwhile to brief some of the major Internet and non-Internet networks. All the non-Internet networks discussed have electronic mail access to the Internet. These descriptions are included to provide some idea of the types of networks that exist, to illustrate the diversity of the networking environment, and to clarify some references you are likely to hear and wonder about.

ARPANET The ARPANET does not exist any more, but we include its description because users will sometimes hear the term ARPANET used interchangeably with the term Internet. The ARPANET was the predecessor of today's Internet.

NSFNET The National Science Foundation (NSF) sponsors the main research and education backbone of the Internet today. The NSFNET is probably the most direct descendant of the original ARPANET in terms of its research mission. The NSFNET is a hierarchical network of networks. At the highest level is the backbone which connects supercomputer centres. At mid-level, the NSFNET interconnects a group of networks originally referred to as "regional" networks. Today, many regions of the United States share more than one mid-level network. At the bottom of the hierarchy are the many campus networks, including colleges and universities and some high schools in the United States. Many commercial companies are also connected to the Internet via NSFNET mid-level networks and would be considered on the same hierarchical level as the campus networks.

MILNET The MILNET was established as a separate network in 1984 when it was partitioned off of the ARPANET. This network is supported by the Defense Information Systems Agency (DISA) of the Department of Defense. The MlLNET is the unclassified component of the Defense Data Network (DDN). There are currently six gateways, called "mailbridges," that link the MILNET with the NSFNET/Internet. When the MILNET and the ARPANET split, the Network Information Center became the DDN Network Information Center.

BITNET BITNET is a worldwide network; a user can send mail to another user across the world just as easily as sending a message to a colleague down the hall. However, some parts of it are referred to by different names, which reflect administrative differences rather than technological ones. In Canada, the network using the NJE protocols and interconnected with BITNET is called NetNorth. In Europe, it is called the European Academic Research Network

(EARN). BITNET supports mail, mailing lists and a type of file transfer. It provides the LISTSERV mailing list function. It does not support remote login or general file transfer. It is administered in the United States by the Corporation for Research and Education Networking (CREN).

USENET USENET is a worldwide network that provides the *news* broadcast service, which is rather like informational bulletin boards. USENET uses the UUCP (UNIX to UNIX Copy Program) protocol and the NNTP (Network News Transport Protocol). The UUCP protocol was developed for UNIX computers, but most other types of computers can access the services via special software packages. There is no central administrative organization for USENET; normally sites wishing to join must find and attach to a site already connected. However, several service providers provide access to USENET news.

NASA Science Internet The NASA Science Internet (NSI) combines the Space Physics Analysis Network (SPAN) with the NASA Science Network (NSN), and other NASA networks, into one worldwide internet. The SPAN portion of NSI was built using the DECnet protocols while the NSN component was supported by TCP/IP. This is a very large internet which has connections to several NSFNET mid-level networks.

ESnet ESnet is the Energy Sciences Network. It is a network of the U.S. Department of Energy with access to the Internet. The ESnet backbone was designed to support the High Energy Physics Network (HEPenet) and the Magnetic Fusion Energy Network (MFEnet), among other efforts. HEPnet has an extensive European component and was one of the first pan-European networks. The use of these networks is restricted to projects supported by the Department of Energy.

FidoNet FidoNet is a network connecting personal computers. It is a cooperative, worldwide network administered by volunteers. FidoNet is open to anyone able to meet the technical requirements, but like other networks, also requires that users adhere to network etiquette and usage policies. FidoNet does not use TCP/IP protocols, but relies on a special dialup protocol. It is possible to send mail from the Internet to FidoNet.

11.2 How to Join the Internet

259. **Types of Internet Access** Access to the Internet falls into two broad categories: *access for sites supporting local area networks,* and *access for individuals*. Internet access is also classified into the broad categories of *dedicated access* and *dialup access*. In general, individuals who have no network access in their place tend to opt for dialup access, while most sites on the Internet access via dedicated lines.

260. **Access for Sites Supporting Local Area Networks** To connect a site to the Internet, the following steps can be taken:

(1) Obtain a unique IP network number, and configure the hosts on the network to use that network number.

(2) Establish a domain.

(3) Locate a site for the physical connection.

(4) Install the appropriate hardware (e.g. gateway) and configure it correctly.

(5) Install the proper software (e.g. TCP/IP Protocols) on the hosts on the LAN.

(6) Install the proper routing protocols on the gateway (e.g. EGP/BGP)

(7) Order the appropriate circuits from the telephone company to connect the gateway to the Internet access point, or arrange some other connection medium.

Actually, most of these steps can be taken in parallel.

261. **Obtain a Unique IP Network Number** All sites wishing to connect to the Internet must obtain an official IP network number. By obtaining an official IP network number when first setting up a TCP/IP network, a site is assured of having unique addresses, and is spared the expensive necessity of reconfiguring their address space to a new, unique number if they later join the Internet. A unique network number is necessary for every network connected to the Internet in order to avoid any routing problems.

