

HISTORY AND USE OF COMPUTERS

Rohith Udalagama

General Business Systems Division, Data Management Systems Ltd.,
159, Dharmapala Mawatha, Colombo 7.

TYPES OF COMPUTERS

The term computer could be used to describe several types of equipment which are frequently used.

These computers could be broadly classified into the following three categories;

1. ANALOG COMPUTERS
2. DIGITAL COMPUTERS
3. HYBRID COMPUTERS

1. ANALOG COMPUTERS

The term 'ANALOG COMPUTER' is used to describe instruments or equipment which are used to measure physical magnitudes. An example of these Analog computers would be:

- a) Speedometer
- b) Slide Rules, etc.

2. DIGITAL COMPUTERS

Digital computers do not measure physical magnitude but operate directly on discrete numbers which are expressed as digits or decimal numbering systems.

Since digital computers do not operate by measuring physical magnitudes, these computers are used on a wide variety of functions from Information Processing to Scientific Analysis, Engineering, Calculation and numerous other Applications.

Today when the term Computer is used more often than not it refers to a Digital Computer System.

The modern computer is a piece of STATE-OF-THE-ART electronic equipment which is capable of storing and executing a pre-defined sequence of instructions which is known as a program. This enables the equipment to automatically carry out a series of operations to complete a given task.

This capability of stored program concept is the cornerstone of the modern day Computers.

3. HYBRID COMPUTERS

Hybrid computers are not a special type of computer but special devices which incorporate both Digital computers and Analog computers and is used for specific applications such as various process control applications.

THE EVOLUTION OF COMPUTERS

Although the concept of the stored program's are vital to modern computers the earliest invention of computers were mainly mechanical.

Since very ancient times, man invented various methods and means to make calculations faster and less tedious.

In pre-historical times, man may have calculated by counting his fingers, by collecting twigs or pebbles, by marking caves, etc.

The first device invented purely for the purpose of calculation was the ABACUS which dates back to around 10,000 years ago.

The ABACUS which resembles a child's counting frame is in use even today, in some Asian countries.

The first real calculating aid was invented in the 17th century was by a Scottish mathematician named John Napier.

This invention which is referred to as the "Napier's Bones" consisted of a set of rods engraved with multiples of integers which simplified multiplication to reading off sets of numbers and adding them.

Napier also developed LOGARITHMS which simplified/reduced multiplication and division to addition and subtraction.

The first machine capable of adding and subtracting was constructed by the 19 year old BLAISE PASCAL in the mid 17th century. While in the 1670s LEIBNIZ invented a machine capable of multiplication.

The concept of the Digital Computer was first defined in the early 18th century by CHARLES BABBAGE who attempted to construct a complex computer. Although he developed the blue print for a digital computer, technology at that time did not permit them to actually manufacture a digital computer system.

The next major innovation was in 1880 when Dr. HERMAN HOLLERITH invented an electro-mechanical machine which used punched cards for the tabulation of Census data in the U.S.A.

This invention heralded the advent of electro-mechanical Data Processing.

In 1944, a Machine named HARVARD Mark-1 was built using the original concepts of Charles Babbage.

The HARVARD Mark-1 was an electro-mechanical device which enabled arithmetic operations to be done in around 5 seconds.

The limitations of the Electro-Mechanical Computers were overcome in 1946 when the first Electronic Computer named ENIAC was built by the University of Pennsylvania for the US Army.

The ENIAC used vacuum tubes or thermionic valves which enabled calculations to be carried out in milliseconds.

The first computer to operate with internally stored programs was the EDSAC in 1949 while the first commercial computer was the UNIVERSAL AUTOMATIC computer introduced in 1951.

The computers which used the thermionic valve technology are known as first generation computers. These computers were not widely used due to the high power consumption and low reliability.

In the late 1950s and early 1960s the second generation of computers came into the market which reduced the time taken to carry out calculations to the micro-second range from the millisecond range.

These second generation computers were more reliable due to the use of TRANSISTORS while they also had lower power consumption.

In the mid 1960s the third generation of computers were introduced which used integrated circuits which once again helped to reduce the time taken for calculation from micro-seconds to nanoseconds and increased the reliability of the systems and reduced the power consumption and cost.

The present generation of computers which is called the 4th generation of computers, use large scale integrated circuits which enable faster processing and lower cost.

HOW THE DIGITAL COMPUTER FUNCTIONS

When we try to examine the functioning of Digital Computers we have to have an understanding of how the Digital Computer operates.

All Digital computers function by using the BINARY numbering system. The binary system uses Zero's and One's to represent any character.

It is by the use of binary that a Digital Computer could use electrical impulses to represent information. In a Digital Computer all information is stored by switching electronic components "on or off" at pre-determined sequences enabling the representation of characters and numbers internally in a computer system.

The on and off status of electricity in a computer is represented by a series of Zeros (0) or Ones (1).

Each of these zeros or ones is called a BIT in computer jargon. Each character represented in a computer system is called a BYTE and every byte is made up by using upto 8 bits. By changing the sequence of the zeros and ones, in a 8 bit sequence different characters could be represented in a computer system.

When we need to measure the ability of a computer system to store information we use the term kilobyte which is 1024 bytes. We use the term Megabyte to measure larger Volume storage requirements. A Megabyte is 1000 kilobytes.

THE COMPONENTS OF A COMPUTER SYSTEM

The computer system itself is only a piece of equipment which requires 3 essential components for successful operations.

These are:

- (a) THE COMPUTER HARDWARE
- (b) THE SOFTWARE (OR PROGRAMS)
- (c) THE LIVEWARE (OR PEOPLE)

THE COMPUTER HARDWARE

All the physical components of the computer are together known as the computer hardware.

In any workable computer configuration, the computer hardware consists of a minimum of four components.

These four components are:

- (a) INPUT EQUIPMENT
- (b) OUTPUT EQUIPMENT
- (c) PROCESSING EQUIPMENT
- (d) STORAGE EQUIPMENT

INPUT EQUIPMENT

Since any information which is to be processed by the computer system requires to be entered into the Computer Input Equipment, it is essential for the operation of the computer.

Upto the second generation of computers the most widely used mode of inputting information to the computer system was through the use of Punch Cards.

However, the Punch Card input system was inefficient as it required a two step operation.

The major disadvantage of this mode of operation was that since the information entered onto the card was stored on the card by the perforation of the card, it was not possible to easily decipher the information on the card which made it necessary to verify the information input to card through other methods.

The first step of Card punching or the initial inputting of information was called DATA ENTRY.

The second stage, called the verification stage involved the re-keying of the information input at the data entry stage. If there was a discrepancy in the information stored on the card and the information typed at the verification stage, an error sign was shown by the card verifying equipment.

Once all the information that required to be input into the computer system was recorded on punch cards these cards were collected and were fed into another piece of equipment known as a card reader which was connected to the CENTRAL PROCESSING UNIT of the computer.

