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MAN/COMPUTER COMMUNICATIONS IN THE 80's

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ABSTRACT

The report deals with the main trends of man-computer communication, the devices used in man-computer interaction and the problems of man-computer interface including language and dialogue. It examines office automation as a special challenge for the 80's.

АННОТАЦИЯ

Статья занимается важнейшими направлениями развития коммуникации "человек-ЭВМ", средствами, используемыми в взаимной связи человека с ЭВМ, а также проблемами интерфейса "человек-ЭВМ" включая сюда проблемы языков и диалогов. Статья изучает вопрос автоматизации контор, как одно из специальных возможных направлений для 80-ых годов.

KIVONAT

A riport az ember-számitógép kapcsolat fejlődési irányzatait tekinti át, beleértve az alkalmazott berendezéseiket, az ember-számitógép interfész nyelvi- és dialógus problémáit. Ezután az irodák automatizálásával, mint a 80-as évek egy különleges "kihivásával" foglalkozik.

MAN/COMPUTER COMMUNICATIONS IN THE 80's

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The report deals with the main trends of man-computer communication, the devices used in man-computer interaction and the problems of man-computer interface including language and dialogue. It examines office automation as a special challenge for the '80s.

INTRODUCTION

Most computer users agree, that the primary problem encountered today, when using computers, is the complexity of the man/computer interface (MCI) [1]. The computer industry is beginning to realise the need to change from technology-oriented criteria to criteria based upon concepts of matching the expectations, needs and satisfactions of the user. Certainly as far as man/computer communication (MCC) or with other words, man/computer interaction (MCI) is concerned, the orientation must be to give priority to the user in the triad of people-jobs-tools or user-task-technology.

In attempting to review the state of the art in this field, we cannot limit consideration to the technical aspects of how to improve communication. The nature of the subject itself compels us to consider also the human implications and wider issues of potential growths in MCC. The field is so wide that there must be restrictions in both breadth and depth of coverage. We shall not consider at all the areas of interactive computer graphics, computer-aided design, and computer-aided instruction or learning; nor shall we consider applications as such e.g. business computing or process control.
MCI is now generally accepted to refer to direct, close coupled, computer usage by users with a job to do, whether their primary work is in computing (e.g. writing new applications programs or designing program systems) or is in a non computing field (e.g. banking or piloting).

It is evident, then, that the interface must be any *hardware and software feature* with which any human may have to interact during MCI. So the interface comprises not only obvious hardware elements affecting an operator but also such aspects as good documentation to assist with maintenance and fault finding. It is useful to consider separately the hardware interface and the software interface. *The hardware interface* comprises the displays, controls, terminals, consoles and similar equipment having a fixed physical form. *The software interface* comprises those parts of the man-computer communication medium which are not hardware, are often more transitory and are usually variable by program control: for example, the logical structure of content and procedures, and the format, layout, verbosity, etc. of sequences of man-machine messages. By definition we are not concerned with the system aspects of the programming language in use. The subject here is the grammar, syntax and other language aspects of the communication process between man and machine during the actual running of programs. [2]

MAJOR FACTORS IN MAN/COMPUTER INTERACTION

The prospect of achieving so good a match in the communication between human and computer that they could become interdependent in *"man/computer symbiosis"*. Man/computer interaction consists of two sophisticated "computers" with very limited communication links between them. The mismatch at present between the input and output characteristics of man and computer (related to man) is evident (Fig. 1).
The general asymmetry in communication mode and the speed between man and computer is illustrated by Fig. 2. It demonstrates clearly the current *asymmetry* in information-flow - man to computer is weak, slow in data rate, inaccurate and unnatural - computer to man is strong, fast, precise and well-matched to our data-input system. Text preparation, colour graphics and speech synthesis are low-cost technologies; handwriting, pictures and speech as computer inputs are still research projects rather than technologies. The *structure* of man-computer interaction is represented by the *synoptic view* in Figure 3. The framework is simple but the contents are complex. This view is obviously derived from the ergonomics workstation analysis concept; for simplicity workspace issues are included under the heading of environment. This synopsis may help to link together the many diverse topics which may need to be considered if the man-computer interaction is to be succesful in any particular application being developed.
The *framework* is elaborated to a first level of detail in Figure 4. This could even be used as a kind of checklist, but it must be remembered that most of the factors are much more complex and detailed than this simple list might suggest. The first five areas, from *human performance to environment,* are the factors which must be fully considered in any application. The last two parts draw attention, by examples, to the fact that each specific application will have its own particular *ergonomics issues* to be considered, and that there are quite a number of special problems which

Man-central processor	*Computer-central processor*
Storage - about 10^8 to 10^{12} "chunks" - associative - errors of detail	Storage - about 10^6 to 10^{10} bits - literal - depends on file structure
Slow - about 5 to 50 bits/sec	Very fast - up to 10^8 bits/sec
Much preprocessing, e.g. 10^8 eye receptors into 10^6 optic nerves	Accurate and excellent calculator
Adaptive and heuristic	Depends upon skill of system designers and programmers
Self-reprogrammable	
Input	*Output*
Multi-channel	Only visual at present
Very flexible	Limited speech mode is developing
Slow	Can be fast
Wide dynamic range (e.g. in intensity 10^6 to 10^9)	
Output	*Input*
Multi-channel	Only manual at present
Multi-axis	Limited hearing mode is developing
Slow	Can be fast
Very flexible	Engineering constraints limit flexibility

Figure 1. Comparison of man/computer central processing, input and output [2]

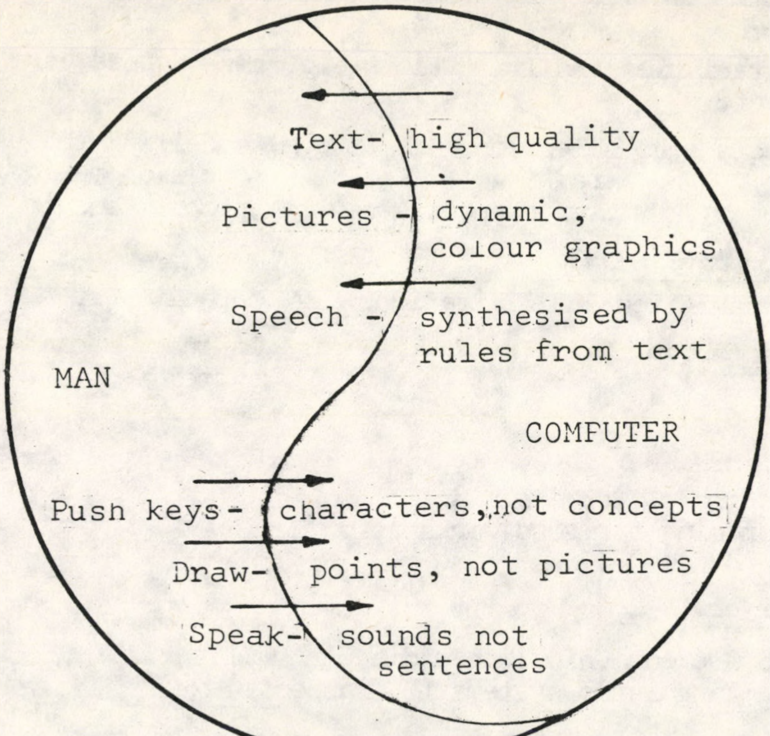


Figure 2. The current state of man/computer communication [3]

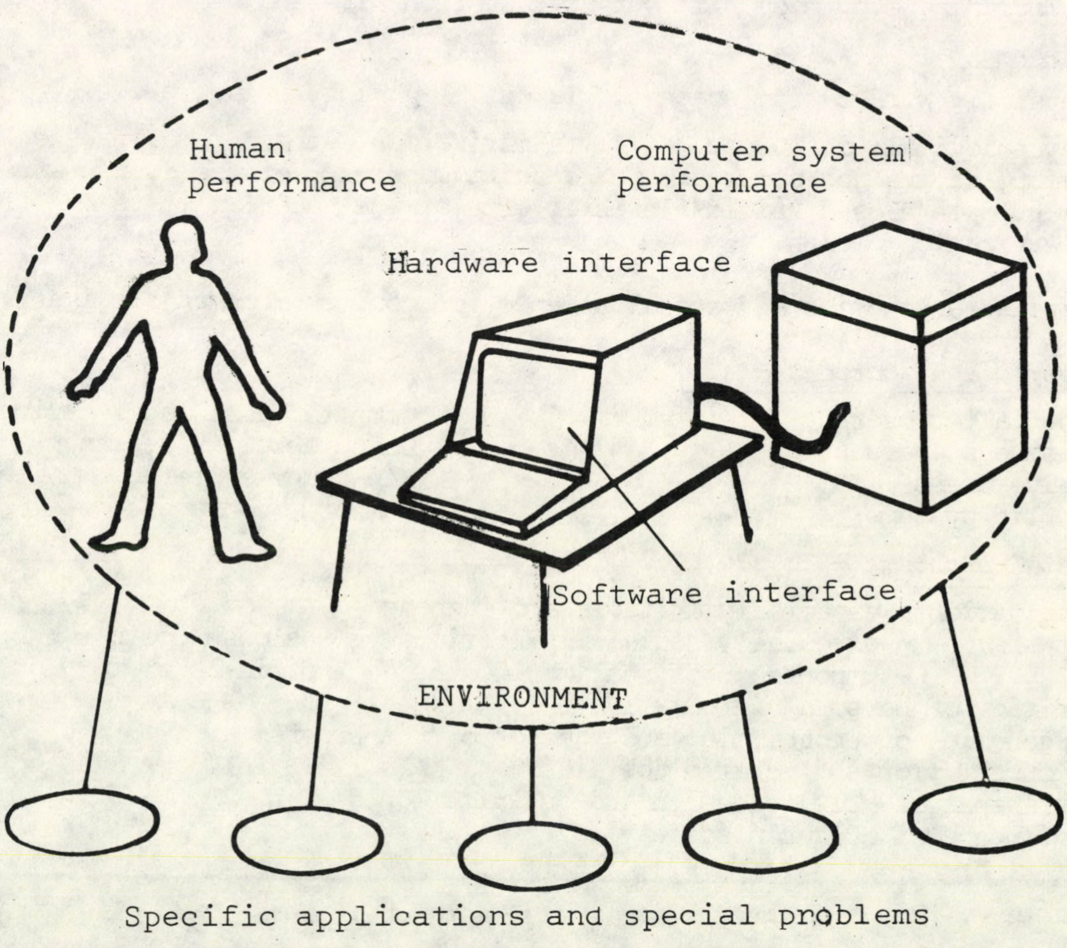


Figure 3. A synoptic view of man-computer interaction [2]

Human performance

Basic characteristics and limitations e.g. size, speed, skills, errors, flexibility etc.

Special aspects e.g. selection / training / user support — e.g. modelling the user / decision-making / problem-solving

Computer system performance

Basic characteristics and limitations e.g. capacity, speed, reliability

Special aspects for MCI — e.g. language facilities / system response time / security

Hardware interface

Displays, controls, terminals and consoles
Applied ergonomics for good workstation design
Human need and new devices

Software interface

The non-hardware communication media
Language and linguistic systems (MCI aspects)

Information organization
e.g. logical structure of content and procedures
e.g. message structure and verbosity, display format and layout (including e.g. microfilm output, questionnaire and other input forms)

Environment

Physical: workstation space and layout, lighting, noise, etc.

Psychological: influence (e.g. via motivation, strain, etc.)of the working group, of the job structure (e.g. shift working), of the system structure (e.g. open/closed, rigid/flexible, etc) of the social climate and of the organization design.

Applied ergonomics and social science for good environment design

Specific applications - e.g.

Specialist users	Computer assisted learning
Business users	Computer aided design
Naive users	Man-computer telecommunications
Public systems	Computer conferencing

Special problems - e. g.

Evaluation - especially criteria and methods
- especially social implications versus cash costs
- importance of real world studies (not in laboratory only)

Privacy of personal information
Ergonomics of programming and the job of the programmer
Dodumentation and related job aids
Influence of MCI job design and organization design
Influence of MCI upon society

Figure 4. Major factors in a man-computer interaction (MCI) [2]

raise general issues and need general study, perhaps by combined research teams.

Although the topics are listed separately in this table, in fact the variour factors in the first five areas will *interact* to varying degrees in any particular MCI situation.