The central IP registration service provider used to be the Network Information Center of the Defense Data Network (DDN NIC), which handles only military actions now. As of April 2, 1993, registration services for the Internet have been moved to the Internet Network Information Center (INTERNIC), which can be contacted by e-mail: HOSTMASTER@INTERNIC.NET. This central registration site has the authority to choose delegate registries which have the responsibility of performing registrations for certain regions. If people who wants to join the Internet do not know whether there is a registration authority in their area, they can contact the INTERNIC and find out the correct authority.

A registration authority assigns only the network portion of the address. The responsibility of assigning host addresses falls to the requesting organization.

In order to obtain a unique IP network number, the user will need to provide the registration authority with some information about the network and who will be acting as a Point of Contact for it. Once this information is provided, the user's application will be processed and a unique address will be assigned to the user.

262. **Establish a Domain** Establishing a domain means adding an entry for the user's site into the distributed database and the Internet uses for name to address resolution, so that other hosts

on the network will be able to send traffic to the site, and other users can specify this host name easily because it will follow the logical pattern of the Domain Name System (DNS).

The Domain Name System on the Internet has a hierarchical structure. At the top of the hierarchy, is the root domain, that entity responsible for maintaining the DNS at the topmost level.

To establish a domain under the top-level domains COM, NET, MIL, ORG, EDU, or GOV, or to have a top-level country domain delegated to the user's country, the user should contact the INTERNIC. Usually, applicant will be asked to fill out a form that requests information about the name of his domain, the names and addresses of at least two hosts that will act as name servers, and points of contact for administrative and technical matters.

A name server refers to a host that acts as a repository for a portion of the domain database. A name server runs software that allows it to answer queries for DNS data. On the Internet, the most commonly used name server software is BIND, which stands for *Berkeley Internet Name Domain* software. The BIND software was written for UNIX systems, but is now available for other platforms.

The user may control his own name servers for his domain. All the user's needs are two hosts, preferably configured so their contact with the Internet cannot be severed easily at the same time, that run domain name server software. When registering for both an IP network number and a domain, the user would register the domain after the IP network number so s/he can inform the INTERNIC of the addresses of the domain name servers that will reside within her/his local network.

If the user is unable to maintain her/his own name servers, the user must gain the cooperation of two other sites on the Internet willing to provide name service for him. There is no central "public" name service clearinghouse, so the user will have to negotiate such an arrangement himself. Some network service providers will provide name service for a fee. And, some network service providers also coordinate the establishment of the user's domain with the INTERNIC for the user.

For the sites in countries other than the United States to join under top-level domains other than COM, MIL, GOV, EDU, NET, or ORG, that correspond to the name of their country, they must coordinate with the administrator of the top-level domain.

A site may wish to join at the third level rather than the second level. For example, the country where the site located may already have a domain established. In this case, the site would probably join under that domain and, hence, need to contact the administrator for the domain under which the site wish to join. The INTERNIC can help users identify the contacts the user will need to work with to establish a domain if it turns out that the NIC itself cannot serve as the user's contact.

263. **Locate a Connection Point** Users of the Internet should determine if they need an

Internet connection primarily for commercial or research activities. Then, a site should be located for physical connection.

In the past, the entire Internet was devoted to research, educational, or military pursuits, mainly because it was funded by research or defense agencies of the U.S. Government. Therefore, any site that joined the Internet, including commercial companies, agreed to send only traffic that complied with this research oriented climate. A recent development, however, has been the emergence of commercial backbones meaning components of the Internet that allow commercial traffic.

Of course, joining a network that allows user to send commercial traffic does not mean that the user must send commercial traffic. Often, any type of organization may join any network it wishes as long as it agrees to abide by the usage policy of that network. So commercial companies may join NSFNET mid-level networks, and universities can join commercial backbones. This rule of thumb obviously does not apply to networks with missions to serve only specific communities, such as the MILNET.

There are two avenues for commercial traffic in the United States. One is to contract with a service provider that supports commercial traffic. The other is to join a network with access to the NSFNET backbone that is a member of the Commercial Internet Exchange Association (CIX). CIX members route commercial traffic differently than research traffic.

264. **Install Appropriate Hardware** A machine, such as a gateway or a router, is needed to act as a gateway between the user's local network and the Internet.

A site may be able to use an existing host already on the network to work as a router rather than buying a special system to act as the gateway between the user's network and the Internet. The system, however, must have two or more network interfaces. Each interface would be connected to one of the networks between which packets will be exchanged. It is necessary to check if the network software on the existing system can provide this type of functionality. If it can, the user will then need to configure the system so that it knows how packets should be routed.

265. **Obtain Proper Software** If the local network to be connected to the Internet has been a TCP/IP network, that means the site is already running compatible protocols and will need only to add the routing protocols necessary as described in the previous section.