The punch card method of inputting information into the system was acceptable for the inputting of data or data entry in a batch environment where information was entered into the computer system in batches at pre-determined periods.

However as computers became cheaper and the need to use computers become more important, this method of inputting information into the computer system became a constraint to the development and widespread use of computers.

This problem was a major constraint in operations where users of computers required information to be input into the computer system as and when transactions occurred. This type of data entry is known as "on-line" data entry.

The advantage of "on-line" data entry is that a transaction which occurred first could be processed and results obtained before any subsequent transaction took place.

This type of processing which is known as "on-line processing" ensured more up to date information to be available.

At present the most widely used input equipment is the Interactive Terminal from which data could be entered on-line into the computer system.

The interactive terminal consists of two components:

- (a) A keyboard - which includes full typewriter like keyboard for the entering of alpha-numeric information, a numeric keypad similar to a calculator keyboard for the fast inputting of numeric only data, a set of editing keys which are used for editing information entered into the system and a set of special function keys which could be programmed to carry out a sequence of operations at the press of one key.

- (b) The display Which is a TV like monitor is used to display information entered through the keyboard or to display responses from the computer system.

The major advantage of the interactive terminal is that since the display unit has the ability to display information input from the keyboard, the data entry and verification stages could be combined as information entered to the keyboard could be visually verified.

At present several types of interactive terminals are available. These could be broadly grouped into two categories:

- (a) Dumb Terminals - Which function by using the electronic components in the central processing unit.
- (b) Intelligent Workstations - Intelligent workstations incorporate electronic components in the workstation itself enabling many of the functions such as character generation to be carried out in the workstation itself. These intelligent workstations also have a buffer where any information input to the keyboard is first stored before transfer to other locations of the computer system.

In addition to the interactive terminal several other type of equipment too could act as input equipment. These include;

- (a) PAPER TAPE READERS
- (b) MAGNETIC TAPE DRIVE
- (c) DISK DRIVE
- (d) DISKETTE DRIVE
- (e) OPTICAL CHARACTER READER
- (f) MAGNETIC INK CHARACTER READER
- (g) OPTICAL MARK READER
- (h) CARD READERS

THE PROCESSING EQUIPMENT

Since the objective of inputting the information into the computer equipment is to process the information, each computer system is equipped with a processing unit.

This processing unit is known commonly as the CENTRAL PROCESSING UNIT or CPU.

The Central Processing Unit consists of several components such as:

- (a) MAIN MEMORY - Where information which requires to be processed is stored. The capacity of the main memory is normally measured in kilobytes.
- (b) THE ARITHMETIC LOGIC UNIT - Where the actual processing of information takes place.
- (c) CONTROL UNIT - Which controls the activities of the other components of the central processing unit.

The three components indicated above are the major components which are found in any central processing unit.

In addition to these components all central processing units incorporate other types of registers for the temporary storing of information.

OUTPUT EQUIPMENT

Once the information is processed, the results generated by the computer system could be displayed or printed using output equipment available on the computer system.

The most commonly used hard copy output equipment are PRINTERS.

Depending on the type of work, volume and quality of output required different types of printers could be used. These printers include:

- A) MATRIX PRINTERS- For medium speed, draft quality output
- B) DAISY WHEEL PRINTERS - For high quality output
- C) BAND PRINTERS - For high volume output
- D) LASER PRINTERS - For high quality, high volume output.

In addition to printing the output information, it is also possible optionally to only display the information.

When the output information needs only to be displayed, the display unit in the workstation is used for this purpose.

In addition to printers and display units other peripherals too could act as output equipment. These include:

- (a) TAPE DRIVE
- (b) DISKETTE DRIVE
- (c) DISK DRIVE

STORAGE EQUIPMENT

Any information stored in the main memory of the central processing unit will be erased from the system if the power supply to the computer is curtailed. However, the information which is input to the computer system at times requires to be stored in the computer system for subsequent processing, for reference purposes, etc.

Since it is not practical to input the same information each time it is required for processing or references, computers are equipped with secondary storage media.

This secondary storage is also known as BACK-UP storage because any information stored on this secondary storage is retained in the computer system even when power to the computer system is cut off.

In the early computers, the only available back-up storage was magnetic tape media.

The disadvantage of using magnetic tape media for secondary storage is that, since the information stored on tapes could only be accessed serially, the time taken to access any information which was stored at the end of a tape was very long.

To overcome this disadvantage in tape storage of being only able to access information serially, the MAGNETIC DISK DRIVES were invented which enabled RANDOM ACCESS of information stored.

The major advantage of Random Access is that any information stored on the disk could be accessed without any consideration given to the actual physical location of the information. Random access speeded up the retrieval of the information from back-up storage.

SOFTWARE

Now that we have looked at the computer hardware in detail we will now examine the second essential component in a computer system.

This component is the software or the set of programs which are essential to make the computer carry out the functions required by the computer users.

The SOFTWARE on a computer system could be divided into two broad categories;

1. SYSTEM SOFTWARE
2. APPLICATION SOFTWARE

1. SYSTEM SOFTWARE

The system software is a name given to the software packages or set of programs supplied by the manufacturer of the computer hardware which enables certain functions on the computer system to be carried out automatically.

The system software supplied by the manufacturer could be broadly divided into the following categories;

- (a) Operating System
- (b) Utilities
- (c) Compilers or Interpreters

OPERATING SYSTEM

The operating system is a program supplied by the manufacturer which carries out the following functions:

A) MEMORY MANAGEMENT

When the computer system is being used by several users concurrently it is necessary for the main memory in the CPU to be allocated such that all users of the computer system will have access to the main memory.

The most commonly used memory management techniques are as follows;

- * PARTITION MEMORY - Is a suitable Memory Management Techniques for computers which are used in an "online" environment.

- * SWAPPING MEMORY - Is suitable for computer systems which are used mainly in batch environment.
- * VIRTUAL MEMORY - Is the most sophisticated memory management system currently available and is ideal for use in both the BATCH and INTERACTIVE environments.

- B) SECURITY - Curtails unauthorized access to information stored in the computer system.
- C) PRIORITY MANAGEMENT
- D) QUEUE MANAGEMENT
- E) PRINT SPOOLING, ETC., ETC.

THE UTILITIES

Utilities are programs which are supplied by the manufacturer of the hardware, to carry out frequently needed functions such as:

- * SORT/MERGE
- * COPY/VERIFY
- * BACKUP ETC.,
- * The Programming Aids are utilities which help speed up program development.

COMPILERS AND INTERPRETERS

Since computers operate by using binary or zeros and ones, all information which requires to be processed by the computer must finally be represented internally in the computer system in zeros and ones before processing could take place.

Therefore, all computer programs ultimately have to be represented in the binary code or the machine code.

In the first generation computers all programming had to be done in machine code or binary.