One of many important issues about *human performance* in relation to MCI is *memory*. How does it function and what are its necessary cues in relation to the longer term storage and retrieval of reference material? What is meant here is not the esoteric psychological research on memory nor the specialized computer programming work on filing structures nor the librarian/information specialist's approach, although probably some proportion of their understanding may help towards the answer. If you go into the offices of many people, you will find various piles of papers, reports and so on; but it is a constructive clutter, a creative chaos. Ask the user of the office for something borrowed from you three months' ago, and he will say "Oh yes, it's that yellow paper with the peculiar arrow symbol on the top, isn't it?" and he will find it in one of his piles of papers within a few seconds. Now computer files at present are not structured and represented to the user at all like this. The stored papers, letters, memoranda and reports all re-appear on the screen in a uniform white-on-black or the equivalent, and will certainly require a longer time to search through. What we really do not know is the extent of the loss and consequential cost, and how to compensate for it. Another important aspect of human performance is *variability*. Between different types of user with different ability, the variability in performance is very large For example, there was a range of 2:1 in speed and 10:1 in errors between different operators in well-practised team tasks [5], arange of up to 15:1 difference in the completion times and interaction times for-man-computer problem solving tasks [6]. This enormous variability must be fully recognized and allowed for in any development of MCI systems. On the other hand, there is also a very real need for studies relevant to practical everyday problems. For example, poor *keyboard* layout and positioning can adversely affect the posture and cause severe discomfort and complaints of fatigue when used for a full working day [7]. This type of problem today a growing emphasis on "the quality of working life" which will rightly force attention to such poor hardware designs.

DEVICES OF MAN/COMPUTER INTERFACE

With regard to the human, vision, audition, touch, taste, smell and kinaesthesis are the basic *sensory modalities* through which information can be received. Perception is the term for organised interpretation of the received information, upon the basis of which (linked as necessary with any stored information in memory) decisions may be taken if appropriate. The communication of decisions will be organised into action or motor output, which will be transmitted via touch, movement and speech.

Information is transmitted from computers via display devices (VDU). Information is transmitted into computers via controls on input devices. A complete combination of displays and controls built into an appropriate workstation for human interaction with a computer is a terminal; a well-designed VDU may prove to be an adequate terminal but is not necessarily so, though often given that name.

Many different commercial versions of *alphanumeric displays* have become available in the last three years, giving a very wide range of choice at competitive prices. The range of quality is equally wide: from typewriter-like units still with upper-case characters only, 64 per line, to the latest "Teletype"and similar devices with lower-case also, much quieter, and 80 or 132 characters per line; and from "*dumb*" VDUs again with upper-case characters only using a 5 x 7 dot matrix, to better designs not all that expensive with lower-case using 9 x 7 matrix in 11 x 9 field and with substantial editing facilities included.

There are a number of *physical aspects* to displays (both alphanumeric and graphics) which affect perception and thus may impact performance - e.g. flicker, luminance, CRT scanning patterns, contrast. Most of these factors are fairly well understood, and acceptable/desirable parameter values can be identified in most cases. Similarly, the effect of various character fonts on visibility and readability is also well known. Although one's choices may be restricted, it is nonetheless important to ensure that one's particulat system is within preferred limits, and there are a number of excellent reviews which can be consulted (e.g.[8] [9] [10]).
The microprocessor has been heralded as one of the most significant developments in recent years. Certainly it has led to a substantial reduction in the cost and a substantial increase in the sophistication of *interactive graphics terminals*. Although with the advent of simple graph plotting facilities on alphanumeric displays the demand for full graphics facilities is limited to the special applications.
The enormous power of visual communication has long been recognised in the various design disciplines. Indeed, many designers regard visual communication as their prime purpose. It is little wonder, therefore, that computer aids for designers have reflected this awareness through their emphasis, and even reliance on interactive graphics terminals and techniques. Thus the designer of road layouts can have the capability of viewing on his display what a driver would see travelling along the various roads. This simulation can be remarkably sophisticated with hidden lines and surfaces suitably obscured, proper perpective maintained and even texture, shadows and highlights to ensure a high degree of realism. The real power of such a system is the ease with which the designer can modify a junction, for example, to ensure adequate visibility without costly models or even more costly mistakes. The designer using such aids is able to interact graphically with what is primarily a visual problem and the benefits are striking and obvious.

Three *basic types of graphical displays* are currently available: the standard cathode ray tube (CRT) with *random and raster (TV-like) deflections and the storage devices* [11]. The advantages of the former ones (aside from the long experience with it) lie mainly in its selective write/erase capability. Its disadvantage is primarily that the image must constantly be refreshed, and this requires additional local storage buffering and refresh capability or else direct stimulation from the central computer processor. For a review of the display device considerations, see e.g. [12] [13].

The CRT has been a standard electronic display for many years. However, it has a number of limitations and drawbacks in terms of size, weight, fragility, high voltage and the instability of the image. A number of *new display technologies* have been developed in recent years but only three offer any real alternative to the CRT in the near future. These are the *Liquid Crystal Display* (LCD), the *Light Emitting Diode matrix* (LCD) and the *Plasma Matrix Display* (PMD). They are all used to varying extents and with varying success in watches, calculators, instruments and so on. In the graphics display market, the CRT will dominate for some time; however, some LED and PMD graphic displays are available. The self-scan plasma display using a 5 x 7 dot matrix is widely used in data processing equipment for applications which require a display larger than a few digits (for which LEDs are widely used) but smaller than a typical CRT display.

The *flat panel display* offers some potential ergonomic advantages in addition to image stability, LCD displays depend on ambient illumination for the legibility. As the ambient illumination increases, so the LCD becomes easier to read unlike the other display technologies. All the flat panel displays are potentially much smaller and lighter than CRTs although the additional circuitry required may be substantial. They do, however, allow much greater flexibility than the CRT in positioning and may therefore be used in workstations where cumbersome CRTs cause problems. Flat panel displays are rapidly catching up on CRTs in terms of cost and resolution and all three are likely to be used increas-

ingly in the near future. Their main potential in the office is not so much in producing high quality display which overcame the limitations of CRTs but rather in their potential as cheap flexible displays for workstations.
As *input devices* in addition to the omnipresent *keyboard* there are quite a number of other devices which have been developed primarily for graphics or other special applications [14].
The *light pen* is probably the most familiar of the graphic input devices. It is used in conjunction with a keyboard or a menu on the display screen to identiy the displayed item to be processed or actioned. In office systems, light pens can be used either to indicate choices, probably in a menu or tree structure, or to manipulate data directly on the screen; e.g. move pieces of text or displayed data [15].

Digitising tablets are used for inputting engineering drawings into computer systems, although small tablets are also used for entering other types of data. The position of a cursor on the tablet is detected by electronic, electromechanical or even sonic means. Small tablets may use a pen-like device for the user to point and in some versions a modified pen have may be used over a sheet of paper or suitable overlay. Overlays have been developed for use with stock control, for example, where the pictorial representation on the tablet provides additional cues for the user to identify products.

Touch panels are similar in nature but identify the position of the user's finger rather than a cursor or stylus. Identifying items on the screen becomes a straightforward natural process although, of course, the additional surface may cause reflections and can be obscured by finger marks.
Joysticks and trackerballs may be used to move cursor about the screen in the direction they are moved or rotated. Both are widely used in computer-aided design and military applications. This list does not complete the range of alternatives. For example, there has been considerable work on methods by which to achieve computer reading of human handwritten characters.

It is possible to display a keyboard on the CRT screen itself (*"virtual keyboard"*) and to use a light pen (or a touch panel) to operate the "keys" [15].

The most popular input devices are the *keyboards*. For the standard typewriter and its equivalents, despite many studies, considerable dislike and a plethore of ingeniour alternatives, the *QWERTY layout* has not been displaced by any other showing significant advantages for general typing. Therefore it has become the de facto standard for computer interface keyboards despite its inefficiency. For general reviews on keyboards see [16] [17]. For a review also giving guideliness on the layout of keyboards for national and cultural groups and also for international operation see [18].

There is an enormous number of *special purpose keyboards* with keys representing anything from phrases to graphic figures to whole programs. Here, careful analysis is required and one should become familiar with the many issues underlying choice of such keyboards [9] [19].

Terminals range from the standard "teletype" to the "intelligent" VDU, and from the cash/dispenser in many banks to the concept of the multi-function workstation for the automated office of the future.

Traditional terminals are those historic electromechanical/electronic keyboard devices that, when attached to a computer system, have evolved to make up the majority of terminals as we currently know them. This class of terminal can be called *"general purpose"*. Most casual user solutions will be met by utilising this class of terminal. The reasons are manifold: inexpensive, flexible, commonly used and general purpose are just some. We will use software to provide ease-of-use. If the software is wrong or the user's requirements change, we "simply" change the software.

Functionally-oriented terminals are relatively new devices whose basic design is oriented towards a specific function. This class can be called *"special purpose"*. (e.g. word processors, graphic terminals, handwritten data capture, cash dispenser etc.)

The importance of written *documents* and *"hard-copy"* output from computers is well recognised. Since the early days of computing the standard device to give a permanent record of computer results have been the *line printer*. It gives excellent horizontal alignment, has an efficient paper feed for continous feed stationery. It can be adjusted to give different line spacings and can be changed to accommodate various languages. However, its repertoire does not include an acceptable range of founts suitable for printing or variable spacing between letters. The fixed width of paper and inflexible letter spacing limits its usefulness, but the use of multipart sets and specially prepared stationery, such as cheques and forms, has made it a very acceptable method of output for a variety of tasks. While very useful, the typical line printer output consisting of a thick wad of paper is a somewhat limited form of MCC. As human users have wanted to develop more interaction, so the usage of on-line teletype machines has developed.

Developments have included the use of the IBM detachable *"golf ball"* head, allowing several alternative founts and alphabets to be employed, although not conveniently on the same line or even page. Other developments have been *"silent" printers* working on heat sensitive paper, or with various forms of *"ink jets"*, where the ink is sprayed onto the paper as a jet in the form of the desired letter. Whiles the former involves constly special paper, the latter appears promising, particularly as it may enable coloured ink to be introduced and perhaps mixed to produce multi-tone printing. In yet another version, each letter is produced by a dot matrix, normally 7 x 9, the selection of dots being done electronically. The quality, although acceptable, is not as good as from the former ones.

Diagrams or drawings are essential in most documents. Various types of *graph plotter* have been produced. Speed improved as systems were developed to move simultaneously along both axes or the paper was moved in the y direction at the same time as the pen moved in the x direction. The most successfull and widely used devices were made by Calcomp. The first plotters had pens which made a single dot at the point of contact and which could draw lines properly only parallel to the axes. *"Incremental" plotters,* operating by drawing short sections of line in a specified direction, have improved performance in directions at an angle to the axes. However, there can still be signs of roughness in drawings produced by mechanically driven plotters, and they demand adjustment from time to time. Pens with more than one colour can be fitted and so varying coloured lines produced. The most recent development in graphic output has been made using laser technology.

An alternative method of producing drawings is to display them on a cathode ray tube or plasma screen and to *photograph* the result. Accuracy here depends on the precision of representation on the screen and on the faithfulness of reproduction possible with the film used [1].
The use of *film and fiche* (film arranged conviently to facilitate search and retrieval in, for example, a library) is growing rapidly for archive storage and similar library uses. Computer output can be written directly to film or fiche and is likewise a developing usage. Large amounts of data can be stored in a very compact way. Storage of, for example, a complete book can be done on a few frames the size of a normal photographic print. It is convenient to archive material in this way, particularly as library shelf space is becoming short in most of our major libraries. The standard method is to reduce the material by a factor of 24x. This results in a *"microfilm"* of the material. A further reduction is possible onto *"ultrafilm"*. In order to reference this material, each page or section can be distinguished on the film and labelled. Apparatus exists for accessing the appropriate section using the labelling system as an index. Microfilm arranged in such a way as to facilitate this search procedure is called *"microfiche"*.

Using graphic techniques of output from a computer it is possible to write output on microfilm or microfiche. The computer can also be used to access microfiche using an appropriate search program and to read what is written into the computer. The process of reading, however, is considerably slower than that of writing and thus, at present, *Computer Output on Microfilm* (COM) techniques are not comparable in speed or cost with magnetic devices, and so not suitable for intermediate storage. Nevertheless, if microfiche is a suitable medium for long term storage of computer output in a specific application, it is possible to use it effectively. Potential applications include working drawings for production engineering and text storage where this is voluminous.

We are in the middle of a major technical revolution in the printing industry, changing from the "hot metal" techniques which have been standard for many years in the printing of books, journals, magazines and newspapers. The complete *printing process* begins with the preparation of a version of the manuscript or typescript on a medium suitable for driving the typesetting machinery. After initial preparation as a "compositor's tape", the tape is edited. This is not only to remove errors and insert corrections from the originator or the editor, but also to introduce pagination and page layout, at least in outline. The second edited tape produced a "page proof" for correction. It is still usually necessary to produce this correct, so far as possible, and then to "impose" any drawings or pictures on the gaps left on the page, normally by cutting and pasting material, the final result being re-photographed before preparing the film from which mats or etched plates are made.

The next stage of development is to link computer aided photosetting with computer aided preparation of the original document, i.e. text processing [20].