If the local network is based on protocols other than TCP/IP, the gateway used in the site must understand the TCP/IP-based traffic it receives from the Internet, and should be able to convert it to a form understandable by the rest of the hosts on the local network.

266. **Order Circuits** Most sites connecting to the Internet in the United States connect via dedicated lines leased from a phone company. Sites at greater distances, for example, in developing countries, often connect in other ways, such as via satellites, fibre optic cables, or microwave dishes.

Lines of different speeds can be leased; of course, the faster lines are more expensive. It is necessary to estimate the amount of traffic the site will be sending at peak times so that lines leased are able to handle the expected capacity and used in an economic way.

If users want to build their own circuits, they need to contact local telephone authorities as early as possible so that there will be enough lead time for their installation.

267. Access for Individuals Individual access to the Internet is defined as a person having an account on, that is, the permission to use, a host that can at least send electronic mail to the Internet. An e-mail account is certainly "access" to the Internet, but it would not provide access to the full range of Internet capabilities in the way an account on an Internet host would.

Individuals, in general, obtain access to the Internet by paying for an account from service providers. There are a variety of types of accounts and a variety of costs associated with them in the United States and other countries. Some accounts, as mentioned, allow only electronic mail access to the Internet, while others allow use of the full range of Internet protocols, such as file transfer (FTP) and remote login (Telnet). Some accounts that offer only e-mail access to the Internet include other services on other types of networks, such as the ability to read newsgroups, play games, or consult databases of specialized information. For the services available at local place, the user needs to consult local service providers.

268. General Access ProceduresUsually these types of Internet accounts are called dialup accounts because users access them via telephones. Before establishing a dialup e-mail connection, the user will need:

- A terminal or a personal computer with terminal emulation software.

- A modem capable of the appropriate baud rate for the connection.

- Access to a phone line.

The general procedures for access to the Internet are as follows:

- Dial one of the phone numbers and use the modem to connect the terminal to the host, terminal switch, or terminal server.

- Log in to the host with the user's unique account name and password.

- Choose whatever services the user needs from those the host makes available, such as electronic mail.

The exact, step-by-step procedures to access to the Internet and take advantage of the Internet should be supplied by the user's service provider.

Different service providers, while usually similar in the constant of providing at least electronic mail access to the Internet, offer different types and ranges of services at different costs. Most electronic mail providers also provide access to network mailing lists, network news, or bulletin boards. Costs for dialup connections often take into consideration the speed (modem baud rate) at which user access his/her account, the amount of time the user is connected, and the range of services available. Sometimes there are membership fees, initial administrative fees, or additional fees for certain transactions or services. Some providers offer services at a flat fee rate.

269. *MX and Dialup IP Access*. Traditionally, Internet access has consisted of a site connecting its big mainframe computer or its local area network to the backbone of the Internet. Alternatively, if someone didn't work at a big site like this, he could have a dialup account for electronic mail access. In the past, Internet access was largely limited only to those two choices. Now there are a few more flavours of Internet access. Two of the most commonly used are MX access and dialup IP.

MX Access. An MX record is a special type of record in the Domain Name System. The Domain Name System (DNS), as discussed in Paragraph 262, is the basis for keeping track of the names and addresses of all the computers on the Internet. It is possible for a user to have her/his own fully qualified Internet domain name even though s/he is not an Internet site. This is done by listing an MX record for the user's site in the DNS. MX stands for **M**ail e**X**change record. An MX record points not to user's site - because the user's site is not directly connected to the Internet - but to a host that acts as an intermediary between the user and the Internet. This host computer agrees to hold a user's mail for the user until the user dial up to get it, or forwards it to the user on a private, non-Internet connection. The advantage of using MX records is that users on the Internet can send mail in one, standard format, even to sites not directly connected to the Internet.

This type of Internet access supports only electronic mail. To set up this type of access for the sites that services are needed, the users need to arrange an agreement with an Internet host to handle their mail, and need to register a domain name, either with the INTERNIC, or another domain administrator. It is possible to set up an agreement privately with some host that will act as a mail intermediary for the user. In addition, some service providers make this service available as well.

Dialup IP Dialup networking can refer to several types of access. The most basic refers to using a modem to connect a terminal to a host, thus affording that terminal dialup access to the host. A terminal in this case can be just a dumb terminal or a more sophisticated computer emulating a terminal. This type of dialup access is referred to as *dialup e-mail* access because it is one method users have traditionally used for such access.

UUCP (UNIX to UNIX Copy Program) mail uses a variation of this method. UUCP is used for exchanging e-mail between computers over phone lines. A user sends one or several mail messages on his local computer, and they are queued up on his disk. Then, once the user's machine dials up another machine, and, using the UUCP protocols, sends whatever mail has accumulated and receives any incoming mail. It is possible for UUCP mail users and Internet mail users to communicate because some of the machines running the UUCP protocol are also on the Internet and can act as gateways between the two systems.