The disadvantage of using machine code or binary is that since the program will have to be in zeros and ones, the time taken to

develop the program was very lengthy. This problem was further compounded by each manufacturer having a different machine code or binary language.

The use of the machine code was considered to be the first generation of programmers' languages.

To avoid some of the problems associated with using machine code, manufacturers later developed second generation programming languages which use symbols in place of binary code.

The second generation programming languages were understood more easily by computer personnel and enabled manufacturers to standardize on computer languages.

However, even these second generation programming languages were time-consuming to learn and use.

As the use of computers became more wide-spread, third generation programming languages were evolved.

These third generation languages are less time consuming to learn and easy to use as they resemble English language more closely.

Examples of these third generation languages are BASIC, COBOL, FORTRAN, etc.

The compiler or interpreter is a SOFTWARE PROGRAM supplied by the manufacturer to convert programs developed using the third generation programming languages to the machine code of the computer.

The initial program developed in a third generation programming language is known as the "SOURCE PROGRAM" while the program after it is compiled is known as the "OBJECT PROGRAM".

When any application program is executed on a computer system only THE object version of the program is used.

APPLICATION SOFTWARE

In addition to the System software which is supplied by the computer manufacturer, another

set of programs are essential to make the computer carry out the functions which are required to obtain the results desired by the users.

All such programs developed to computerise specific functions are called Application Software.

Some Examples of Application Software are programs developed to handle the following functions:

- * PAYROLL
- * ACCOUNTING FUNCTIONS
- * INVENTORY CONTROL
- * CURRENT ACCOUNT BANKING
- * TEA AUCTION DOCUMENTATION & BLENDING, ETC.

LIVE WARE

The third and final component essential for the functioning of a computer system is the "LIVWARE" or the people involved in operating and using the computer system.

The LIVWARE in the computer environment could be categorised into two types:

- A) THE COMPUTER PERSONNEL
- B) THE COMPUTER USERS

THE COMPUTER PERSONNEL

The computer personnel are the people involved in the day-to-day operations of the computer system such as:

- (a) DATA PROCESSING/INFORMATION PROCESSING MANAGER
- (b) SYSTEM ANALYST
- (c) PROGRAMMERS
- (d) DATA ENTRY OPERATORS, ETC.

THE COMPUTER USERS

The computer users are people who give input information to the computer personnel and use the information/results obtained from the

computer system.

In today's computer environment, the distinction between these two different types of users is being reduced as in an on-line computer environment, the computer users themselves would input data into the computer system and directly obtain results from the computer system.

THE USE OF COMPUTER SYSTEMS

Now that we have examined in detail the various components essential to the successful use of computers, we will briefly examine their varied uses.

Although computers were initially invented to handle large scale number crunching and data processing functions with the advent of technology, present day computers are able to support several other technologies in addition to Data Processing.

These include:

- * WORD PROCESSING - To process information in the form of written words.
- * IMAGE PROCESSING - To process information in the form of pictures and graphics.
- * AUDIO PROCESSING - For the processing of information in the form of spoken words and optimise the use of telephone systems, etc.
- * COMMUNICATIONS & NETWORKING - Which will enable different computers in physically separate locations or used to process different types of application to be inter-connected for the interchange of information.

Today, computers are available which supports all the above types of processing on one system.

Due to these powerful features, and frequent reduction in prices, computers are in use in varied types of application in Business, Education, Scientific, and numerous other areas.

The potential uses of computers are restricted only to the imagination of users.

COMPUTER APPLICATIONS IN SRI LANKA

M. Munasinghe

*Chairman, National Computer Policy Committee & Senior Energy
Advisor to the President,
No. 10, De Fonseka Place, Colombo 4.*

The information revolution, which has been compared in terms of its likely impact on contemporary society to the industrial revolution of the last century has been underway for the past quarter century in the industrialized countries. This process has gathered momentum during the past few years, largely due to the dramatic fall in the cost of computer equipment as a result of advances in solid state technology and the mass production of micro-electronic devices. Further reductions in costs and improvement in both hardware and software capability are anticipated in the coming decades.

While the uses of computers and information in urbanized commercial and industrial activities are well known from the experience of the Western countries little is known about its likely impact on the rural, agricultural-based lifestyles of the vast majority of Third World citizens. I am confident that the ARTI will lead the way in Sri Lanka to establish a sound and practical approach for bringing the benefits of modern technology to the rural masses.

As a developing country, Sri Lanka must seek to rationally and efficiently allocate scarce financial and manpower resources, so that these new technologies may be harnessed to maximize socio-economic developments. We are very fortunate in this respect, to have strong support for computer development originating from President Jayewardene himself. His initiative and vision of the future are evident in the following extract from a speech made at the University of Sri Jayewardenepura on February 26, 1984.

"The microchip is today a carrier of knowledge. It is my intention to encourage the use of these devices to bring new knowledge to the people of our villages. We can take advantage of the work that has been done so far and lead this nation into the 21st century."

The Natural Resources, Energy and Science Authority (NARESA) set up the National Computer Policy Committee (COMPOL) in November 1982 to formulate policy guidelines and recommend a practical framework and action programme for implementing such policies. The committee's April 1983 report was accepted by the government including its principal recommendation to set up a national level

advisory body on computers, functioning directly under the President. This 10 member Computer and Information Technology Council (CINTEC) will advise the government in formulating, co-ordinating and implementing policy. CINTEC would provide a guiding framework within which Sri Lankan public and private sector institutions in the computer field can develop and interact fruitfully, without unnecessary duplication, wastage of scarce resources and policy conflicts. The emphasis will be on promotion, encouragement and co-ordination, rather than controls and regulation that can stifle initiative in this rapidly progressing field.

INFANCY

The use of computers in Sri Lanka is in its infancy both in terms of the number of systems installed and their level of sophistication. However the establishment of CINTEC is based on the conviction that given the support and guidance of the government, and a commitment of resources that will be very modest in terms of our overall national investment programme the resulting developments in computers and information technology will bring about fundamental improvements in our lifestyles and contribute significantly not only towards material progress but also to sociopolitical development and national cohesiveness. Let us examine below a desirable and practically achievable scenario for computer development in Sri Lanka

In the short-run (2 to 3 years), we may expect progressive gains in productive efficiency of private and especially public sector organisations through the use of computers. Improving the quality of high level decision making where management skills are scarce will help create more jobs at lower levels rather than making workers redundant. Working level operational efficiency and quality of work will also improve. Better application of computers to science and technology will enable the intellectual community to enhance their contribution to national development. The initiation of a major effort in computer education encompassing schools, universities, industry and commerce and the general public is already under way.

ASSETS

The medium term (5 to 10 years) is likely to lead to the development of Sri Lanka as an

Asian Service Centre for computerised international banking and trade. Our assets include the attractive economic policies of the government and stable climate for investment, convenient geographic location, highly educated manpower base and acceptability among all countries in the region.