It can be argued that *speech* is a more fundamental form of human communication than any other medium [21] [22].
There has been considerable progress in the *machine synthesis of speech* over the last six or seven years. The use of speech output has spread much more widely, a variety of very inexpensive devices for synthesising speech from low bit-rate representations have become available(e.g. [23])and several practical schemes for converting ordinarily spelled English text to the parameters required to drive such synthesisers have been published. It is possible to buy a synthesiser capable of producing almost unrestricted English speech for a few hundred dollars so that even hobby computers and small business systems may use speech output. Speech output is now so compact and inexpensive that a number of calculator firms have produced hand-held calculators that supplement the displayed output with spoken output.
Three *main techniques* are presently being used to synthesize human speech [23]. They are formant synthesis, linear-predictive coding (LPC), and waveform digitization with compression. With these techniques, vocal utterances, or phonemes, can be linked by linguistic rules to generate words. With vocabularies of over 200 words, these rules and the electronic overhead from their implementation become cost-effective. For smaller vocabularies, however, full-word generation is generally most economical. As memory costs are reduced, the size of the vocabulary for this tradeoff will increase.
Formant synthesis is a technique for modeling the natural resonances of the vocal tract. For recognizable speech, at least three formants should be used for each voice utterance. With formant synthesis, voiced sounds are generated from an impulse source that is modulated in amplitude to control intensity. The resulting signal is passed through two levels of filtering. The first is a time-varying filter composed of cascaded resonators that correspond to the source-spectrum and mouth-radiation characteristics of the speech waveform.
Unvoiced sounds are generated as white noise is passed through a variable-pole-zero filter. The second filter used for voiced

sounds can be reused for the unvoiced sounds. The coefficients for these filters are stored in ROM. An approximate number of memory bits required for a second of speech is 400.
Linear-predictive coding is very similar to formant synthesis. Both are based in the fequency domain and both can use similar hardware. A basic difference is that LPC uses previous conditions to determine present filter coefficients. The quality of the synthesis improves as the number of coefficients is increased. With ten coefficients, an approximate number of bits per second required for speech is 1.200.
Waveform digitization is the earliest approach taken for speech synthesis, and relies on nothing more than sampling of the waveform in the time domain at twice the highest frequency of interest. However, critical to the use of this technique is data compression, otherwise, memory requirements are prohibitive.
The situation is much less advanced in *speech recognition* by machine. Major unsolved problems still exist at all levels of the speech-input-response-generation task solution. If we seperate speech recognition into three levels, i.e. isolated word recognition, speech but with enlarged delays between words, and continuous speech recognition, we can say that quite good success is being achieved with the first; the second can be handled less well, and is not really very useful; the third is not even within sight. Voice recognition or input systems are becoming more commonly available. The current drawbacks of cost, accuracy, and size of concurrent vocabulary will be overcome. When this is so, we shall have an exciting and effective solution for many of the man/computer communication problems.

"HIGHER LEVEL" MAN/COMPUTER INTERFACE

Here we are concerned with such aspects as the organization of information for better perception, understanding and remembering, and with the design of dialogue and language for better MCC. These various aspects contributing to the transfer of meaning between man and computer come together at this "higher level" interface.

The primary value of computers is in their programs and data where they act as extensions or amplifiers of a person's memory and reasoning power. The way in which sophisticated, skilled users, working together in an interactive community, rapidly learn to use as building bricks the program segments written by colleagues is a good example of how the computer can amplify memory and reasoning power. In IBM, the attractive phrase *"captured intelligence"* is applied to this growth.

Recently the importance of the software/hardware interface has been recognized [3]. It is certainly attractive to consider the hardware and the software of the computer interfacing with the hardware (anthropometry, physiology) and software (intelligence, cognitive structure) of the man.
There are therefore four *types of link* which need to match:

- The *hardware* of the computer must match the *physical aspects* of the man, e.g. the size, travel and operating pressure of keys must suit the strength and size of the human finger.
- The *hardware* of the computer must also suit the *psyhological characteristics* of the man, e.g. the layout of the keyboard should be easily remembered and not overload the user's shortterm memory.
- The *software* of the computer systems hould match the *physical characteristics* of the man, e.g. the refresh rate of characters on a VDU should be such that the persistence of his retinal image prevents flicker being perceived.
- The *software* of the computer system should also suit the *psychological capabilities* of the user, e.g. the structure of a database should be logical to the user and consistent with his cognitive structure.

There are many layers in the software "continuum". At one end there is *system software* which determines the operating procedures, languages available to the users, etc. and also influences such factors as system response time, character generation, error diagnostics and editing facilities. To many users, particularly infrequent users, these features are outside user control. To this extent they are like most of the hardware, once it is there you cannot change it. This type of software can be regarded as *hard-software* which cannot readily be changed by the naive user. At the other end of the continuum there is the *"application software"* which forms the programs, packages of programs or subroutines available to the user. These the user applies directly to his problems by selecting the appropriate packages and perhaps specifying or programming the links between them. To the user, therefore, these programmable aspects of the system form the *soft-software.* As the user becomes more and more sophisticated, what was the hard-software becomes softer. However, in a successful interactive computer system the user should be able to access all the facilities he requires from his high-level language program without having to know about the hard-software. Thus to the user it is often irrelevant whether a particular feature of the system is a function of the hardware or of the software.

There are two main requirements [24] for a successful *software interface* (see Fig.5).

First, it should fit the *function* it serves in the overall design of the system. This depends on the nature and *purpose* of the system, e.g. stock control, resource allocation or order entry. It also depends on the type of *job* the user is performing. A general purpose software interface seldom suits all users. The interface must therefore be geared to the specific needs of the various tasks which comprise the user's job. For example, clerical, managerial and engineering design jobs involve a range of tasks, some of which are common but many of which are quite different for the types of user. Finally, the function depends on the *interaction mode,* the range of facilities available to the user. These may range from a mode which involves the user primarily in data entry, through menu selection of available displays, to a direct programming mode.

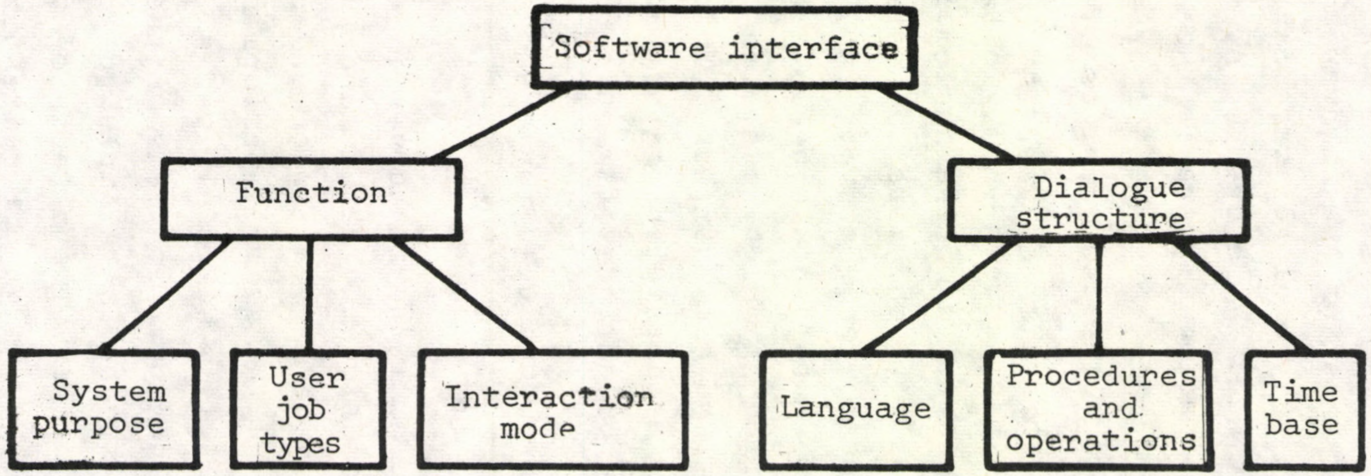


Figure 5. The software interface [24].

Secondly, the *structure* of the interface should be such that it can fulfil its function, suiting the purpose of the system, the user job types and the interaction mode. The *language* through which man and computer communicate can range from a powerful programming language to a simple command language and must be matched to the function. The way in which the language is organized into *procedures and operations* through which the user interacts with the system must again match the function. Finally, it is important that the *time base* of the interaction is appropriate. The function of the interface (the first part, on the left of the diagram) depends upon the specific system being designed. Therefore only the aspects under dialogue structure are discussed further. There are several aspects of the *language* of the communication which are important [24]. These include such factors as the power of language, the size of vocabulary, the richness of expression and precision and the relationship between the man/computer language and natural language. One language problem experienced by the naive user is that computer oriented languages are often of necessity terse, coded and abbreviated. Human language on the other hand is highly redundant and missed items can often be accurately inferred from the context of the communication. Although such coding is usually for the computer's benefit in minimising core store use it can save the user time either in data entry or in waiting for teletype output. Lastly, there is the grammar of the language itself which should be such that unambiguous communications can both be easily constructed and easily interpreted by the user.

Secondly, there is the organization of the language into *procedures and operations* through which the user interacts with the computer. There are procedures concerned with the input of data and information from the computer to the user. There are also procedures which are concerned more with the interactions as a whole than specifically with either input or output.

The third component is the *time base* of the interaction which in many ways pervades the other aspects of the interface and is the factor which determines the relative significance of the other components. The time base includes such factors as the delay of the system in responding to terminal enquiries, the frequency at which the database or input is updated, the speed with which the system can be modified to suit new task needs and the susceptibility of the system to breakdowns and maintenance delays.

Data is not information; information is not knowledge. In each case the transformation is made by a process of organization. This suggests that the method of organising information, to improve MCC at the cognitive interface, is to pre-process and present the data so as to fit better the user's *"internal model"* of the required information structure.

The *formatting of information* can best be considered in the context of displays; the principles apply in general also for inputting the information. The basic requirement is that communication from and to the computer should be organised and structured in a form appropriate to the task and viewpoint of the user.
At least six *factors* may be identified which contribute to good *format design;* these are logical sequencing, spaciousness, relevance, consistency, grouping and simplicity (see Fig 6) [24].

The *sequence* in which information is presented should be logical both in terms of the display itself and in terms of the user's task or other information sources being used.

Spacing and blanks in a display are important, both to emphasise and maintain the logical sequencing or structure and also to aid the indentification and recognition of items of information.

In many situations, information of only "potential" *relevance* should be excluded from the primary display in order to ensure that the essential relevant information can be easily and accuretely indentified and read. The degree to which the user can tolerate highly compressed or even cluttered displays depends on the individual's training and experience, or the task to be performed and on a variety of other factors.

A. Bad format

PART NUMBER FILE SUB-FILE MISC BKTS
SUPPLIER J.BLOGGS & SON, ROTHERHAM
PART 096431X DESCRIPTION LH BRONZE STUD BRACKET
GROUP B CLASS R STATUS NOT YET ALLOCATED
SUB-ACCOUNT 92 BUDGET GROUP 2413
QANTITY UNIT DOZENS DEPRECIATION PERIOD 15 ACTION
DATE OF ADDITION 1/12/75 ADDED BY F.BRIGGS DES 9
DATE LAST AMENDED 14/5/75 AMENDED BY PROC 11 R.SMITH
DATE OF DELETION
COMPONENTS NONE
SUB ASSEMBLIES NONE

B. Better format

Spaciousness

PART NUMBER FILE		MISCELLANEOUS BRACKETS	
PART: 0926431X	LH BRONZE STUD BRACKET		
GROUP: B	BUDGET GROUP:	2413	
CLASS: R	SUB-ACCOUNT	92	
UNITS: DOZENS	DEPRECIATION PERIOD:	15	
ACTION	PRODUCT STATUS:	NOT YET ALLOCATED	
ADDITION DATE:	1 DEC 75	F.BRIGGS DES 9	
LAST AMENDED:	14 MAY 75	R.SMITH PROC 11	
DELETION DATE:	NONE		
MAIN SUPPLIER:	J.BLOGGS & SON, ROTHERHAM		

Sequencing

Grouping

Relevance Simplicity Consistency

Figure 6. Formatting recommendations [24]

The displays or output language formats also require *consistency* both within and between formats. This applies to the various format factors already discussed and also to those still to be discussed, for example grouping and coding. The value of consistency is of course that an unfamiliar or new output can be more readily and accurately interpreted, if it conforms to existing practices in its use of language and structure.

Where there are relationships between items of data and information it can improve the display if relevant items are *grouped* together. There is also evidence that displays of many similar items can be more rapidly and accurately searched if the items are grouped into manageable "chunks".

All the above factors should be taken into account in designing formats, but the overriding consideration should be to present the appropriate quantity and level of information in the *simplest* way. This does not mean that there is no place for highly detailed complex displays, but if they are necessary they can still be organised and structured and should avoid inessential complexity. This level of detail can also be achieved by providing several simple displays rather than one complex one.