Dialup IP is distinct from these other dialup methods. Dialup IP applications are built on the Serial Line IP (SLIP) or the Point-to-Point Protocol (PPP). In general, PPP obsoletes SLIP, but services built on both are available.

These protocols allow two machines to communicate using TCP/IP protocols, but over a standard dialup phone line instead of a permanent network medium such as Ethernet. By using SLIP, for example, a machine that has no permanent connection to the Internet (and it would have to be a computer running the network protocols, not a dumb terminal) would dialup another machine that is a terminal server or a gateway with SLIP capabilities or perhaps just an Internet host. The SLIP program would login to that remote machine, then issue a command that would cause the phone line to become a TCP/IP network connection, from which time only IP packets would go back and forth across that line. Once this connection is established, everything works for the user as if his personal machine were directly on the Internet. The user has access to all Internet protocols and services. When he is finished, he simply hangs up, severing his Internet connection. This last type of dialup service is referred to in *dialup IP*.

11.3 Applications of the Internet - Electronic Mail

270. From the Internet user's point of view, access to the network and its services is accomplished by invoking applications programs. It is not necessary for a user to fully understand the details of these application programs. However, it might be helpful to be aware that when these programs are called upon, they use the underlying Internet protocols to provide the user with some particular network service. At the same time, it is also important to realize that having Internet standards for the applications encourages their widespread use in the Internet.

The most popular "traditional" services provided by TCP/IP are **electronic mail**, **file transfer**, and **remote login** via the Telnet Protocol. The following sections provide basic information on using these popular applications, and introduces several useful "information server" programs available to Internet users. These sections are intended only as an introduction to some popular applications; it is hardly a comprehensive resource guide of what is available, nor a user guide delineating specific procedures.

271. ***Electronic Mail*** Electronic mail, or e-mail, allows to send messages electronically to any individuals or groups of individuals. In addition, system programs accept and store mail messages that come in for users from other hosts. These programs automatically recognize the incoming traffic as electronic mail, translate it to a format compatible with the receiving mail program, and direct the message to the correct recipient. Most users have an online mail file where all messages addressed to them are stored. Internet mail makes mail delivery more reliable. Instead of relying on intermediate machines to relay mail messages, Internet mail delivery operates by

having the sender's machine contact the receiver's machine directly.

Of course, the Internet is accessible to many other networks via e-mail. To send mail to some of these networks, user may have to explicitly address a gateway machine, or the user's message may go through a mail gateway if his/her target host is registered as an MX record in the Internet's Domain Name System.

Although there is a variety of electronic mail software supported by different computer systems, the format described in RFC 822, *Standard for the ARPA-Internet Text Messages* is the standard used by the majority of research and development computer networks internationally. It is important that mail programs on the Internet conform to the Internet standards in their mail headers, especially in their "reply-to" or "from" fields. A non-conferment "reply-to" field will mean that when people reply to a message, their reply will not be transmitted correctly.

It is generally considered prudent to reserve e-mail for informal correspondence. E-mail is not very secure and it is considered wise not to commit to e-mail anything that the user would not want to become public knowledge. Users' message could end up in someone else's mailbox if the machine goes wrong. A user's reply to a message that was sent to a group of people might end up being sent to everyone in the group. It is also a simple matter for some one to edit and forward a user's message to another user without noticing the user. Obviously, confidential messages should be encrypted.

272. In very basic terms, mail messages are broken down into two portions: the header and the body. There is an empty line that separates the two portions of the message, which is itself a requisite piece of the message format. The header lists information about the sender of the message, the recipient(s), the posting date of the message, and a subject field. The body holds the text of the message itself, usually in ASCII format (or EBCDIC for BITNET). Some sites set a limit on message size; some limits are as low as 10 kbs, although the general rule is 64 kbs. Another limitation to be aware of is line width; the general rule is 80 characters.

Internet addresses have two parts separated by an @ (at-sign). The part to the left of the @ is the local part, and usually designates the person to whom a message is sent. It may also indicate a mailing list that includes several people. The part to the right of the @ indicates the destination host. The @ is a convention used in electronic mail based on the Simple Mail Transfer Protocol (SMTP). Addresses with @s are sometimes called *SMTP addresses* or, more often, *RFC 822 addresses*, after the RFC that specifies the standard format for Internet messages.

Electronic mail can be send to some non-TCP/IP networks with which Internet users commonly correspond. Addressing information can be found either from the published books on the directory of computer networks or the document available on-line.

273. X.400 Addressing Standard. Recommendation X.400 is the international standard for message handling developed by International Telegraph and Telephone Consultative Committee (CCITT) in cooperation with the International Standardization Organization (ISO). Many networks

support this electronic mail format or have plans to do so. It is currently being implemented by RARE (Reseaux Associes pour la Recherche Europeenne) networks in Europe, for example.