In this time frame, we also expect the development of more decentralized domestic institutions to meet the needs of administration, finance, production and exchange of goods and services. The use of computers will significantly improve the flexibility of citizens to make use of their skills and talents. This will provide an additional impetus for entrepreneurial activities more in keeping with national character and temperament. Exports of computer software and hardware as well as programmers and analysts provide encouraging prospects. By this time carefully nurtured centres of excellence will be making significant contributions.

TRANSFORMATION

In the long-run towards the turn of the century, we should aim for a systematic transformation of the economy. Sri Lanka can move rapidly from the agricultural to the services oriented stage of economic development, while avoiding some of the worst aspects of the intermediate heavy industrial stage, like environmental pollution, urban slump, etc. We can concentrate on industries that are knowledge intensive and efficient in the age of scarce resources such as capital skilled manpower, land and energy. It will also be possible to avoid investment in industries where future developments world-wide especially in robotics, are likely to erode the advantages of our low cost labour.

The first and second generation of computers built from vacuum tubes and transistors respectively, have already passed us by. The industrialized world is presently well into the third generation of computers characterised by large scale integration (LSI) techniques and is anticipating the move towards the fourth generation that will utilize very large scale integration (VLSI). We, in Sri Lanka, will have about one decade, i.e. in 1985 to 1995 to catch up with these developments and prepare ourselves for the fifth computer generation expected in the mid 1990's. Although opinions vary, enthusiasts and experts claim that these machines will

process knowledge in a quasi-intelligent way, rather than processing data mechanically like existing computers. Since costs will fall unlike in most industrial activities requiring machinery imports, Sri Lanka and other developing countries must seek to develop the manpower base to take advantage of these advances.

EFFORT

CINTEC hopes to play the leading role in co-ordinating and guiding the sustained and systematic national effort necessary to bring about this scenario.

The proposed organization of the computer sector in Sri Lanka is indicated in the attached figure.

CINTEC is expected to create a Central Computer Secretariat (CECSEC) to service its needs and those of the sector. Permanent committees of CINTEC will also be established on: (a) Computer education; (b) Computer Application in Public Sector; and (c) Telecommunications and data transmission; to advise on and promote activities in these areas. These committees will ensure close collaboration with the Minister of Higher Education and Education, as well as other concerned government institutions.

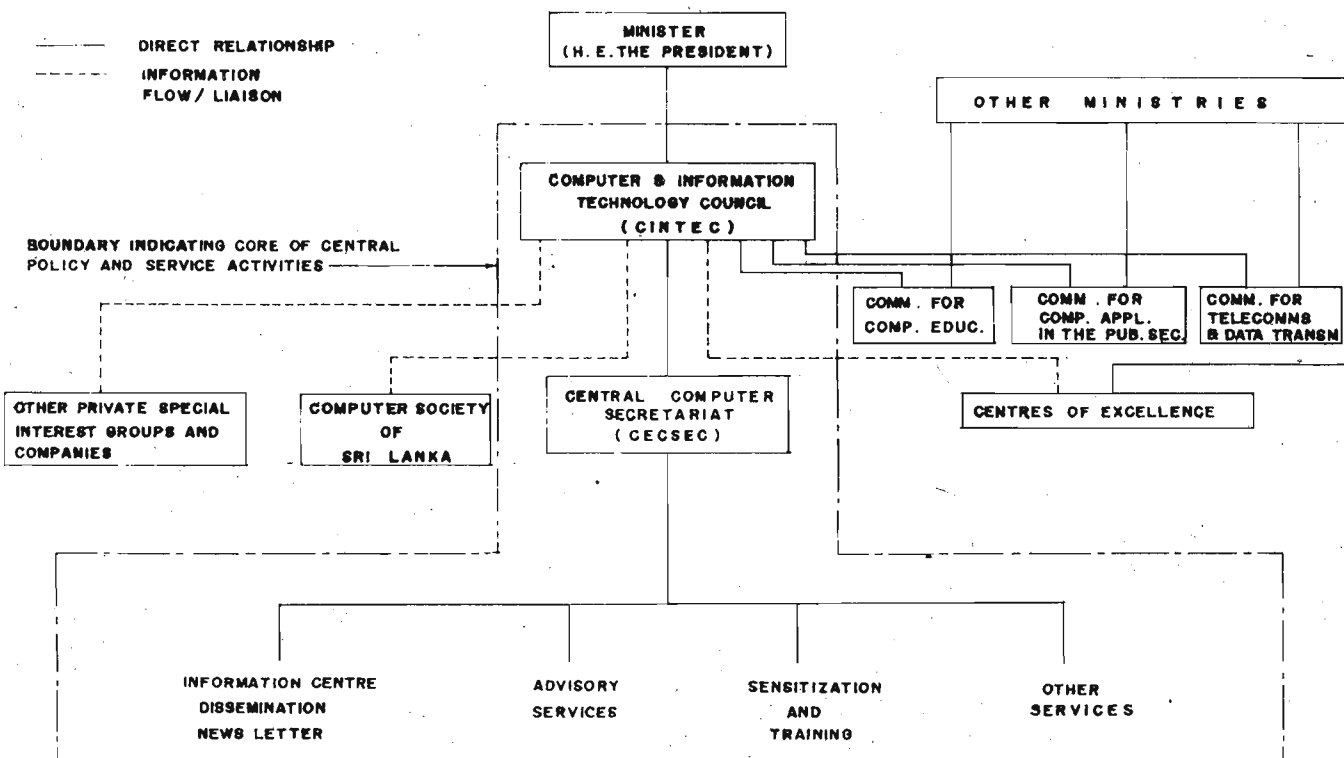
The growth and development of several centres of excellence, identified in the first instance as the Arthur Clarke Centre, the Universities of Colombo, Moratuwa and Peradeniya and the National Institute of Business Management will be supported. CINTEC also hopes to establish channels of communication with and draw on the contributions of the Computer Society of Sri Lanka, and other private special interest groups and companies.

One of the first items on CINTEC's 1984 work programme would be the organizing of several regional/international workshops on the latest applications of computers in science technology and business. Leading foreign and local experts will lecture and demonstrate thus enabling a large number of Sri Lankan participants to obtain valuable up-to-date training and skills in these areas. Specific studies concerning the scope of application and impact of computers in different sectors will be initiated. Other organizations will be encouraged to assist in these efforts.

Sri Lankan society is transforming itself rapidly today, adapting to fast paced changes worldwide. Some teething problems must be expected but there is confidence that our experienced and farsighted leadership will solve the sociopolitical problems. At the same time the professional and technical community must provide the necessary effort to meet the physical and economic challenges. Our country is blessed with a unique and invaluable resource - a highly enlightened and well educated population, especially the youth, which we must harness. The primary impetus for intellectual growth must come from indigenous sources. Foreign technology transfer can and will accelerate this process but a high degree of self-reliance and self-respect is essential.