The *coding of information* can often benefit the user in speeding up the communication; it is also especially useful to help discriminate among different classes of information simultaneously present on a display. The main *coding dimensions* are [24]:

At alphanumeric coding the language may be coded or abbreviated so that the words used are shortened. The three main principles in the derivation of codes are copying, association and transformation.

Colour coding plays an important part in everyday life and certain colours can be readily associated with particular messages, e.g. red for danger. About six colours are recommended as the number which can easily be distinguished.

Brightness coding can also be an effective coding dimension and need neither be particularly expensive nor compromise other performance factors. Two or three levels of brightness can easily be distinguished on a VDU and selective brightening of parts of the screen clearly indicates critical or interesting items of information.

Spatial coding, basically the same as formatting, allows particular classes or types of information or the relationships between items of information to be emphasised by their respective positions.

Shaped symbols are useful as an addition to normal alphanumeric characters, particularly if they can easily be associated with the objects they represent. The *size of the character* can also be varied to indicate relative importance or different status (e.g. headings and text). Only two or three different sizes are really acceptable on one display. The shape and size of alphanumeric characters can also be varied to provide more information, and different typefaces can be used to distinguish different classes of data.

Particularly urgent or important information can be distinguished from other parts of a VDU display if the appropriate lines or characters are made to *flash* (typically at 2 - 4Hz). This is extremely attention attracting and can therefore be too obtrusive and disruptive to the user.

Finally, a further method by which information can be structured to represent its organisation more readily to the user is by *partitioning* the display. The screen could be partitioned into *seperate areas* for the following types of information [11]:

Main work area (e.g. 20 lines) - either for text, system-supplied selection menus, or for a transaction record.

Input preparation area (e.g. 1-2 lines) - for generating (and locally editing) the next input to the system.

System facility indicator (e.g. ½ line) - indicating what system facility has been invoked (e.g. editor, compiler) and what the operating level of that facility is (e.g. for editors, the recursion level and tab settings, for compilers, the options and execution mode).

Diagnostic area (e.g. 1 line) - for indicating, when appropriate, what the nature of the condition was that terminated processing in some facility, and also what the user could do to restart.

Fixed response area (e.g. 1-4 lines) - for implementations in which the dialogue is menu-driven or for applications in which a fixed set of inputs/responses area applicable for all activities within the application.

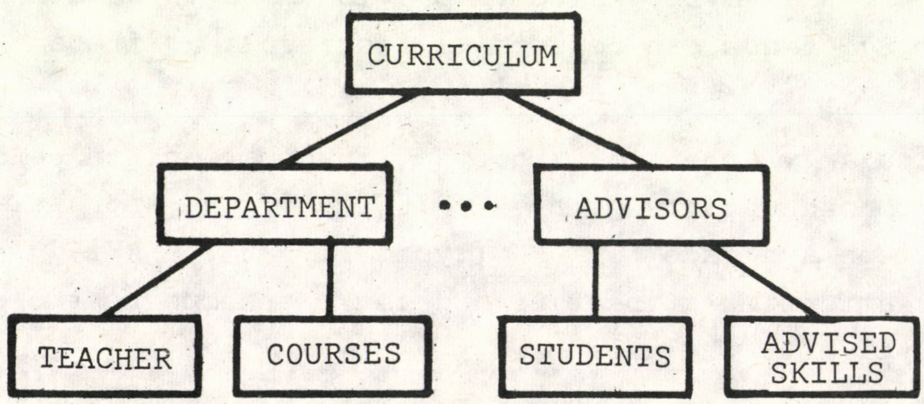


Figure 7. A hierarchical data base [25]

A fundamental problem is how to organise the co-ordinated *storage of and access to the data* so as to enable subsequent retrieval to be both efficient and meaningful. The state of progress in the computer context and MCC appears to be still at the stage of intuitive development of *database storage* and *query systems* (e.g. see [26] [27] [28]).

There are three implications for the design of *information retrieval* systems. First, the *conceptual structure* of the database should conform to the semantic relationships among the data elements. Second, the *language used to interrogate* the database should allow for the direct expression of the different types of relationship. Finally, having the user *fill in some physical form or skeleton* which is consistent with the general type of organisation found in the data may have an advantage over free-form entry.

The *user interface* can be considered as a *logical interface* into a database system [25].

The three popular approaches to *data base access* can be classified as hierarchical, network, and relational. In the *hierarchical approach,* records with some characteristic in common are grouped into sets. For example, a data base for a university curriculum might contain records of information on courses in a department; these records might be grouped into sets by department. The same data base might contain records on information on students; these might be grouped into sets by advisor. A complete structure might be as shown in Figure 7. Here, each "department" record is the owner of a "teacher" set and a "courses" set. The "department" set is in turn owned by the "curriculum" record. If one wanted to access data about a given course (for example statistics) within a given department (for example mathematics), the set belonging to the "curriculum" record would be searched until the "department" record was found. The "course" set belonging to the "department" record would be searched until the "mathematics" record was found. The set belonging to the "mathematics" record would be searched until the "statistics" record was found. The process of following logical paths from owner sets to member sets, and to records within member sets, is called "navigation."

A *network data base* is a generalization of a hierarchical data base. A hierarchical data base is restricted to a single owner for each member set; however, a network data base can have multiple owners for a member, as is shown in Fig.8. Here, the "students" set can be reached through either departments or advisors. In a *relational data base,* the information is stored in the form of "relations, "with each entry in the relation called a "tuple" or record. Our example of a college data base could include the relations shown in Figure 9. To find the name and location of the teacher of statistics, the course-teacher relation is searched to find the "statistics" record from which the teacher name "Lindgren" is obtained. Then the course-location relation is searched to find the "statistics" record from which the location "Science 26" is obtained. The answer from the data base then is "Lindgren, Science 26." obtained from the record value "statistics" held in common.

LANGUAGE AND DIALOGUE

The terms "dialogue" and "language" are tending to be used somewhat flexibly, and with close if not overlapping meanings, as the computer professional world becomes more involved with the issues of MCC. Strictly, *language* is the underlying structure, with its various components and the rules and procedures for linking them, whereas *dialogue* is the interactive usage of a mutually agreed language between the communicators so as to exchange information. The following definition may be a useful starting-point [29]:
A *dialogue* is a set of procedures for the exchange of information, commands and responses to computer based system and its human users through the medium of an interactive device such as a VDU or keyboard/ printer terminal. Within each "dialogue" we might have a number of *"transactions"* (see Fig.10). A transaction is a self-contained exchange with the computer and will compromise one or more input and one or more output messages. (E.g.a Sales Accounting Dialogue might include an Order-Input Transaction, a Credit Note Transaction, a Customer File Update Transaction and so on). In turn, each message will consist of a number of *data items* and various *formatting and control characters.* Figure 11 illustrates how a user, once having signed on, has access to a *transaction handler* which will enable him

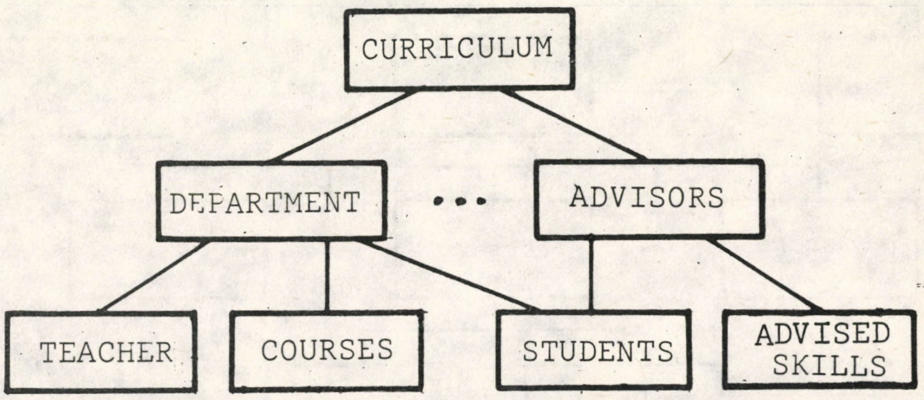


Figure 8. A network data base [25]

COURSE-LOCATION RELATION		OTHER RELATIONS	COURSE-LOCATION RELATION	
COURSE	TEACHER		COURSE	LOCATION
ELECTRONICS	SMITH		CALCULUS	MAIN 101
CALCULUS	JONES		PHYSICS	SCIENCE 202
PHYSICS	COX		STATISTICS	SCIENCE 26
STATISTICS	LINDGREN		ELECTRONICS	SCIENCE 306

Figure 9. Organization of a relational data base [25]

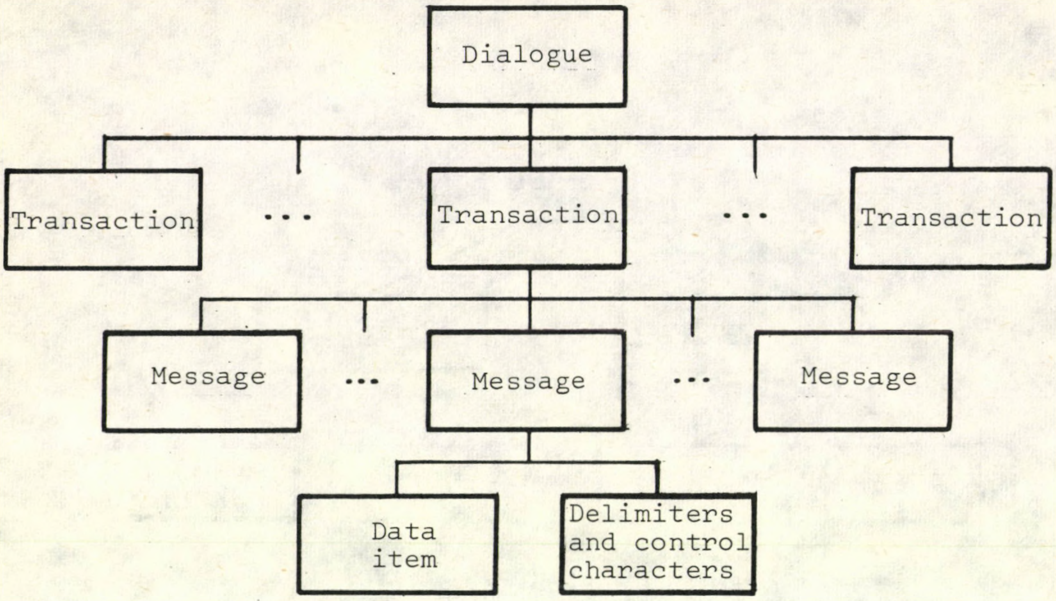


Figure 10. The structure of user/terminal dialogues [1]