The X.400 standard supports not only *normal text*, but can contain other formats as well, such as *FAX messages* and *voice* recordings. Addressing is done by using a unique set of attributes for describing each recipient. These attributes are then used to search in an electronic directory, which is fashioned much like a telephone book for electronic mail; domains and addresses. X.400 uses the following attributes in the address field of its messages:

Country: Country specification; uses the ISO country codes; Can be abbreviated as **C**.

ADMD: Administration Management Domain. This is the name of the public X.400 carrier. For example, in the UK, the national carrier is PTT British Telecom. Can be abbreviated **A** or **AD**.

PRMD: Private Management Domain. The private X.400 carrier that is being used, such as ATTMail, SprintMail, etc. Can be abbreviated **P** or **PD**.

Organization: The organization the recipient belongs to. This can be a company or university, etc. Can be abbreviated **O** or **OR**.

Org.Unit: This could be the department or "suborganization" within the organization the recipient belongs to, such as the chemistry department at a college or university. Can be abbreviated **OU**.

Surname: The family name, or last name, of the recipient. Can be abbreviated **S** or **SN**.

Givenname: The first name of the recipient, or the name used as a username. Can be abbreviated **G** or **GN**.

In some systems, **PN** is used for Personal Name. In these systems, a person's whole name is designated under this attribute instead of using the Surname and Givenname attributes. The first names and last names of PNs are often separated by underscores or dots, such as Mary.Jones or John_A_Smith.

It is possible to send mail from the Internet to a user on a network that supports the X.400 message system if there is a gateway between the Internet and that user's network. In doing so, the X.400 syntax is used in the local part of the address, and the mail gateway is designated as the host part of the address. The X.400 syntax may change slightly to conform to the specific attributes used by the specific X.400 implementation.

11.4 Applications of the Internet - Mailing Lists and Newsgroups

274. One of the most versatile features of an electronic mail system is the easy distribution of one message to many people simultaneously. Electronic discussion forums are among the most useful features of the Internet. These forums are commonly known as newsgroups, bulletin boards, and mailing lists. Participation in these forums is easy.

275. ***Mailing Lists*** A mailing list is simply a computer file containing electronic mail addresses in a specific format. Once a name has been added to a mailing list, the user is said to have subscribed. Messages from other subscribers are automatically sent to the user's electronic mailbox. The simplest and most direct method is to subscribe to a special interest group mailing list. A file containing a listing of Internet mailing lists can be found on ftp.nisc.sri.com in *netinfo/interest-groups*. A hardcopy version of this file, *Internet: Mailing Lists*, is available as one of the volumes in the *SRI Internet Information Series* available from Prentice-Hall. More than 800 lists are described in this book, and it is the best place to start. The listings cover almost every subject imaginable - from discussions of network protocols to the human genome project to birdwatching.

The general convention for being added to or deleted from a mailing list is to send a message to *list*-request@host. Lists that are maintained through an automated server mechanism like **LISTSERV** or majordomo usually have a central address such as **"majordomo@greatcircle.com"** to which administrative requests should be sent. Following these conventions will direct user's request to the person or program who maintains the list, rather than to the membership of the entire mailing list.

Some lists may not provide this capability, but it is always best to check first. For example, tcp-ip-request@nic.ddn.mil is the address to which requests for changes to the TCP-IP mailing list should be addressed. After subscribing to a list, messages that are sent to the mailing list will appear directly in your electronic mailbox.

There are several types of mailing lists. One type, commonly known as an unmoderated list, allows free form discussion. There is no restriction on the messages sent to the list, and anyone can participate. This type of list is frequently the most active, since messages may turnaround in a matter of minutes. However, the drawback is that these lists also often receive heavy traffic (some of the more prolific lists average more than 30 messages a day), and some of the messages may be junk (such as "Please remove me from this list").

Moderated lists are just that - messages which are sent to these lists are first read by a moderator. If the moderator feels that the message is appropriate, the moderator then forwards the message on to the list. The quality of messages on these lists is usually higher than those to an unmoderated list since junk messages are removed before they are circulated. However, there is usually a longer turnaround time for messages to this type of list. Also, since most moderators do not receive compensation for their efforts, this type of list is not as common as the unmoderated type.

Digests are another common type of list. Messages which are sent to such lists are gathered by the moderator into one big file, which he then mails as one message to the whole list. This type of list is usually used for topics that receive heavy traffic. It helps to minimize network traffic by reducing the number of messages that subscribers receive. Digests typically have a table of contents at the beginning of each message to show what has been included in that message.

276. ***LISTSERV*** LISTSERV is an automatic mailing list maintainer. It is one of the services offered by EARN and BITNET, although it is accessible to Internet sites as well. There are more than 150 mailing lists available covering a broad range of subjects. Users can add and remove themselves from a list using electronic mail and issuing simple commands in the body of a message. For a complete list of LISTSERV lists, send the command *list global* to listserv@bitnic.educom.edu. Typing *help* in the body of a message and sending it to the same host will retrieve a help file listing some of the more general commands.