From ancient times, intellectual development has been a revered goal in Sri Lanka. Over the centuries the nation has displayed the wisdom and good sense to absorb the best elements of knowledge brought from abroad without fear or favour. In the same spirit, Sri Lankans must continue to look outwards with open minds into the futuristic world of computers and modern technology, secure in the basic strengths provided by a rich socio-cultural heritage and our sound contemporary intellectual skills. The future may be uncertain but it is not entirely beyond our control. We are confident that the challenge of modern technology will offer an unique opportunity to speed up development efforts and build a truly united Sri Lanka through the enhanced application of the human intellect.

FIGURE 1. ORGANIZATION OF THE COMPUTER SECTOR IN SRI LANKA



AUTOMATED INFORMATION SYSTEMS AT SLSTIC

N.U. YAPA

*Director/Information, Natural Resources, Energy & Science Authority
of Sri Lanka, 47/5, Maitland Place, Colombo 7.*

The Sri Lanka Scientific and Technical Information Centre (SLSTIC) which is a division of the Natural Resources, Energy and Science Authority of Sri Lanka, acts as the national coordinating centre for scientific information activities. It promotes cooperation among libraries and helps them to develop their resources.

The Information services offered by SLSTIC could be broadly divided into two categories:

- (a) Services that are aimed at exchange of information at the International level.
- (b) Services that are organized for the promotion of cooperation among libraries at the National level.

These two categories of services comply with the two information programmes launched by UNESCO namely, UNISIST and NATIS. The main objective of the UNISIST programme is to establish a mechanism for the global transfer and exchange of scientific information. According to this programme, each country designates a National Scientific Information Centre to serve as the national focal point of the global information network. The National centre is responsible for collection and dissemination of information about scientific resources of the country. Inventories of scientific resources such as scientific literature, scientific manpower, scientific institutions and scientific research projects are prepared by the focal point. SLSTIC/NARESA is actively engaged in the preparation of these inventories.

The second category of information service, i.e. services aimed at promotion of library cooperation at the national level, are organized in keeping with the NATIS objectives. According to NATIS, the national focal point is responsible for the establishment of a national scientific information network. SLSTIC has created the Sri Lanka Scientific and Technical Information Network (SLSTINET) to promote cooperation among scientific libraries. Within SLSTINET a number of subject-oriented sub-systems are created for agriculture, health sciences and renewable energy. Compilation of Union Catalogues, exchange of current periodicals contents pages, cooperative acquisition plans are some of the services organized by SLSTIC to promote library cooperation.

The Information services of SLSTIC were initiated as manual systems. But in January 1983, SLSTIC installed a mini-computer, WANG MVP 2200, with 64K memory and 10MB online storage. Action was taken to convert some of the services, on a priority basis, into automated systems. SLSTIC hence became the first library facility to operate computerized information systems in Sri Lanka.

Any information system, manual or automated, involves 5 major operations: (a) collection (b) organization (c) storage (d) retrieval (e) dissemination. These function could be done manually or mechanically. In a fully automated system, all the operations are performed by using computer and telecommunication techniques. SLSTIC uses computer facilities in some of the operations such as storage and retrieval. Hence, information systems of SLSTIC fall into the category of semi-automated systems.

The operations described above could be organized at two levels: (a) Network operation, when a number of libraries jointly carry out an operation (b) Domestic operation, when the work is confined to one's own library. Network operations are possible if the participating libraries adopt common procedures and standards. A fully automated information system for a library network is possible if all the operations of the system are done using computer and telecommunication capabilities and if, common standards and procedures are adopted by the libraries participating in the network.

Two information systems, one involved with network operations and the other, with domestic operations, are described below to illustrate the organization and performance of computer-assisted information systems of SLSTIC.

(1) Union Catalogue (UNICAST)

Union Catalogue of Scientific and Technical Books in Sri Lanka Libraries (UNICAST) is one of the major information services of SLSTIC. The main objective of the service is to compile a composite catalogue of scientific and technical books available in the libraries in Sri Lanka. About 30 libraries participate in

UNICAST by sending information about books acquired by them to SLSTIC. The Union Catalogue helps to find out which library has a particular book.

Upto 1983, UNICAST was organized as a card catalogue arranged alphabetically by author. It could be used only for searching a book by a known author. In 1983 the UNICAST data base was computerized.

The collection and organization of information for the Union Catalogue is done in 3 stages:

- I. preparation of catalogue entries by the participating libraries according to their own practice. One catalogue card for each book is sent to SLSTIC.
- II. conversion of bibliographic information in the catalogue card into a standardized format at SLSTIC.
- III. appending the Union Catalogue.

Before SLSTIC installed its computer, these operations were done manually. Since libraries adopt different cataloguing and classification practices, it was necessary to convert the bibliographical information received from other libraries into a standard format at SLSTIC. Since this was time consuming and sometimes not possible without examining the book concerned, only the most important elements in the catalogue entry were converted into the standardise formats.

At present, conversion of bibliographic information into a standardised format is done at SLSTIC by recording the information in input sheets. Input sheets are used to enter data into the computer to append the UNICAST database. Hence, the three stages mentioned above could be re-defined, with respect to UNICAST data base, in the following manner:

- I. preparation of catalogue cards by libraries according to their own practice.
- II. preparation of input sheets according to the standard format.
- III. input data into the computer.

Many participating libraries have agreed to carry out stage II at their own libraries. Such libraries now send input sheets, instead of catalogue cards, for the books acquired by them.

Stages II and III could be combined if a participating library follows the same bibliographic format adopted by SLSTIC. This means that all participating libraries are required to follow the same bibliographic format. Attempts are being made at the national level, to bring all the libraries into an agreement of adopting a standard cataloguing practice. This would involve training of staff, conversion of catalogues, purchase of new manuals, equipment, etc.

The input sheets are used by Data-entry operators at SLSTIC to input data to the computer. It would be possible in the future, when participating libraries acquire computers which could be connected to the computer at SLSTIC through telecommunication networks, to carry out stage III at their own libraries.

SLSTIC, at present, faces two limitations with regard to the growth of the UNICAST data base. These limitations could be attributed to the configuration of the WANG MVP 2200 computer. The two limitations are:

1.1 the length of a record is limited to 256 characters. Hence SLSTIC had to design the bibliographic format with a maximum of 256 characters. Two internationally recognized bibliographic formats, UNIMARC and UNISIST formats hence could not be used for UNICAST. In order to overcome this difficulty, SLSTIC decided to simplify the bibliographic format by omitting certain bibliographic data elements. Major simplifications are as follows:

- (a) restriction of entries to monographs.
- (b) restriction of persons responsible for the contents of the books to two persons.
- (c) using same field for both persons and corporate bodies. Type of authority is identified by a tag.
- (d) restriction of the length of the title to 80 characters.
- (e) omission of notes and series areas.

The SLSI data base was created in 1983 to enter information pertaining to the Sri Lanka Science Index. The index entries are input directly to the computer. Entries for a given quarter are sorted for the production of SLSI quarterly bulletin.