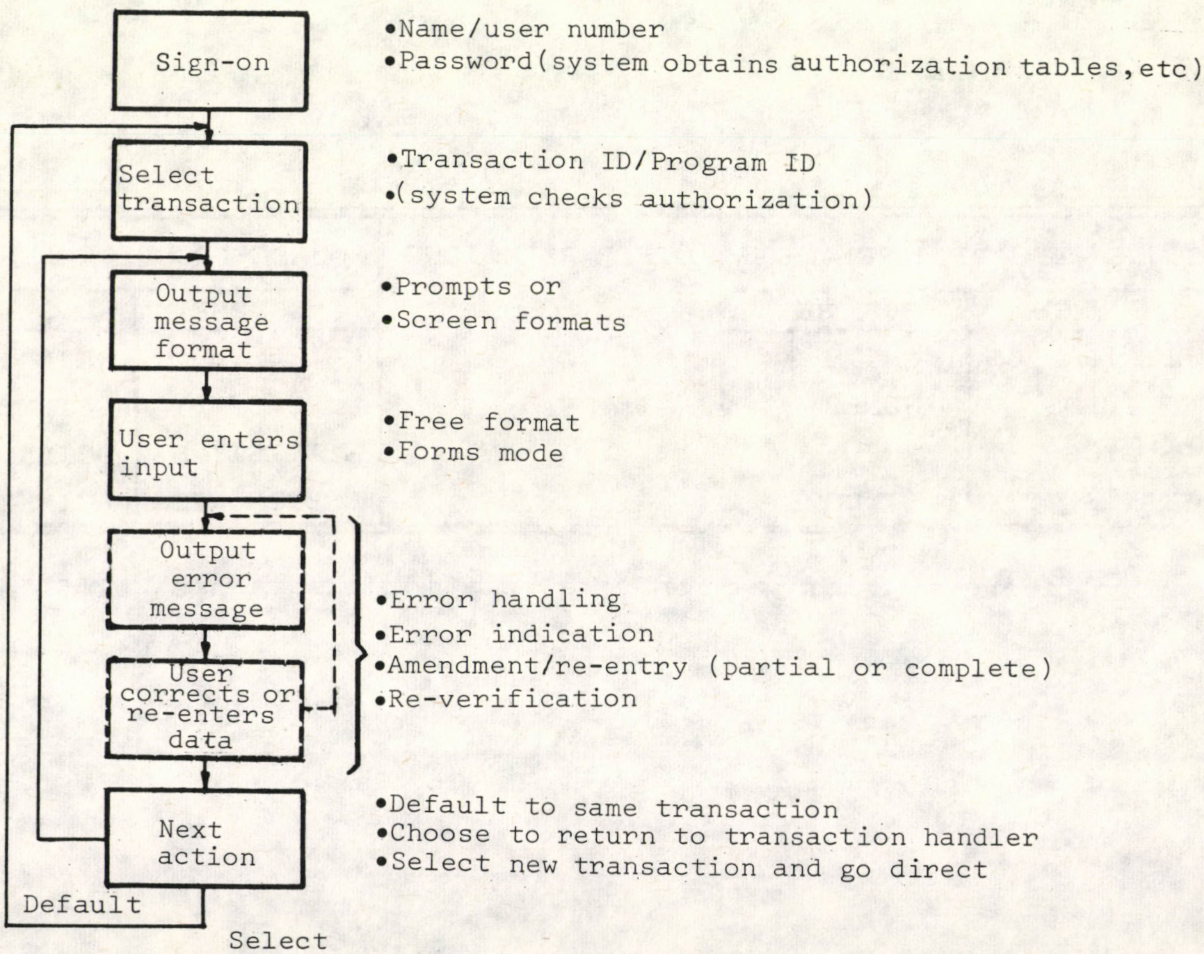
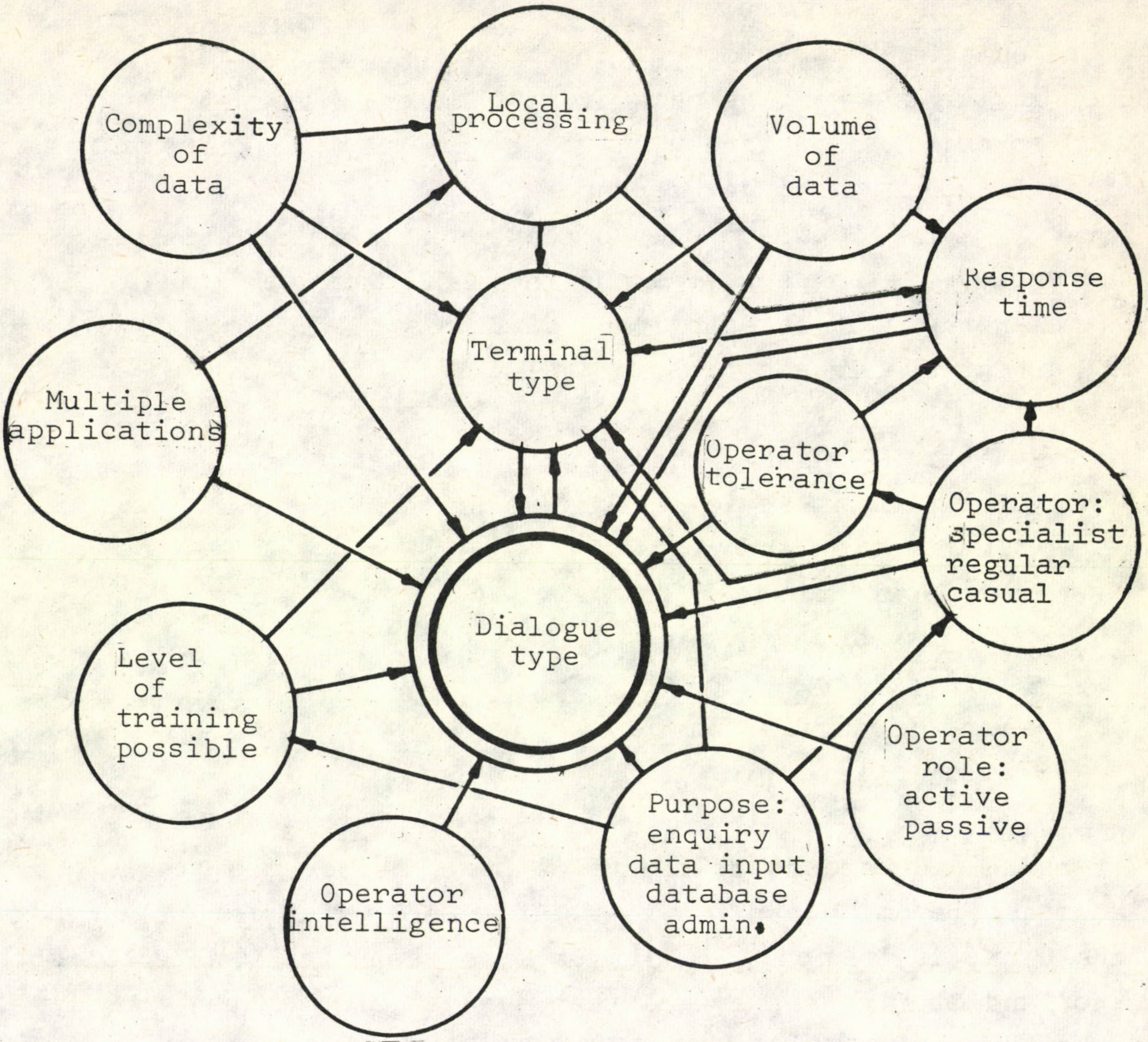


Figure 11. Profile of a typical dialogue [29]



1	Purpose	Enquiry/Data input/Database admin.
2	Operator type	Specialist/Regular/Casual
3	Operator role	Active/Passive
4	Operator intelligence	High/Average
5	Operator tolerance	High/Low
6	Level of training	Less than 5 mins/Less than 1 day/More than 1 day
7	Response time	Less than 1 sec/1 to 4 secs/Over 4 secs/Over 15 secs
8	Volume of data	High/Low/Input/Output
9	Terminal type	Slow keyboard-printer/Fast keyboard-printer/TTY-compatible VDU/Commercial VDU
10	Local processing	Intelligent terminal
11	Complexity of data	High/Low/Input/Output
12	Multiple applications	Multiple applications per terminal

Figure 12. Factors influencing choice of dialogue: structure of relationships [29]

to select the transaction-processing program he wishes to talk to. Once in the program, he can get to another by returning to the handler or, in some cases, by going directly via a "next transaction" field in the input format.

Figure 12. is to illustrate the complexity of relationships between the various dialogue styles and the influencing factors.

There are lots of categories of *dialogue style*. The eight main styles in current use are as follows [29]:

- Natural language based
- Programming-style dialogues
- Instruction and response
- Menu-selection
- Displayed formats
- Form filling
- Panel modification
- Query-by-example.

It is an understandable temptation to consider the *"natural language"* approach for many applications. After all, that is the language of the user, is it not? But language is essentially a verbal phenomenon and it might be argued that even in the written form it becomes "unnatural" [30]. However, with a degree of flexibility and compromise, quite good dialogues are possible (see Fig.13).

```
FIND HARRINGTON AND ALTER DELIVERY-ADDRESS TO 'STATION YARD,
                              WARRINGTON'

     H HARRINGTON LTD
     DELIVERY-ADDRESS    OLD VALUE - HIGH ST., WARRINGTON
                         NEW VALUE - STATION YARD, WARRINGTON

*** PLEASE CONTINUE
```

Figure 13. Natural language based dialogue style [29]

Programming-style dialogue often uses logic alien to the user's normal mode of thinking (Fig.14).

```
UPDATE PERSONNEL FROM SOURCE1;
STRUCTURE SEGOL FROM SEGB;
EQUATE;
EMPNO TO MANNO;
SALRY TO WAGE;
END EQUATE;.

IF ACTION EQ 'D';
LIST PERSONNL:  RECORD;
REMOVE SEGOL;
ELSE;
DECREASE TAXRATE BY 5;
INCREASE BNEFITS BY 100;
IF ACTION EQ '1';
INSERT SEGOL;
IF ACTION EQ 'R';
REPLACE  SEGOL;
```

Figure 14. Programming-type dialogues - how not do it [29]

Figure 15 shows a simple (and self explanatory) example of an *instruction and response dialogue* which is very suitable for less frequent users of a system.

```
ENTER PERSONNEL CODE OR 'END'
1297684
BARRINGTON, GERALD
ENTER SECTION REQUIRED, 'PERSONAL', 'EDUCATION', EMPLOYMENT' OR'SALARY'
SALARY
ENTER ITEM REQUIRED, 'BASIC', 'GROSS-TO-DATE', 'TAX-TO-DATE', 'OTHER'
BASIC
BASIC IS £ 3000 PER ANNUM
DO YOU WISH TO CHANGE THIS ITEM? ENTER 'YES' OR 'NO'
NO
ENTER PERSONNEL CODE OR 'END'
```

Figure 15. Instruction and response dialogue [29]

In recent years, such styles have increased significantly in importance and usage. This is caused mainly by the extensive use of mini based commercial systems which employ extended-BASIC interpreters such as DEC's RSTS/BASIC-PLUS.

```
                    ELECTO-CARS LTD

              SPECIFY ORDER DETAILS ; 2,4,9,12

MODEL               MOTOR POWER          NO. OF DOORS   COLOUR

1. SPARK            4.  15 HP             8. 2 DOORS    10. RED
2. SPARK DELUXE     5.  20 HP             9. 4 DOORS    11. GREEN
3. SPARK GT         6.  25 HP                           12. WHITE
                    7.  30 HP

FIFTEEN HORSE-POWER WHITE SPARK DELUXE WITH FOUR DOORS
PLEASE CONFIRM (Y/N):
```

Figure 16. Menu selection (multiple) [29]

When visual display terminals first become widely available on the marketplace, the salesmen often used the *"menu selection"* technique as a justification for their use in preference to slower, hard copy devices. "Idiot proofing" was a comonly used expression. Menu selection can be best used with very complex data (as shown in Figure 16 or in combination with other styles.

Displayed formats are probably the simplest of dialogue styles and can be used efficiently in a wide variety of applications and on most terminals. In practice, the displayed format shown in Figure 17 may be omitted by experienced users. The menu selection technique could be employed to indicate the transaction required. Even simpler is the idea of prefixing each message with a transaction code. Such *"free-format"* messages are very efficient but can be difficult to learn at the beginning, even if the prompts are used.

The dialogue style which the VDU has made extremely popular is *"forms filling"* or *"forms mode"*. This involves the displaying on the screen of a format map which corresponds in layout as closely as possible to the related input document. The "map" is protected and cannot be inadvertently altered by the user from the keyboard. The user can then key data into 'variable' areas of the screen which are unprotected. When the 'send' key is pressed only the data has been entered (sometimes all the variable fields) is transmitted to the computer. Such techniques are very easy to use.

```
                         BOOK ORDER

ENTER  AUTHOR / TITLE / PUBLISHER / ISBN / NO. OF COPIES /
       CUSTOMER NAME  / CUSTOMER ADDRESS / POST OR COLLECT?

HEBDITCH/DATA COMMUNICATIONS:  AN INTRODUCTORY GUIDE/ELEK
SCIENCE LTD/ NK/4/A WISEMAN/NA/COLLECT
```

Figure 17. Displayed formats dialogue style [29]

An example is shown in Figure 18 . In the case of fixed-length fields (e.g. the Account Number) the cursor automatically tabs to the next input field when the last character is entered. With variable fields (e.g. the Customer Name) the user has to press the tab key at the end of the data. The various control characters vary in implementation and in some terminals do not appear on the screen. On acceptance of one input message, the data in the variable areas of the screen can usually be cleared by the computer sending a single control character; the map need not be retransmitted unless the user wants to enter a different message. Complications arise when the computer has to display data back in response to input (e.g. product names for product codes). This usually can only be cleared by over-writing with blanks or by sending a completely new screen.

```
                    NEW ACCOUNT DETAILS

ACCOUNT NUMBER   [    ]  CUSTOMER'S ORDER REF   [              ]
CUSTOMER NAME    [                              ] TYPE [   ]
STREET           [                              ]
TOWN/CITY        [                              ]
COUNTY           [                              ]
DELIVERY ADDRESS       [                          ]
DELIVERY INSTRUCTIONS  [                        ∇ ]


                    NEW ACCOUNT DETAILS

ACCOUNT NUMBER [84978632   ]  CUSTOMER'S ORDER REF [ ∇         ]
CUSTOMER NAME  [THE SQUINTING CAT ∇                ] TYPE [PUB]
ADDRESS LINE 1 [84 WESTVILLE ROAD NORTH ∇          ]
ADDRESS LINE 2 [ILKLEY ∇                           ]
ADDRESS LINE 3 [WEST YORKSHIRE  ∇                  ]
DELIVERY ADDRESS       [AS ABOVE ∇                          ]
DELIVERY INSTRUCTIONS  [BEWARE OF THE FIERCE DOG ∇          ]

RETURN TO INDEX FRAME [   ]

     [ = TAB STOP     ∇ DEPRESSION OF TAB KEY
     ] = AUTOTAB
```

Figure 18. Form filling dialogue style (with forms mode) [29]

```
NEXT FUNCTION TYPE    [__]        NEXT  EMPLOYEE NAME [
SALARY DETAILS            DAVIS,     CHARLES DAVID ANTHONY
FIGURES MARKED BY '*' MAY BE CHANGED
BASIC SALARY *[3100]                ANNUAL BONUS  *[200]
GROSS PAY TO DATE      2600                 TAX TO DATE    190.00
PENSION FUND CONTRIBUTION     *[02.50]  PER CENT
TOTAL CONTRIBUTED TO DATE   2497.00  PENSION AT RETIREMENT  140.00 PA
NATIONAL INSURANCE RATE    2.45 [CONTRACTED OUT]
DATE OF LAST INCREMENT   31.01.74    REASON    SCALE  [ON SCALE]
```

Figure 19. Panel modification technique (with or without forms mode)[29]

Panel modification technique is only recommended for experienced operators handling relatively complex data. An example is shown in Figure 19. Data is displayed on the screen in response to an input key (e.g. Employee Number). If required, some of the fields may be modified and sent back to the system. The use of forms-mode terminals can be used to restrict the fields which may be modified by each level of security clearance.