277. ***Newsgroups*** In addition to special interest group mailing lists, a useful information source can be found through USENET, also known as netnews. Netnews originated on UNIX based systems as a way to exchange information in a common area.

Information in netnews is divided into newsgroups, which cover specific areas of interest. There are more than a thousand newsgroups, although not all newsgroups are available on every system. The newsgroups are arranged in a hierarchical (tree) fashion, with each root of the tree devoted to a major topic. Some of the major roots are:

alt Alternative newsgroups, a testing ground for prototype newsgroups.

bionet Biology related news groups.

bit Bitnet related groups.

comp Computer related topics. Hardware, software packages, operating systems, and network protocols are included in this tree.

gnu Newsgroups covering software from the Free Software Foundation.

ieee IEEE related newsgroups

kl2 Newsgroups for students in kindergarten through twelfth grade, and newsgroups to discuss education.

misc Miscellaneous newsgroups. Groups which don't fall into any of the other categories are placed here.

news Newsgroups about news.

rec Recreation related newsgroups.

SCI Science newsgroups.

soc Newsgroups covering aspects of sociology.

talk Newsgroups for discussion on a specific topic.

vmsnetVMS related topics.

Like a tree, each of these roots has many branches, with each branch further defining the subject area. For example, the newsgroup discussing the TCP/IP protocols is called comp.protocols.tcp-ip; sci.space.shuttle is for space shuttle issues; and rec.juggling is devoted to people who juggle.

278. ***Bulletin Board*** Bulletin boards are a common feature of most communities, serving to reinforce community ties and indicative of community vitality. In 1977, the first electronic bulletin board in the United States, the Community Memory Project was founded in Berkeley, California. Now, there are more than 30,000 Bulletin Board Systems in the United States. Information can be posted on the Internet using many freely available computer programmes designed for this purpose. Local Bulletin Boards can be used by government agencies, NGOs and educational, scientific and research organizations, for the private sector and for local authorities for posting information and gathering feedback.

279. ***Electronic Conference*** In an electronic conference, the user group agrees to create files on computers or hosts that are networked and which they can visit by virtue of their membership. These files can be many and can, by agreement, contain subject-specific information grouped under the headings relevant to the users. These conferences are very useful for posting "news" or other information of interest to the groups that moderate and visit the conference. Electronic conference can be used as a way of disseminating official documentation and also as a way of sourcing outside input to the process and to its follow-up. Individuals and organizations unable to come to the meetings could communicate their views with decision makers and others. Bulletin boards are a variant of electronic conferencing.

11.5 Applications of the Internet - File Transfer Protocol (FTP)

280. ***File Transfer Protocol (FTP)*** The FTP makes it possible to move a file from one computer to another, even if each computer has a different operating system and file storage format. Files may be data, programs, text - anything that can be stored online. Users are required to log in to each computer, thus ensuring they have the right to take or put files on those computers. File

transfer across the Internet is reliable because the machines involved can communicate directly, without relying on intermediate machines to make copies of the file along the way.

Using FTP requires that the user knows the hostname or host address of the remote host, a username and password on that host, and the pathname of the file to be retrieved. A pathname is the location of a file on a particular host, and typically includes name of the file and the names of the directory and any subdirectories in which the file is stored. FTP also requires that the user has permission to access the files that the user wishes to retrieve or transfer. Not every file can be transferred through FTP. Only files that have a protection permitting transfer, i.e. allowing public read access, can be transferred through FTP.

The general steps for transferring a file are as follows:

- Log in to user's local host, and invoke the FTP program.

- Provide the hostname or host address for the remote host.

- Once connected to the remote host, log in with username and password.

- Issue commands to copy or send files.

- When finished, log out from the remote host, and exit from the FTP program.

Depending upon the implementation of FTP at the local host and the remote host, it may also be possible to display a directory listing of public files on the remote host, as well as system status information.

281. Anonymous FTP. Several hosts provide the username anonymous for FTP retrieval of files from their system. This service is called the FTP anonymous login convention. The hosts that allow anonymous login do so by establishing a special anonymous login account, which works *only* with FTP, and cannot be accessed for general use of that host. The "anonymous" account is a special one with access limited to the FTP archive offered by that host. Some hosts that implement anonymous FTP act as repositories for Internet information.

User cannot use the anonymous convention to send files to a remote host as this requires a login account on that host. User may only pull files from an Internet information repository to the user's local workspace. Hosts that provide information to the Internet via anonymous FTP are often referred to as *FTP hosts, Internet repositories*, or *anonymous FTP archive sites*.

With anonymous FTP, the login name for a remote host will always be *anonymous*. The remote FTP program will often request a username as the password; most programs also accept *guest* as the password. If a host requests a user "ident," type the user's username rather than *guest*.