In addition to the limitations mentioned under UNICAST, with respect to the SLSI data bases SLSTIC encountered the problem of entering information about documents issued in Sinhala.

WANG MVP 2200 had no facility to define special characters for printing and displaying. This limitation was overcome by formulating a transliterations scheme. Standard transliteration schemes were not helpful as diacritical marks cannot be produced by the SLSTIC's computer. Hence, it was decided to use a special transliteration scheme for storage of data and to insert typed scripts in Sinhala in the print-outs.

Since SLSTIC was the first library facility in Sri Lanka to use computer for information processing and since the computer owned by SLSTIC had certain limitations, the following problems were encountered by SLSTIC.

- (a) Non-availability of software packages - this was envisaged and system analysis and programming work were initiated long before the computer was installed. Hence it was possible for SLSTIC to run the basic programmes soon after the computer was installed.
- (b) Lack of trained personnel - Computer needs personnel at different levels. Data base management, systems analysis, programming and data entry operation are considered as different levels of operations relating to computers. Due to lack of personnel some of these functions had to be combined.
- (c) Lack of facilities for network operations- Networks established using telecommunication capabilities are used to transfer and exchange information between computers. Data stored in one computer could be used by another computer for its own processing. This ensures accuracy and avoids wasteful duplication of effort. Due to the limitation in the computer configuration owned by SLSTIC, it would not be possible to use the network technique effectively.

In a few years from now, it is envisaged that a number of libraries will start automated information systems. Experience and knowledge gained by SLSTIC in the creation and operation

of information systems would be useful to these libraries.

- 1.2 On-line disk storage capacity of UNICAST had to be restricted to 5MB (equivalent to 10,000 records). Hence UNICAST will be organized into a number of files each containing information about 10,000 books. This process would slow-down the retrieval operations as for a retrospective search, each file has to be searched separately.

2. Sri Lanka Science Index

The Sri Lanka Science Index is compiled to index the local output of Scientific Literature. Three document collections are created for this purpose:

- (a) National Scientific reports depository, includes published and unpublished documents relating to Sri Lanka (conference documents, research reports, technical reports are included).
- (b) Sri Lanka Scientific periodicals collection: contains scientific journals published in Sri Lanka.
- (c) Scientific newspaper clippings - collection of scientific and technical articles published in local newspapers.

The scientific documents are indexed using Universal Decimal Classification scheme (4th edition and extension codes). Each article is given a specific and detailed UDC number. The bibliographic depository is prepared according to ISO 690/1975 with minor modifications.

For the manual system the index entries are prepared in cards and the cards for a particular quarterly period are arranged under broad subject headings for the purpose of production of the SLSI quarterly bulletin. When the quarterly bulletin is compiled, the cards are inter-filed in the central index.

INCREASING PRODUCTIVITY USING COMPUTERS

B. RANASINGHE

Data Processing Manager, Ceylon Petroleum Corporation, Kolonnawa.

INTRODUCTION

About a century and a half ago, the western world was faced with a situation which was to change its existence more than anything had done for the previous thousand years. A way of life based essentially on agriculture was gradually replaced by one based on manufacturing industry and many craft-based skills learnt over generations became of little use. The "Industrial Revolution" had arrived.

Today, with the sum total of the world's knowledge being doubled every ten years, we are faced with a new revolution - the "Technological Revolution". But unlike the industrial revolution, the time scale in which we must learn to adapt is considerably shorter. Individuals may find themselves being retrained several times within their working lives and governments are having to re-examine traditional ways of thinking.

But probably the greatest challenge is that faced by the developing countries, whose success depends upon their seizing the opportunities presented by the new technologies to create new wealth for improving the quality of life without losing their traditional values and identity.

The Information Era

In recent years, there has been a tremendous growth in the field of microelectronics, which is a knowledge-based technological development. No individual, no organization and no nation (whether developed or developing) can afford to ignore the impact this is having on industry and on our lives.

Digital computers are forerunners of the microelectronics invasion. The applications of the computer have developed to such an extent that the economic and social organizations of our society and our way of life is being transformed as a result. We are entering into what is called an "information era".

Nature of Today's Change

The "Agricultural Revolution" of the Neolithic period was essentially related to survival. In

the case of the "industrial revolution" changes were essentially related to the mastering of inanimate, permanent sources of power/energy and the extension and replacement of human mechanical dexterity. Current changes due to "Microelectronics revolution" are essentially related to the replacement and extension of human intelligence function, thus constituting a third major technological breakthrough in human history.

According to Alvin Toffler (the author of "Future Shock") mankind is now experiencing a revolution (he calls it the "third wave") which is being propelled by microelectronics. The revolutionary character of present changes is explained by the fact that for the first time in history we have a comprehensive and economic system to handle and process information based on a single type of signal - the electronic bit. This has been made possible by the interrelated developments of; (i) semiconductor technology (particularly silicon integrated circuits); (ii) computers; and (iii) telecommunications.

MICROELECTRONICS REVOLUTION

The invention of the microprocessor and the microcomputer provides the basic components for the "Information Revolution" in a fashion similar to the place of the wheel in the "Industrial Revolution".

Information Technology Trends

Digitalization is making an important contribution to contemporary society's need for information. In the 80's our society is becoming more informational. Telecommunication has an increasing role to play in this changeover. Until recently, the main instrument of telecommunication has been the telephone. We now have new non-telephone services, such as data communication, image and facsimile services. Voices travel through the telephone as analog information, for which analog networks have been the appropriate method of communication. But for data communication, facsimile, and image services, digital systems are superior in many respects, particularly for storage and processing. With the progress in the computer, satellite, and fiber-optics technologies, the move towards the information era is becoming quick.

Even though the phenomenal growth in computers is primarily due to the availability of low-cost microcomputers, not all of the technological advances have been at the low end of the market. A few of the advances that have been made in recent years are: (1) large computers that can rapidly search and manipulate massive data bases; (2) computers that can handle many user inquiries simultaneously; (3) computers that can monitor and control a large automated factory virtually without human intervention; and (4) computers that manage other computers in complex networks.

Microelectronics in Industry

Microelectronic devices have enormous advantages over older generations of mechanical, electromechanical, electric and electronic equipments used in industry. In addition to the well known reduction of cost and increase in performance, there are considerable savings in maintenance, energy and space. Microelectronics alter products and/or manufacturing processes by the introduction of one or more of the following factors:

- (i) Replacement of mechanical components (e.g., watches, clocks, carburettors)
- (ii) Replacement of electromechanical components (e.g., cash registers, typewriters)
- (iii) Replacement of electric and old electronic components (e.g., computers)
- (iv) Improving product design (by CAD)(Computer Aided Design)
- (v) Improving production control (by process controllers)

INCREASING PRODUCTIVITY WITH COMPUTERS

Computers enable achievement of higher productivity through automation. Automation can be characterized as a process by which the relative importance of direct labour costs (office plus manufacturing) diminish. This can be achieved by absolute decrease of direct labour input and or increase in productivity (output hour) which in turn is obtained by withdrawing inefficient elements from the production process. Current computerization processes permit further savings, such as a more rational allocation and use of resources, smaller and tighter stocks (quicker

turnover), automated or semi-automated warehouses and offices, optimization of distribution, close monitoring and higher flexibility of production, saving in space, energy, etc.