Query-by-Example technique has developed as a means of inputting enquiries and searches to relational databases. The user starts by indicating the data set on which he wants to enquire. The system responds by displaying the data elements in the record concerned. The user then indicates the fixed parameters of the search and the unknown variable he wishes to see. Two simplified examples are shown in Figure 20.

In attemting to review the state of the art of man/computer communication, we limited consideration to the technical aspects of how to improve communications. More widespread recognition of the potential of this field has brought resistance, not merely because of the communication gap, but also because of occupational and societal problems (e.g. unemplayment, privacy of information, etc.) however we had to consider the human implications being out of the frame of this report.

```
DATABASE:  PERSONNEL
ELEMENTS:
NUMBER     NAME              DEPARTMENT          SALARY
47863

RESPONSE:
NUMBER     NAME              DEPARTMENT          SALARY
47863      JONES,HENRY       SALES               12500.00
```

(a) Simple enquiry

```
DATABASE:  PERSONNEL

ELEMENTS:

NUMBER     NAME              DEPARTMENT         SALARY
  *          *               SALES              >10000.00

RESPONSE:
NUMBER     NAME              DEPARTMENT         SALARY
47402      SMITH,JOHN        SALES              18450.00
47863      JONES,HENRY       SALES              12500.00
47959      BROWN,MARK        SALES              13100.00
END
```

(b) Search

Figure 20. Query-by-example technique [29]

OFFICE INFORMATION SYSTEMS: A CHALLENGE FOR THE 80'S.

The technological revolution of hardware, that began with the introduction of the microprocessor, is now beginning to impact areas of everyday life. The reduction in price of microprocessors and their packaging and proliferation are generating many new applications for computers. Perhaps the biggest potential use of microcomputers and their most important impact will be in the office. There are many factors, both technical and economic that point to the need for office automation and office information systems [33][34][35]. In analyses of the wide range of tasks performed in offices [34], one constant factor emerged: Office work serves to *inform*. Data is constantly *produced, shaped, and revised* according to rigid and uniform procedures. In terms of functions performed by office equipment, the procedures can be broken down into handling information and processing information. Handling consists of *oral* exchanges as well as *data, texts, and graphics*. Processing includes *data collection, text production, documentation and filing, and graphics production*. Advanced equipment that aids these processes is starting to blur the boundaries between the two categories. One piece of equipment often serves many activities. Office activities are becoming closely interrelated (Fig.21).

In all of these areas, automated tools based on *microelectronics* and other *new technologies* are now readily available. There are tools on the area of text processing. *"Word processors"* were easily developed, both by adding computer power to sophisticated typewriters and by programming small computers to process text; because entry-level systems are so cheap; because word processors offer immediate and measurable improvements in typist productivity for almost every kind of work; and because word processors can be installed instead of typewriters with the minimum of office reorganisation. Over a period of several years, word processors have developed into powerful text manipulation systems. The facilities offered have been extended, printers

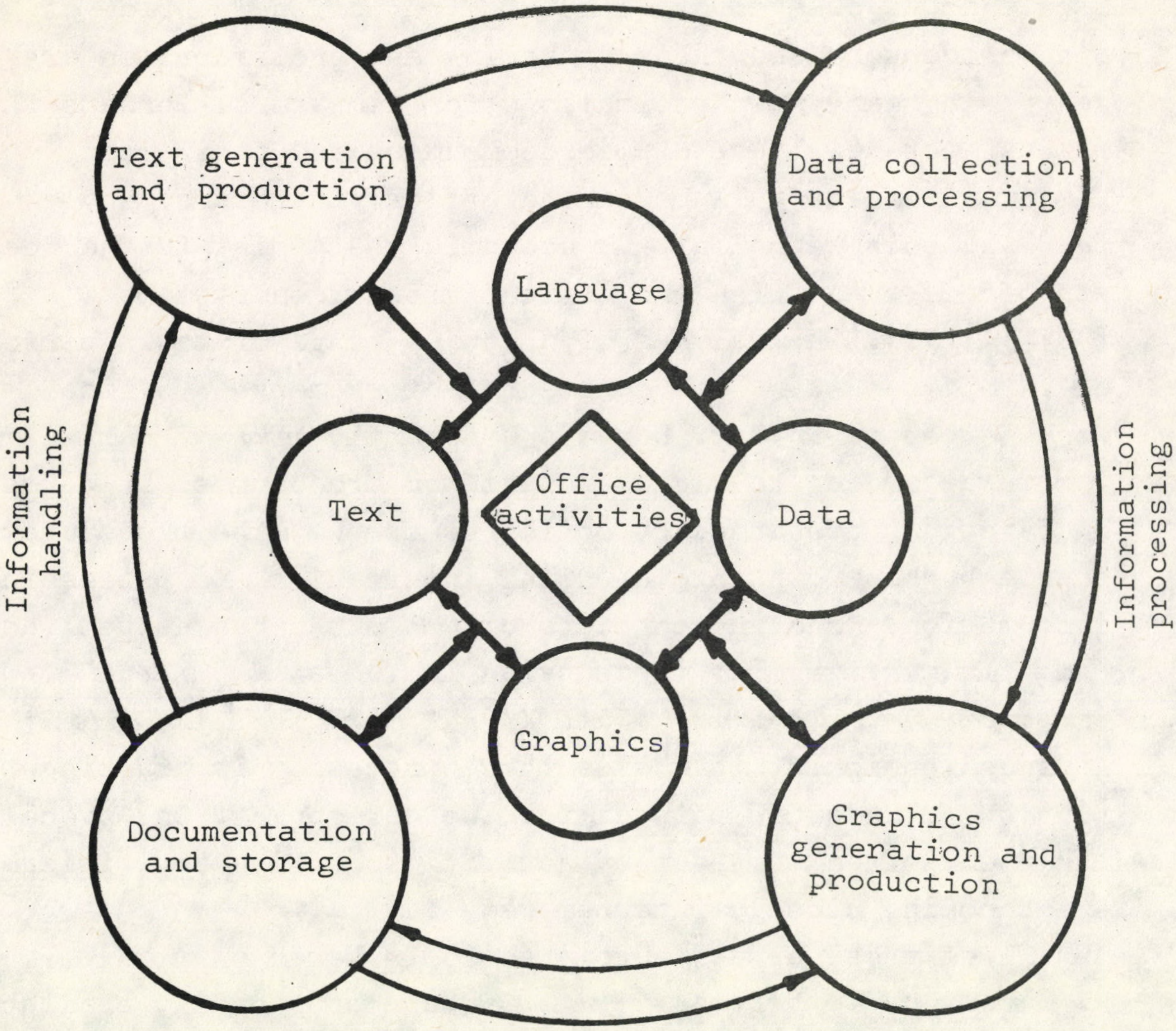


Figure 21. Office activities [34]

have improved, and the user interfaces have become more *"friendly"* and so more acceptable to non-technical clerical users.
Typical modern word processing systems are based on computer equipment and software programs run within the equipment to enable text to be typed, "processed" and printed. To give an idea of this, most equipments comprise - in essence - the following five elements:

- An electronic *keyboard* (to take the place of customary typewriter keyboard)
- A visual *display* means (for displaying on either a strip or an electroluminescent screen the text typed)
- A central *processor* unit (for running the software programs necessary for the manipulation and retrieval of text to be displayed)
- A disk *storage* unit (for storing standard texts and documents to be printed)
- A high quality electro-mechanical *printing device* for the actual printing of the typed text.

A large proportion of typing work consists of amendment, or to use the word processing term, *text editing*. To do this on a VDU, the typist must know where she is about to place characters, and this is invariably indicated by means of a "blinking cursor". This can be moved around the screen at will to any portion of the text by special cursor control keys. Use of this enables the typist to backspace to correct the character just typed, or by references to the position of the cursor, to delete words, lines, sentences, paragraphs or even a whole page, in a flash. (This is done by use of special control keys, or by typing in code letters interpreted as commands.) Also, each of these items may be inserted anywhere the typist chooses, the rest of the text shifting logically to accomodate the new material. Furthermore, it is not usually necessary to effect a carriage return at the end of a line as a feature known as word wraparound looks after this; thus, if a word spills over an electronically set right margin, it is automatically placed at the beginning of the next line. Typing can be continuous and text may be prepared perfectly on one's screen before committing it to be stored or printed. Once a page has been typed, it may of course be held within the storage unit, rather than printed, for accessing later, for further amendment or printing as desired. The page may comprise part of a "file", or "document" within the system, and this may have its own "name" or "identifier". The storage unit may be used for interposing standard texts in the original work being typed.

Besides these fairly basic facilities, many word processing systems provide a whole host of further aids to the typist, some of which are remarkable. The following are some examples. Suppose text has been typed between margins of "columns 1 and 60". It is decided that, for reasons of presentation, this is too wide (or narrow). By simply resetting with control keys, the left or right-hand margins, the text will be logically reorganised between the new margins - observing "word wraparound" where necessary - to present a new format which will be either wider and shorter, or narrower and longer. Suppose then it is desired to spread each line out so that the right-hand word always ends at the right-hand margin (justification). Further use of control keys effects this change, and the text may be printed accordingly.

Other text facilities include such features as being able automatically to centre selected blocks of text, underline sections at a stroke, search to selected words and "globally" replace them, recall standard paragraphs into text wherever desired and merge together lists of names and addresses with standard letters according to pre-defined parameters [36].

In addition to these text-editing facilities, there is a further potentially important area of use of *mixed data and word processing* (**Fig.**22).

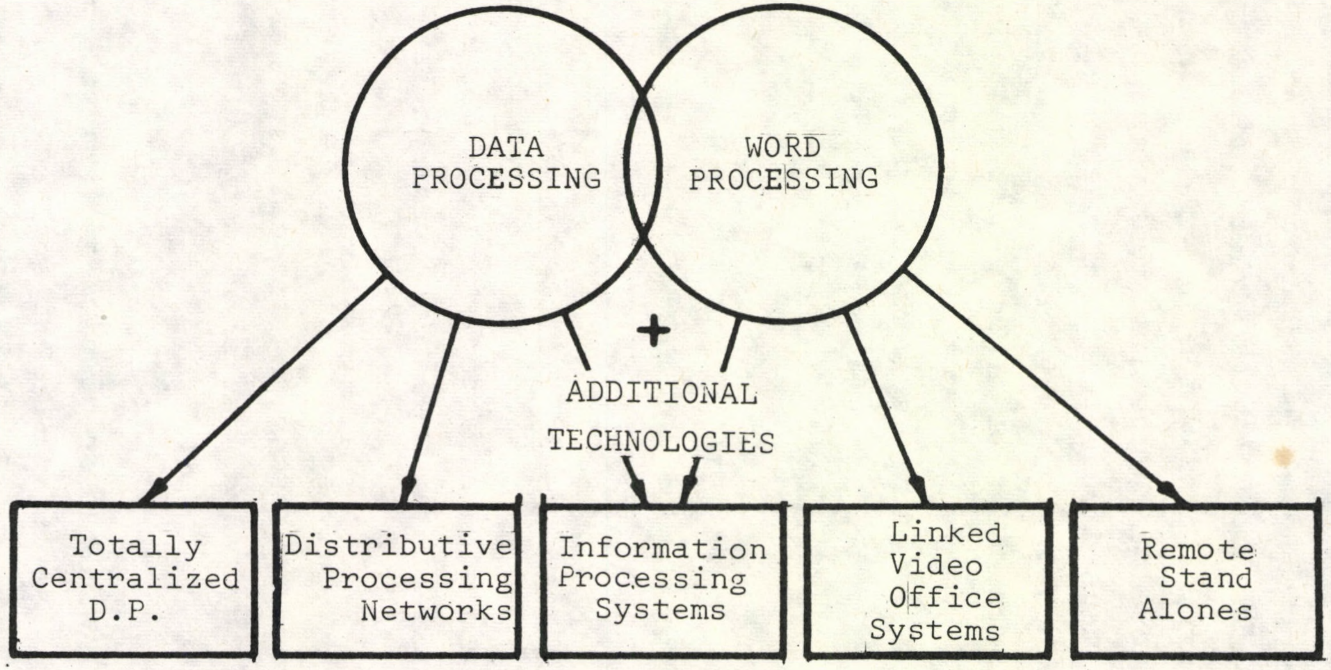


Figure 22. Mixed data and word processing

Word processors can be interfaced with mainframe computers to have access to information stored in very large databases, and once the information is obtained, further calculations may be performed. Now it is possible to set up the format of a standard letter, in which blanks are filled in by the typist.