The other difference between anonymous FTP and the more general FTP is that with anonymous FTP, files can only be retrieved from an anonymous FTP repository, not deposited there.

11.6 Applications of the Internet - Telnet

282. The Telnet Protocol allows an Internet user to log in to a remote host from his local host. Once connected and logged in to the remote host, a user can enter data, run programs, or do any other operation just as if he were logged in directly to the remote host. While running Telnet, the program effectively makes the local computer invisible during the session on the remote computer. Every keystroke the user types locally is sent directly to the remote system. When the remote login session terminates, the application returns the user to the local system. Telnet is a powerful tool in resource sharing.

The steps for running Telnet may be summarized as follows:

- Log in to your local host.
- Invoke the Telnet program on that host.
- Identify by hostname or host address the remote host the user wish to access.
- Once connected to the remote host, log in with username and password for that host.
- When finished working on the remote host, type the command to log out. Then break the connection (if it is not broken automatically upon logout). The user is now back where s/he began on the initial host.

Telnet has many other advanced features, too numerous to discuss here.

283. Publicly Available Programs Some hosts make certain programs on their hosts available to the public by not requiring an individual account on the system to use the program. It is used, in particular, to access lots of public services, including library card catalogues and other kinds of databases. An example is the WHOIS program available on the nic.ddn.mil host. To use WHOIS, the user needs only telnet to the host and type *whois*. No other login procedures are required to use the program.

Another method of allowing public access is to publicize a certain account name (in much the same way that whois is the well-known name of the WHOIS account on nic.ddn.mil). For example, to use the White Pages service on host psi.com, the user telnets to the host and login as *fred*, with no password. These are ways some Internet hosts make services available to the Internet public.

Often other services, such as access to supercomputer time or the ability to search certain databases, are also available via Telnet if users arrange for access in advance. Such arrangements usually include the assignment of an account name and password on the remote host, or access to a special guest account.

11.7 Applications of the Internet - Information Servers

284. Many hosts on the Internet have available collections of software, graphics images, digitized sound recordings, technical papers or other information. It is possible for host administrators to make an Internet archive available to the entire Internet community using the anonymous FTP convention.

There is no single directory of all resources available on the Internet. The network is growing and changing so rapidly that such a directory would be out of date as soon as it was published. Those who intend to make substantial use of online information of the Internet need to begin by conducting an extensive search for relevant sources themselves. Currently, several efforts are underway to develop easy methods of discovering, locating, and retrieving information available freely on the Internet. Most of these efforts developed independently of the others and have only recently become aware of similar efforts. This section describes five of these information tracking projects: the Internet Gopher, World Wide Web (WWW), Archie, Prospero, and WAIS.

285. ***The Internet Gopher*** The Internet Gopher combines features of electronic bulletin board services and databases into an information distribution system that allows users to either browse a hierarchy of information or search for the information that the user needs using full-text indexes. Gopher can store references to public Telnet sessions, phone book servers, finger-protocol information, and sounds. The Internet Gopher software was developed by the Computer and Information Services Department of the University of Minnesota.

Gopher servers store a wealth of diverse information, including computer documentation, phone books, news, weather, library databases, books, recipes, and more. Information is stored on multiple Gopher servers, which are connected together in a network. This allows for capacity to be added to the system in small, inexpensive increments. It also allows the Gopher system to cross institutional boundaries, since other servers can be "linked" into the system easily. Large indexes can be spread over multiple servers, resulting in significant speed-ups.

At the initial connection, the root server sends back a listing of the objects in its top level directory. These objects can be: Directories, Text Files, CSO Phone Books, Search Engines, Telnet References, or Sounds. Each object has associated with it a user displayable title, a unique "selector string", a hostname, and a port number. The client then presents the user with the list of titles, and lets him/her make a selection. The user does not have to remember hostnames, ports, or selector strings related to where information is on the Internet. After the user makes a selection, the client contacts the given host at the given port and sends the selector string associated with the object.

Client software for Macintoshes, PCs, NeXTs, X Windows, and UNIX terminals is available for anonymous FTP from the host boombox.micro.umn.edu in the directory/pub/gopher. Or, if users just want a quick look at the UNIX terminal, they can client Telnet to the host consultant.micro.umn.edu and login as *gopher*. Running the client on a local personal computer or workstation is recommended. These local clients have a better response time and an easier user interface.

286. ***World Wide Web (WWW or W3)*** The most recent addition to the Internet is an application called the World Wide Web (also known as WWW, W3, or simply `the Web'). The World Wide Web (WWW or W3) Project was founded on the idea that much academic information should be made freely available to anyone. Its purpose is to allow global information sharing with internationally dispersed teams, as well as the dissemination of information by support groups. It merges the techniques of information retrieval and hypertext to make an easy but powerful global information system.