Automated or Semi-Automated Factories

Computers allow both high flexibility and automation in manufacturing industries. Even traditionally labour intensive textile industry is being invaded by computers.

The use of self-programming robotic arms for cutting, and computerized systems for design, producing patterns, monitoring quality of fabric and guiding laser beam cutters, are changing the face of the industry. Microprocessors are being used to control knitting heads (instead of the centuries old Jacquard's card), to control ink-injectors with high flexibility to change design and colours; they are used to control sewing patterns and fast stitching. These are part of a growing number of applications - the trend being towards a "total system concept which means the use of computerised techniques to detect flaws, keep track of patterns and orders, monitor the progress of work throughout the plant, automate the matching of patterns and the cutting and sewing".

In addition to the labour saving on the use of microelectronics there are other ones vis-a-vis developing countries. The transition of the industry to the "high technology" category implies greater emphasis on management, software, design (product and processes), quality, planning and marketing which have been traditional advantages of developed countries. The changes at all levels involve an increasingly software and R & D oriented industry. In fact, the links between end-producers, machine manufacturers and electronic/ computer firms have been multiplied in an application oriented joint effort to achieve higher levels of automation.

The combined emphasis on management and related, software, R & D and higher investment per employee has transformed the industry, posing problems for developing countries with export ambitions. The current trend in textiles and clothing suggests that there will be an uneven diffusion of the technology due precisely to the new emphasis. Furthermore the labour cost differentials are eroding as some countries industrialize (Hong Kong, Taiwan, Republic of Korea). In the medium term the competitive edge in textiles and garments will no longer be labour costs but technology. This

is already largely true at the upper end of the market, but will permeate the industry as a whole.

In general, computers help to achieve increased productivity in manufacturing industries through:

- (i) better designed products;
- (ii) improved quality products;
- (iii) increased quantity production;
- (iv) reduced production cost by waste minimization and tighter inventory control;
- (v) higher efficiency and safety of workforce;
- (vi) effective management information systems, etc.

Along with the startling progress in manufacturing productivity, growing automation of the paper work (office automation) is also contributing a lot to overall improvement in industrial productivity.

Office Automation

The marriage of computers and communications together with the drive toward greater productivity has opened the door to a wide variety of innovative technologies. Perhaps the best illustration of this is the automated office. Since the introduction of the telephone and the typewriter in the office early in this century, and the widespread acceptance of copiers in the 1960s and 1970s, there have been no major innovations in the way an office work group performs its task. Today, the marriage of computers and communications is changing not only the way in which office functions are accomplished, but also the structure and organization of the office itself. Within a few years, some businesses may find they do not even need an office as we know it today.

The rapid acceptance of office automation is being forced by two primary factors - (1) the need for greater productivity in the "white collar" segment of the economy; and (2) the diminishing number of people who are interested in clerical positions.

Some of the major components of electronic offices are:

- (i) Small Business Computers;
- (ii) Copiers;
- (iii) Facsimile machines;
- (iv) Word Processors;
- (v) Personal Computers;
- (vi) Telecommunication Links; etc.

Computers have made possible the collection, processing and dissemination of voluminous information very quickly and also economically. Thus it is becoming an important tool for management decision making. Computers can provide following types of information for effective decision making:

- (i) Descriptive (historical) information;
- (ii) Performance (current status) information;
- (iii) Predictive (forecast) information; and
- (iv) Simulated (what if) information.

Industrial organizations are already using computer for many activities, such as:

- (i) market research;
- (ii) product design;
- (iii) process monitoring and control;
- (iv) production planning;
- (v) quality control;
- (vi) materials control;
- (vii) plant layout analysis;
- (viii) financial control;
- (ix) distribution networking; etc.

There are many software packages available in the market which are related with the above mentioned activities:

- (i) Accounts receivable;
- (ii) Accounts payable;
- (iii) General ledger;
- (iv) Inventory control;
- (v) Material requirement planning;
- (vi) Order entry and invoicing;
- (vii) Production planning and control;
- (viii) Payroll;
- (ix) Sales analysis; etc.

There are also many MIS (management information system) and DBMS (data base management system) packages available for larger organizations.

COMPUTERS IN DEVELOPING COUNTRIES

Although computers are becoming very popular even in developing countries, there are still some mixed feelings regarding the wisdom of introducing computers in the underdeveloped world. The major arguments against the introduction of computers in developing countries are: (i) it replaces labour, and therefore will create more unemployment in the labour-surplus economies; (ii) it is a very advanced technology, and hence not suitable

for technology-poor countries; and (iii) it requires large amount of foreign exchange, which is scarce in resource-poor nations.

A Strategy

In many developing countries, the industrialization process is going through a change in emphasis from "import substituting industries" to "export oriented industries". However, the survival of export oriented industries depends solely on being competitive in the international market. If the competition is using computer technology to achieve higher productivity as discussed earlier, can the developing countries ignore computer use? Moreover, even in traditionally labour-intensive textile and garment industries, computerized automation is threatening the 'cheap-labour edge' some developing countries have. What should the developing countries do?

As shown in Table 1, we find noticeable increase in the world-wide use of small-scale computers due to: (i) sharp decrease in cost; (ii) tremendous improvement in functional

capabilities; and (iii) considerable ease of use. In addition, we know that computers can be very useful tools for problem solving and technological development. Thus, properly selected computer applications may have the potential to reduce the north-south gap!

CONCLUSION

Computer technology promises an array of benefits, and the microelectronics age is already well underway. As it progresses during the last two decades of the twentieth century, it will lead to improvements in productivity in factories and offices, changes in the way information is processed, stored, and communicated, and alterations in the content of many jobs. Like all major technological changes, the transition to micro-electronics age will raise difficult political issues, among which the impact on jobs and employment is the most prominent. However, it is obvious that in developing countries, computer technology offers the prospect of enhanced productivity and the chance to vitalize some economic activities.

Y E A R	1960	1970	1973	1973	1983	1988
USA	5,500	65,000	110,000	200,000	400,000	700,000
WESTERN EUROPE	1,500	21,000	55,000	110,000	225,000	450,000
JAPAN	400	6,000	19,000	45,000	70,000	140,000
OTHER COUNTRIES	1,600	18,000	46,000	95,000	205,000	460,000
TOTAL	9,000	110,000	230,000	450,000	900,000	1,750,000
FOR THE WORLD MINICOMPUTERS IN %	--	40	60	70	85	90

(SOURCE: DIEBOLD EUROPE, 1979)

TABLE I - Number of computers in the world

COMPUTERS IN THE PROFESSIONS

Francis Suraweera

Department of Mathematics, University College of Bahrain, Bahrain.