The second area concerns *communication*.

Like "word processing", *"electronic mail"* or "electronic message system" (EMS) are fairly new expressions which are already commonly heard, but used to denote many very different services. "Electronic mail" can mean any system which uses electronic telecommunications technology to provide a communications capability within or between offices. This extremely broad definition encompasses everything from the telex service to computer-based message switching, storing and handling systems. Several key *characteristics* are accosiated with every electronic mail system. All such systems must include equipment for the following [37]:

- Information input
- Information output and display
- Data transmission.

In addition to these minimal characteristics EMS may be capable of performing any or all of the following functions as well:

Input may be via a teletypewriter terminal, a keyboard and CRT display, a word processor, a personal computer attached to a home TV, an optical character reader, or a facsimile scanner.

Output may be on a similar or dissimilar terminal, which produces output on a screen, or on paper using character oriented or raster scan techniques. In many systems, a user may first read a message on a video terminal, and then decide that he would like it to be printed on a hard copy device.

Data transmission may be via dial-up circuits or leased private lines; or it may be via packet networks or satellites using burst transmission.

Message switching may be handled by the common carrier, as when the voice telephone system is used to connect word processors; or the switching may be performed by one or more computers connected by direct lines or through a packet network. The switching function may be distributed among many nodes in a fully connected network or may be handled by one central switch in a "star" network.

Editing capability exists to a different degree in different systems. Conventional telex and company message systems generally use input terminals which do not provide editing capabilities. But virtually all future systems will provide an editing capability whether in the terminal itself, such as a word processor, via a local minicomputer, or centrally from a timeshared CPU. Message composition may be aided by the use of standardised forms in which many fields are filled out automatically.

Filing and retrieval functions, when integrated with an electronic message system, raise it out of the category of a simple communication device to a basic building block of the electronic automated office. There is also great variety among systems in their long-term capabilities for accessing stored messages. Some only allow access by a message number. Others provide capacilities for filing a message under multiple keywords (such as, date, author, subject) and the use of Boolean search techniques.

Accounting and control may be provided to the end user by one party, as with telex, or accounting and billing may be handled by the user's switching computer, or it may be simply part of the phone bill as in the case of word processors tied together over dial-up lines. In some systems speed and code conversion are included with communication costs. In others, they are billed as computation. Thus, the costs of terminals, communication and computation may be accounted for separately, in various combinations, or all together.

Addressing/distribution are handled in a variety of ways, depending upon the application and the technology. A key distinction can be made between systems which address messages to a *person* and systems which address a message to a *physical terminal*. Telex is an example of the latter. An example of the former is a timeshared computer system in which each user has a "mailbox". When a message is sent to that user's mailbox, it is simply stored in a particular file with his name on it. The user can then log into the computer from any physical terminal, and, by identifying himself with *password*, have the message displayed at that terminal. This permits a user to continue to receive this messages even when he is travelling, by logging into the computer using a portable terminal or one at a hotel. The more sophisticated message systems might have facilities for: sending to an address list, posting notices "bulletin board" fashion, forwarding messages to a third person, and distributing messages by subject, rather than to a specific person.

Authentication of message authorship is an issue of concern to many EMS system designers and users. Correspondents may wish to use EMS to send and receive contracts and other legal documents which must be signed.
As yet there are no agreed protocols for dealing with the authentication issue. Where a user identifies himself with a password in order to use the message system, this identification may be attached automatically to every message sent, a form of authentication only as good as the computer system's protection of passwords and the security of the message software. Many systems are like telex, however, in that the only identification sent is

the location of the terminal, not who is using it. In a network of communicating word processors, there is no central computer to check passwords. Some communicating word processor users rely on voice contact before sending the message as a way of authenticating it.

Privacy protection is a related issue of concern. Some systems use *encryption schemes* or mix data with voice transmissions over the same leased line in order to make it difficult to listen in on message transmission. Systems vary considerably, however, with respect to the privacy accorded a community of system users. Many shared-logic word processors have no provision for protecting the privacy of documents among the common users. Some computer mail systems allow an *"account supervisor"* to peruse any and all messages and provide detailed statements of who sent messages to whom. Others allow a message to be read by a third party only with the recipient's explicit authorisation. Systems now being designed for the military can distinguish multiple levels of security classification and can even classify separate portions of a message at different levels.

Coordination of various tasks or document handling using EMS might require such capabilities as: maintenance of an action log of who is currently responsible for a document; providing a capability for various persons to *"sign off"* on a document and for those authorisations to be permanently affixed to the message; providing the ability to forward a message with an annotation of change in a manner which clearly indicates what was the original text and what is the proposed change.

Content processing refers to that vast category of programs which actually read the message and take some action based on its "contents". This may be as simple as determining the appropriate subject classification for a message by scanning it for key words or as complex as abstracting a long document.

The chief *techniques* are [35]:

Facsimile, which uses conventional telephone or telex lines to carry data obtained from a raster scan of a page. Because facsimile systems scan the page rather than encoding the data written on the page, they can be used to send non-textual data (such as graphs, maps, signatures, and Japanese Kanji characters) which are difficult or impossible to transmit over other electronic mail systems.

There are *telex-based services* as *Mailgram* in the USA which is a computerised telegram service [37].
Another way of communication is the so called *teletex service*. It aims to provide terminal-to-terminal transmission (typically between word processing-like devices) rather like telex, but the character set will be far more embracing, including small and capital letters and a wide range of punctuation, and the transmission speed will be higher (probably 2400 bit/sec) [38].
There are different *computer-based message systems* [39].

These systems fall into three *categories*:

- Those developed from a *store-and-forward message* switch (Fig.23).
- Those built on *computer networks* (Fig.24).
- Communicating *word processors* (Fig.25).

Repeated studies of office communication patterns show that written messages account for less than 10% of all communication: face-to-face accounts for 70% and telephone for 20% [37].
Studies of the time required for various cooperative problem solving activities reveal that oral modes are significantly faster than written ones for many applications. Computer conferencing represents attempts to develop electronic aids for oral and visual interaction.

"Computer conferencing" is a term used for three quite separate services [37]:

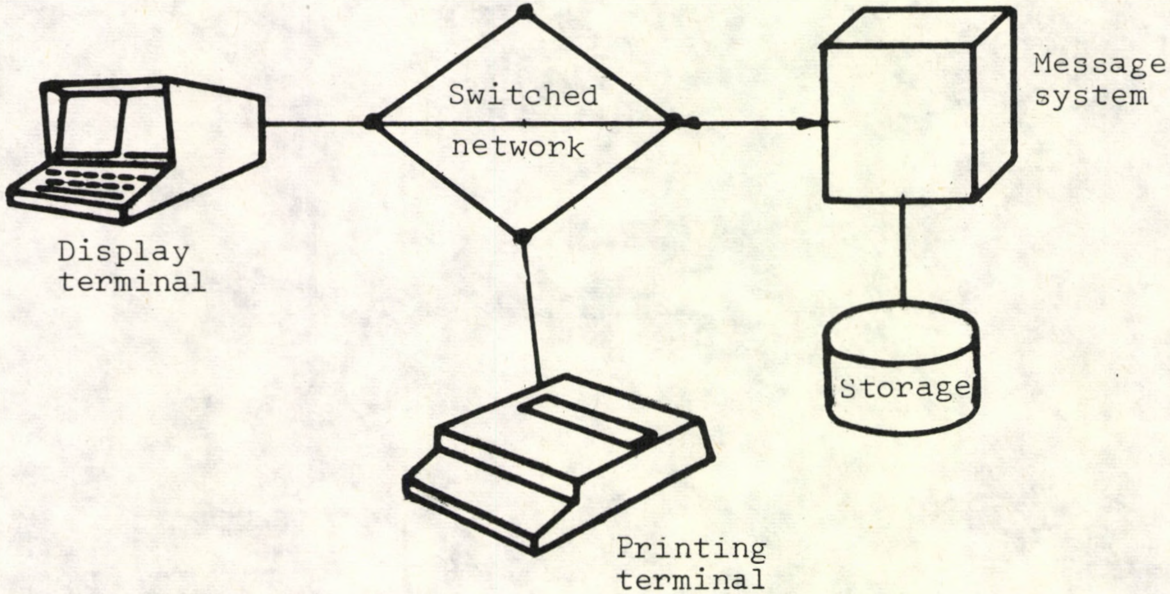


Figure 23. Store and forward electronic message system [37]

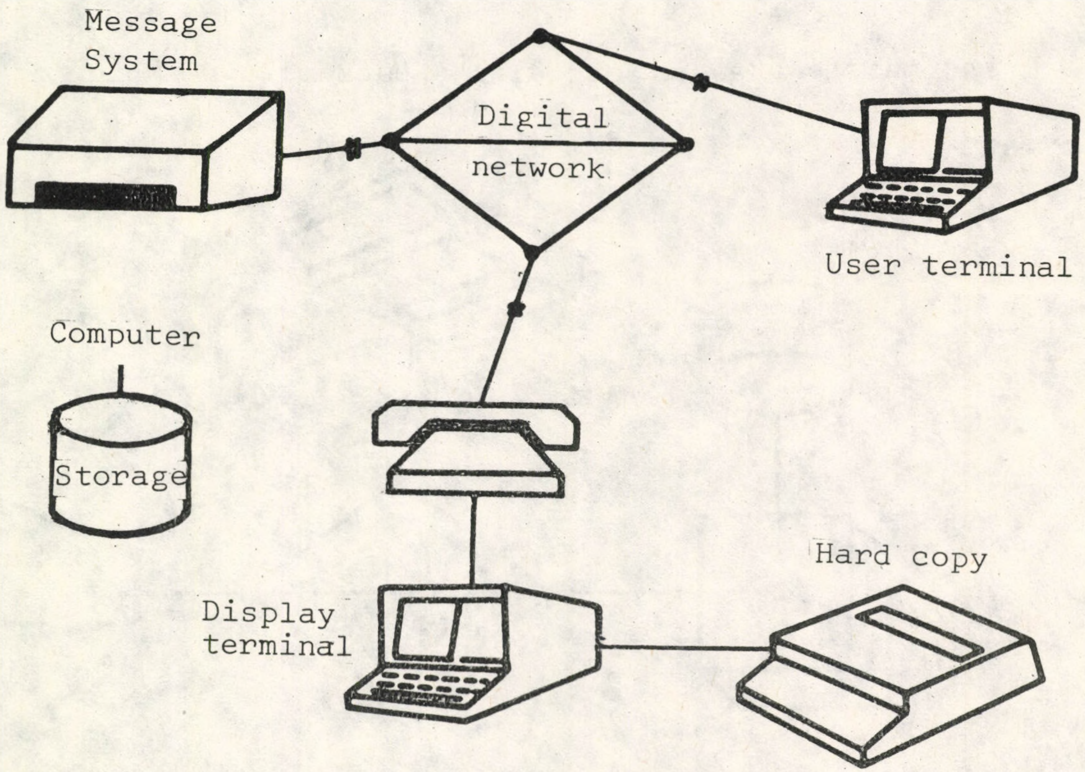


Figure 24. Computer message system [37]