The Web is based on information in the form of `hypertext'. *Hypertext* is a way of presenting information in which selected words of a document can be `extended' into more information about these words. By using these `links', documents can be intertwined creating a real `web'. In fact, a link can point to another text document, or a picture, a sound, or anything. These multi-media facilities are limited through, to certain `viewers', such as *Mosaic*.

Basically, the Web seeks to provide access to the web of information available. This web contains many types of documents, in many different formats. The Web considers documents to be either real, virtual, or indexes. Users need only provide keywords or other search criteria; they do not need to understand the various types or formats of documents.

The requirement for using the Web is access to an Internet computer running a Web browser program. A browser is a program that is able to interpret and display documents that have been formatted with hypertext links. There are several browser programs currently available. These range from programs such as **Lynx**, limited to simple text displays, to **Mosaic** which can incorporate complex, multi-media applications consisting of images or even sounds. The levels of user friendliness vary tremendously between the two, as do the computer equipment requirements necessary to run them.

287. ***Archie*** Researchers originally at McGill University in Montreal, Canada, recognized that there was a multitude of information available on hosts acting as anonymous FTP archives, but that there was a big problem in finding out what that information is, who has it, where it is, and how to get it. In response to those needs, they designed Archie. Archie is a collection of resource discovery tools that together provide an electronic directory service for locating information in an Internet environment.

At its simplest, Archie is a means of locating files in anonymous FTP archives. It polls such archives regularly and compiles a database of references to available files. It makes this database available for searching, allowing users an entry point to the world of Internet resources. Searches are possible via Telnet, e-mail, or by using an Archie client program. Archie can also be accessed through the Prospero system. Archie servers are replicated throughout the Internet. It is best to use one near the user itself to reduce network load.

When a user searches the Archie database, he/she is returned information about files that match the user's search criteria, including where they are located. This information makes it easy to retrieve what the user needs via the network.

288. ***Prospero*** Prospero is a distributed file system based on the Virtual System Model. Prospero is a tool that assists Internet users in organizing the large amount of information available on the Internet.

The Prospero file system supports a user centred view of files scattered across the Internet. It can be used to organize references to files as if they were on the user's local system, without the need to physically transfer them locally. Prospero also provides access to directories and indices that can be used to find files of interest that are available from Internet archive sites.

Prospero is being used to organize information on papers that are available by anonymous FTP. To use Prospero, users must install Prospero on their systems. Users need only install the clients, though users are certainly encouraged to install the server too.

Users are encouraged, though not required, to create directories containing references to their own papers. They are also encouraged to pick a topic in which they have expertise and to maintain a directory with references to the FTPable papers that they have found related to that topic. A user that is maintaining such a directory should send a message to pfs-administrator@cs.washington.edu to have that directory included at the appropriate place in the /papers/subjects or /papers/authors hierarchy.

At this writing, Prospero supports SUN's Network File System, the Andrew File System, and the File Transfer Protocol (FTP). It is also capable of retrieving directory information from independent indexing services, such as Archie. Future plans include adding WAIS, WWW, and other indexing services.

A release of the Prospero file system is available via anonymous FTP from cs.washington.edu in the file pub/prospero.tar.Z (392 blocks). The distribution contains the sources necessary to run the Prospero server and client. No special privileges are required to install the client. Papers describing Prospero can be found in the directory pub/pfs/doc.

Announcements of new releases are made to the mailing list **info-prospero@isi.edu.** A second mailing list, **prospero@isi.edu**, is for general discussion of Prospero, as well as for announcements of new sites that have come on board, and new directories that people have created to organize the information already accessible. Requests for that list should be sent to prospero-request@isi.edu.

289. ***Wide Area Information Server (WAIS)*** The Wide Area Information Server (WAIS,

pronounced "ways") began as an experimental joint venture developed by the alliance of four companies, all of which share a mutual interest in information retrieval. The four companies developing the prototype were Dow Jones & Co., Thinking Machines Corporation, Apple Computer, and KPMG Peat Marwick.

WAIS is designed to retrieve full text documentation from various sources, either locally or via servers on other networks. WAIS uses a single user interface, through which a user can access multiple archives, thus sparing the user the need to be familiar with different operating systems or with different database management systems. The user has transparent access to a multitude of local and remote databases.

The WAIS system has three parts: clients, servers, and the protocol that connects them. The client is the user interface, the server retrieves and indexes the requested information, and the protocol transmits the questions and responses.

In very basic terms, the system works much like going to the Reference Desk at the user's public library, but WAIS was designed to automate this procedure. The user formulates a question in English, selects the sources s/he wishes queried, and then receives responses to her/his question. WAIS knows to ask all servers for the necessary information, making this interaction transparent to the user. The responses are sorted and deposited in one spot that is easily accessible to the user. Responses can be in the form of text, picture, sound, video, etc. The user can examine the responses, mark those that are sufficient, and/or amend the original query and try again.

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