INTRODUCTION

Since its inception, computers have been applied in a great many areas and in diverse fields. The number of applications run into thousands² and many more are added every week. However, the potential of computers as information processing machines has not yet been fully realized. The aim of this paper is to present some novel applications/uses of computers in a few selected professions. The Webster's Dictionary defines a profession as follows⁷:

- (a) a vocation or occupation requiring advanced training in some liberal art or science, and usually involving mental rather than manual work, as teaching, engineering, writing, etc.; especially, medicine, law, or theology (formerly called the learned professions).
- (b) the collective body of persons engaged in or practicing a particular calling or vocation.

According to the above definition, quite a number of today's employments would be regarded as professions. But can we call academics, research scientists, actuarists, etc., professionals? In a certain sense, they are. Nevertheless, from a purely traditional view point, there are many who would disagree with the above statement. Therefore, in what follows, we shall limit our discussions to the following professions only: accounting, engineering, medicine, law, and teaching.

Computers and Accounting:

It is beleived that the years between 1958 and 1963 saw the beginning of business computing throughout the world⁴. Since then the majority of the computers installed in offices are working on payroll, routine statistics and accounting. The benefits accrued are timely and accurate information for managerial decision making. The other benefit, of course, is the reduction of clerical duties. Several software houses and computer vendors have written basic accounting packages and their use has become wide-spread. Recently, a few organizations have developed their own computerized financial and management accounting informations systems. These systems extend beyond the basic accounting packages and are, essentially, specialized forms of management information systems (MIS).

Computers and Engineering:

It is said that the initial applications of computer in any area or discipline is to perform specific computations, or to carry out well-defined processes. Consequently, present day engineers are able to calculate in much more detail than has hitherto been possible, in the design stage. Also, it has been suggested that once the tedium of calculations is delegated to the computer, engineers could use their skills more creatively. A computer technique which is coming to the fore is computer-aided design. Here, the computer is used to design various structures ranging from bridges to super jet planes, computers included. A few typical uses of computers in some engineering disciplines are given in Table 1.

TABLE 1. Some Computer Applications in Engineering

Discipline	Applications/Uses
Chemical engineering	Plant simulation; process control
Civil engineering	Structural analysis; project planning, scheduling and control
Electrical engineering	Design of motors, electrical circuits
Electronic engineering	Design of integrated circuits
Industrial engineering	Management techniques
Mechanical engineering	Design of gears, springs and other machine parts
Production engineering	Process optimisation

Under each of these disciplines, there are a number of subordinate branches which are themselves gaining prominence, in their own way. One such area is process control. This is a real-time computer application in industrial plants and processes. In these situations, computers are being used for the automatic control of an actual industrial or scientific process. A process control computer performs the following important functions:

- (i) control complex or high-speed processes;
- (ii) monitor dangerous operations to ensure safety;
- (iii) maintain product quality;
- (iv) maximise the output;
- (v) aid the operators by simplifying the presentations of information.

Examples of this type of computer application abound: steel mills, nuclear reactions, electric power industries, petroleum and chemical processes are typical.

Computers and Medicine:

The use of computers in medical research is well established throughout the world. Vast amounts of experimental data concerning patients could be analysed by the computer to find the probable causes of an unknown disease, or the effectiveness of a certain drug against a particular disease⁵, in a matter of seconds! In the more advanced countries, computers are assisting the physicians by presenting them patient history, results of laboratory tests, treatment information and the like. In some areas of medicine, the computer is used in the activity of diagnosing diseases and the success rate is incredible. The skill demonstrated by the computer in the diagnosis is equal to or better than the best physician in that area⁹. Patient and resources allocation by computer is becoming commonplace. Quite recently the Science Digest of Voice of America reported a revolutionary development of computer application in medical technology - the use of computer assisted cartography - in producing a three dimensional X-ray image of any part of the human body. One of the direct applications of this technique is the detection of cancerous tumors thereby reducing the number of costly exploratory surgery cases. The above technique has saved a great deal of surgeons' time as well as millions of dollars. It has also been reported that the computer is used to monitor patients' conditions in the intensive care unit after complicated surgery while its use in the blood and organ matching in contributing significantly to transplant successes¹.

Computers and the Legal Profession:

In legal work computers could be used in searching and retrieving information such as statutes, precedents, and judgements. A recent issue of the Law Reporter noted the following:

It is difficult to predict when every lawyer will have at his desk a computer terminal or other microprocessing equipment. But, it would provide him with a facility for instant recall of all written legal sources that he would not have matched even on the day of his final examinations. There is no doubt that there is a clear prospect of computer hardware for all⁶.

It is a well known fact that trial courts are way behind their schedules. Consequently, a great many people are inconvenienced, for instance, those who cannot pay for their bail. The computer could be used with advantage to schedule magistrates, attorneys and select jurors^{3,8}. In crime detection, computers have come to the aid of law-enforcing officers by identifying sets of finger prints and searching large data bases for identification of criminals.

Computers in the Teaching Profession:

Besides their ability for record keeping functions, computers also have instructional applications in education. One of the early applications in this area is the 'drill and practice'. Although, many of the drill and practice exercises have used examples from Mathematics, its use is not limited to Mathematics alone. It has been used in diverse areas, for instance, acquiring skills in reading. Another educational technique which is gaining respectability is computer assisted instruction (CAI). Essentially, CAI works as follows: a unit of information is presented to the participant through the terminal (often a visual display unit). Following this, a question to be answered or a statement to be completed is given. The participant responds to this stimulus. Then the computer evaluates the response and informs the participant whether it is correct or not. If the response is wrong, the participant may also be told why. Next, the second unit of information is presented, and the above process is repeated until the whole lesson is finished. At the end, the computer may give a summary of the participant's performance.

Scheduling of classrooms and assigning of groups of students to tutors by computer are becoming commonplace. At a more higher level, computers have been used in the "tutorial mode". In these situations, the computer is doing the job of a tutor, i.e. teaching. One of the advantages of this technique is that the students can repeat those parts of the course which were troublesome and do this at his or her own pace.

CONCLUDING REMARKS

In the preceding paragraphs we have attempted to highlight some of the areas and applications of computer in the professions. However, the list of examples presented is by no means exhaustive. In libraries, for instance, computerized circulation and

retrieval systems are commonplace; computers are increasingly being used in printing and publishing. They have also been used in diverse fields such as literature, archaeology, leisure activity (chess, checkers) etc. With costs of the machines dropping quickly, some industry watchers even predict that by 1990 small computers will become as common as automobiles. These will be used for financial, educational, and informational purposes. By then there is no doubt that there is a clear prospect of computer hardware for all.

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