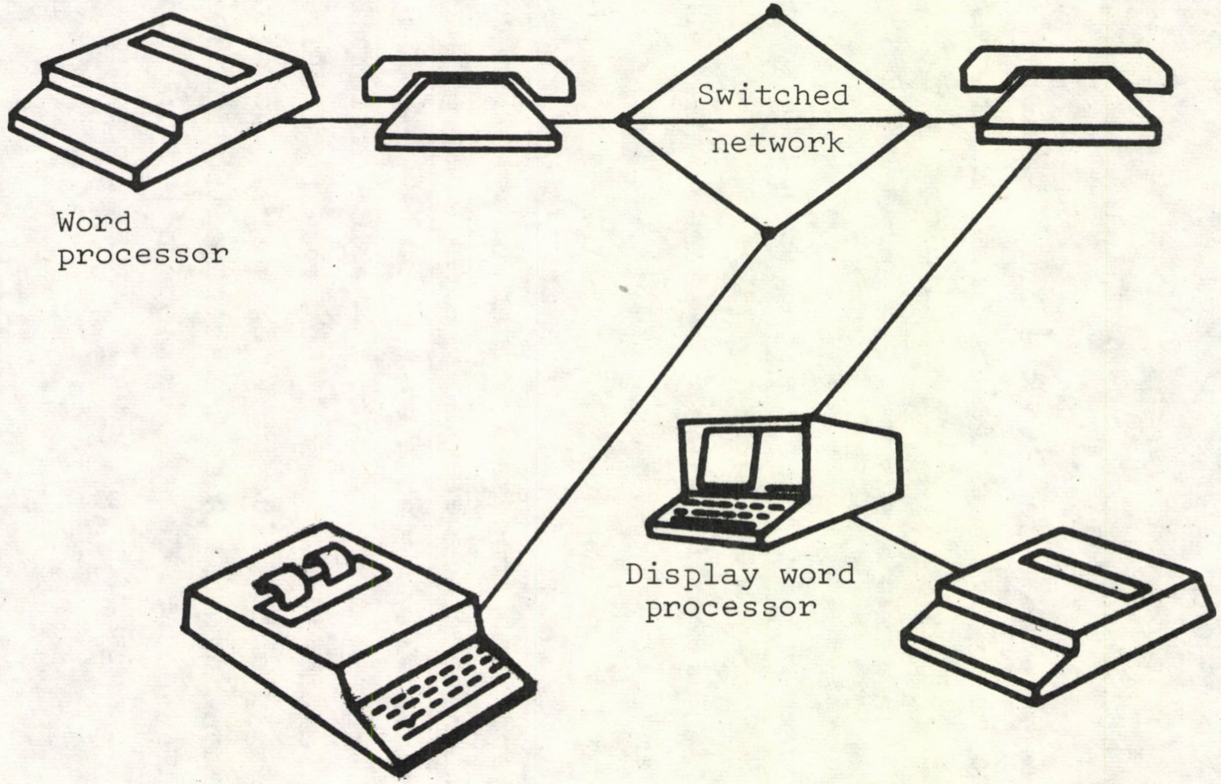


Figure 25. Communicating word processors [37]

Video conferencing is an attempt to mirror the existing conference format while allowing participants to stay geographically far apart.

The principle is to allow people remote from each other to hold conversations and view each other live on TV screens. Technically, this can be done, but at great expense.

Audio or telephone conferencing is a less ambitious means of allowing remote conversational conferences. The participants cannot see each other, but only hear each other's voices.

Computer-mediated conferencing refers to the use of a computer-based message system to carry out a conference between several people.

All exchanges are *written* (i.e. typed into computer files from terminals) which means a record of every contribution to the conference is automatically kept,

Communication might or might not be synchronous - participants log in to the system whenever they like,

"Conferences" last as long as required. Some are continuous over months or even years.

The ultimate goal of current research efforts is the *integration* of mail, facsimile and text processing technologies with voice and video communication to produce a truly electronic office (see Fig.26). Technically, such a system could be built today. With the continuing rapid decline in the price of computer logic and communications equipment, the hardware could be put together at an acceptable price in a few years. The fundamental barrier to implementing this kind of electronic office communication system is the need to develop new operating procedures and to redesign the organisation in order to take advantage of its potential.

At the forefront in bringing the computer into the office is the application of *software architectures* and the techniques of modern *computer science.* For example Prime Computer [40] built its complete, highly integrated Office Automation System on its Prime 50 Series multifunctional 32-bit super-minicomputer systems. Using the extensive software base and the Primenet

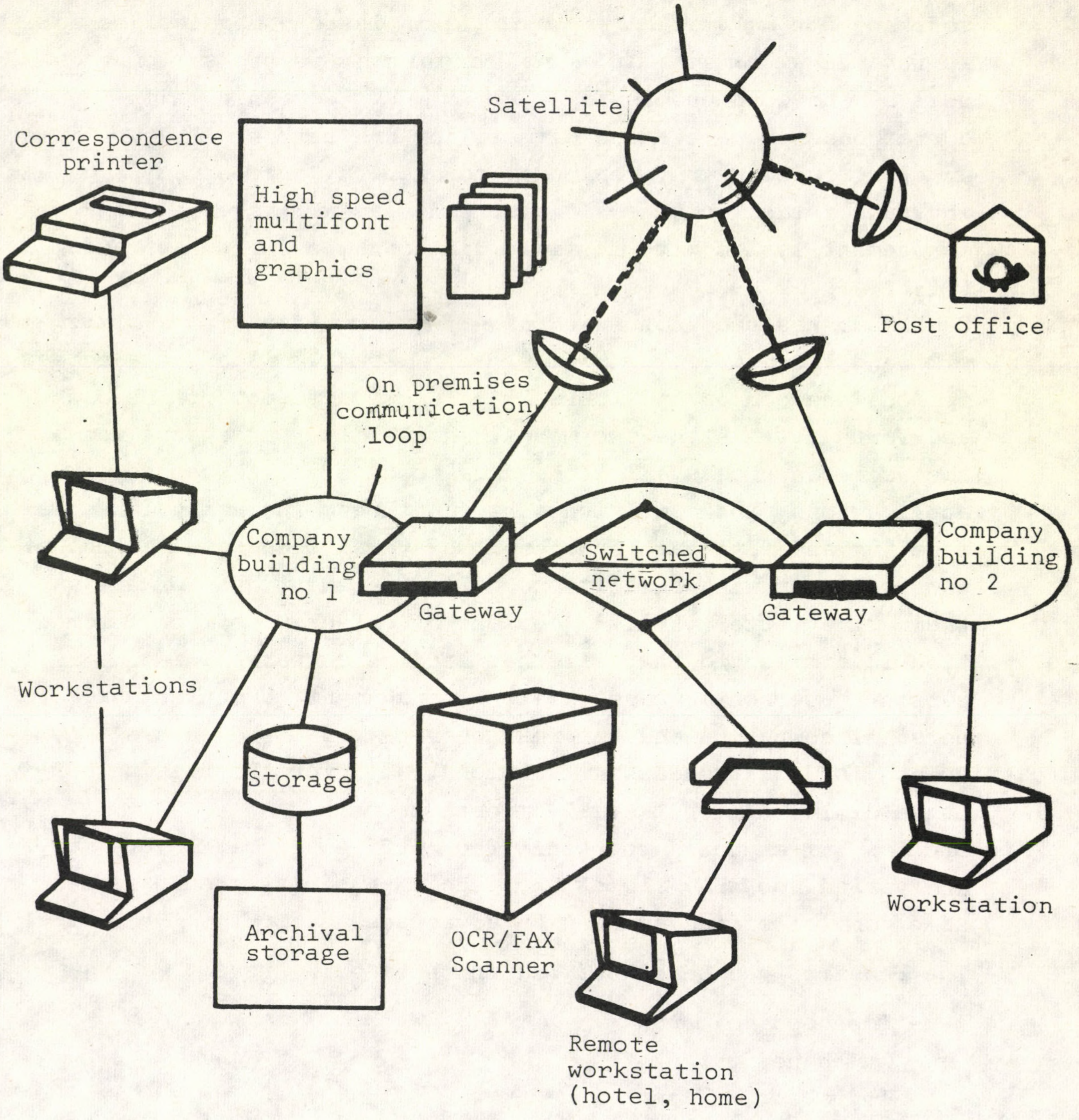


Figure 26. Integrated electronic mail system [37]

networking of these systems, Prime developed office system software for *managers and professionals* in large companies, as well as for the *secretaries and clerks*. For the managers, the system goes well beyond word processing, combining electronic mail, correspondence management with filing and retrieval capabilities, an electronic in-tray, calendar management, appointment scheduling, and a tickler file. It also contains an advanced text management system with multiple dictionaries for proofreading (Fig.27).

Each user has access to two *modes of operation*-the *office automation mode* and the *data-processing mode*. The file structure and data-access methods are common and there is a function to move files back and forth between the two modes. In the data-processing mode, the user can access all Prime data-processing languages, applications, and communications functions, including financial modeling and data-base management systems. These give a kind of personal computing facility to help management and workers use their time better. Prime's concept of effective office automation is similar to that of other leading companies, including person-to-person messages, better management communication, personal computing and information retrieval, and access to the company's data-processing functions, with word processing taking a diminished, but still important, role.

The *benefits* expected to result from office automation are many and varied, so that almost any type of business should find some form of office automation advantageous.

The benefits can be *classified* in three main areas:

- Improved *productivity*.
- *Cost* benefits.
- Improved *facilities*.

When reviewing the benefits of office automation, it is wise to remember that these are potential benefits. An unsuccessful office automation project whose system is poorly designed, unsuitable, or rejected by the staff, will not bring any advantages [41].

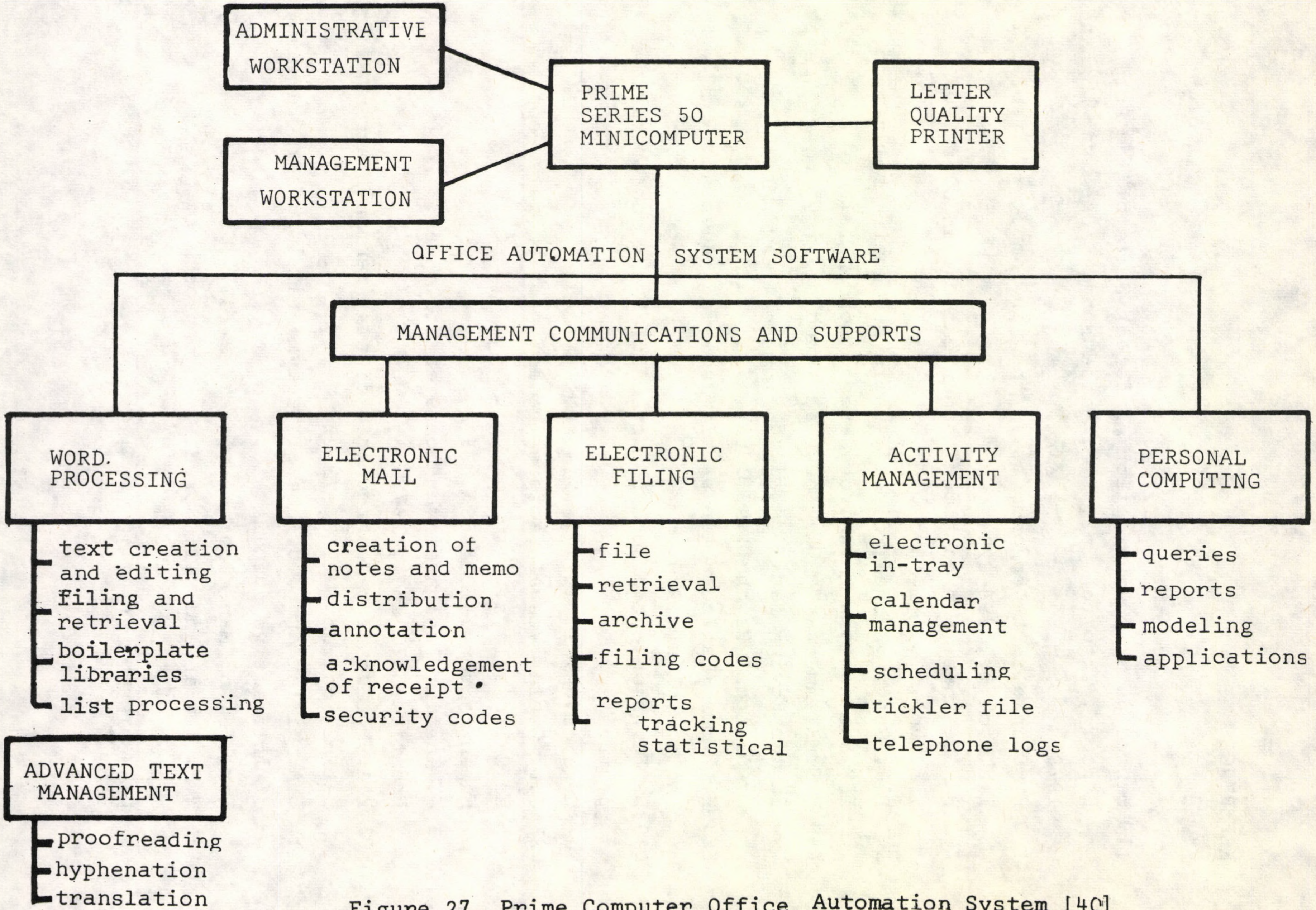


Figure 27. Prime Computer Office Automation System [40]

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