# INTERPERSONAL COMMUNICATIONS USING COMPUTERS

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## ABSTRACT

The most important telematic services for interpersonal communications supported in computer networks are studied by overviewing their main features and the present state of standardization development; this study includes Electronic mail, Document interchange, Directory service, Group communication and Videotex services. Finally, the concept of the emerging Integrated Services Digital Network is introduced and a reference is made to its impact on interpersonal communications.

## 1. INTRODUCTION

The use of interpersonal communication services supported in computer networks is already well established in some communities of users. This activity is being fostered by the increasing availability of wide area computer networks in many regions of the globe, and a further use of these services is foreseen in connection with the progressive integration of data and voice communication networks.

A computer network consists of a number of computers that can communicate among themselves by using the same protocols over a transmission medium. Wide area computer networks, which may cover long distances between the users, and whose utilization is many times offered as a public service, are particularly suited to interpersonal communication as they assure a widespread connectivity among the users.

The diagram of a wide area computer network (WAN) is shown in Fig. 1. The WAN is physically constituted by a set of switching nodes that establish the different communication paths between the user terminals and/or the computers, and by the transmission media, which may include cables, optical fibers, microwave circuits and satellites.

A WAN can be either circuit-switched or packet-switched. In a circuit-switched WAN there is a physical path established between the users for the complete duration of the communication, much like in the Telephone network. In a packet-switched WAN it is not necessary to establish a dedicated path between users. Every message to be sent is divided into blocks, called packets, which are passed along the network from node to node until they reach the destination where they are reassembled. A public owned WAN is normally called a Public Switched Data Network (PSDN), and the majority of the existing PSDN are packet-switched.

The user access to the network is made through a communication subsystem, existing either in the terminal controller or in the computer. To guarantee a uniform access to the network

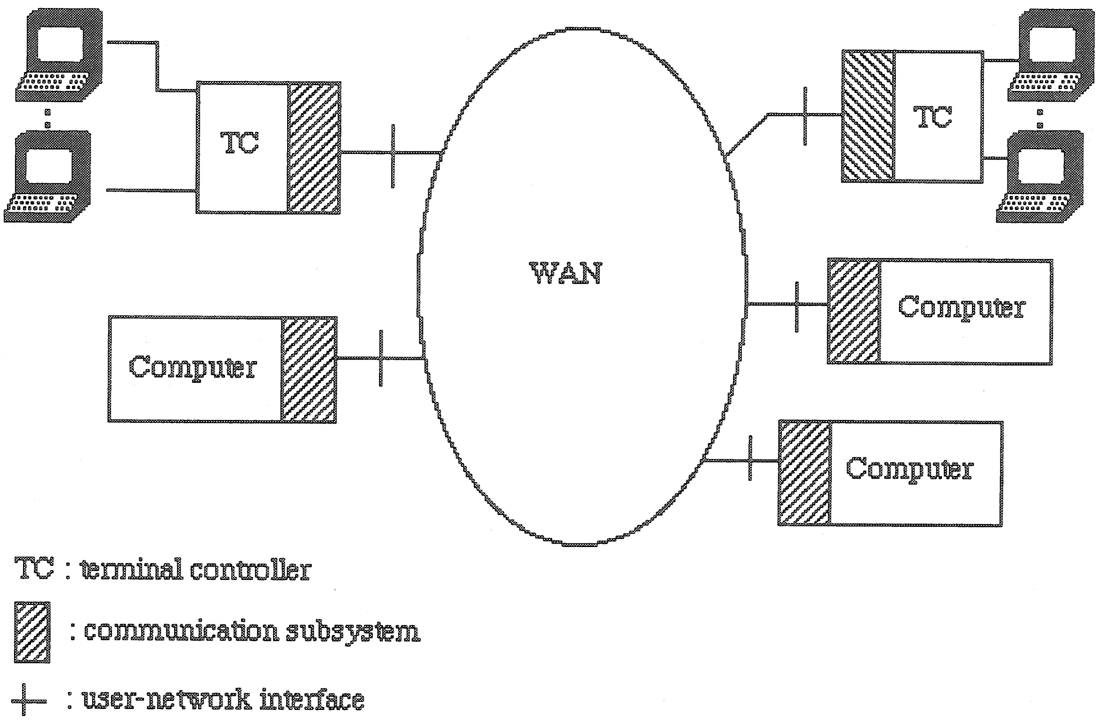


Fig. 1 - A wide area computer network

to all users, the PSDN has a standardized user-network interface : X.25 in a public packet switched data network (PPSDN) and X.21 in a public circuit-switched data network (PCSDN).

The importance of WAN in general, and of PSDN in particular, for interpersonal communications, is dependent on the type and number of services available in the network. The services offered in a data network are mainly oriented for text, graphics and data communication; this type of services, i.e, non-voice services, are called telematic services [1].

Two different types of telematic services exist : network oriented and terminal oriented telematic services.

The network oriented telematic services have the following characteristics:

i) the communication is done via a network storage, implying that there is no direct end-to-end communication between the user terminals;

ii) the addressee is always a person to whom a mailbox is allocated;

iii) the message is stored in the network, and the user has to access the store to get the message.

On the other hand, the terminal oriented telematic services have the following characteristics:

i) there is a direct end-to-end communication between the user terminals;

ii) the addressee is always the number of the called terminal;

iii) the received message is in the terminal.

There are five network oriented telematic services that assume particular importance for interpersonal communication. These services are the Electronic mail, Document interchange, Directory, Computer conferencing and Videotex.

In Electronic mail, users at distinct points of the network exchange interpersonal messages.

In the Document interchange service, documents containing text and graphics are exchanged between users, keeping the same document format at both ends, being also possible for the receiver to edit and process the document as at the originator's site. The Directory service provides a structured storage of information on the network resources and gives the possibility to the users of accessing that information in a friendly way. Computer conferencing is a tool for communication between more than two people, in which the communication is organized into a number of distinct communicating groups. Videotex is a service that allows the users to access a remote computer, containing particular types of databases, such as stocks, share prices, travel information, news reports, etc.

There are also other network oriented telematic services that are being standardized and should be offered in data networks in the future, although they are not specifically oriented for interpersonal communication. They are the File Transfer and Management (FTAM) [2], Virtual Terminal Protocol (VTP) [3] and Job Transfer and Management (JTM) [4].

The terminal oriented telematic services that are presently available as public services are the Telex, Teletex and Facsimile.

Telex is an old service, originated in 1933, which uses a specific network. It is presently the second telecommunication service in the number of subscribers, after the telephone service. However, its low transmission speed (50 bit/s), the use of a restricted character set and the requirement for a special purpose network are serious limitations for further expansion of this service.

Teletex is a new service that may be considered an evolution of telex, in which the complete character set of an office typewriter may be exchanged between similar terminals at a speed higher (2400 bit/s) than in the telex service. The present offering of this service is very limited, and some interrogations exist concerning its future, as it requires special purpose terminals and it overlaps the operating environment of Electronic mail [5].

Facsimile is a facility for transmitting scanned images of documents electronically between similar terminals. It is a service in expansion, which is presently based on the public switched telephone network (PSTN), therefore operating at low speed. The next generation of facsimile terminals (Facsimile Group 4) will, however, have better resolution and require the support of a data network capable of transmitting at higher speeds [6].

This paper has the main aim of surveying the network oriented telematic services primarily used for interpersonal communication, by giving an overview of their main features and of the state of standardization development. In chapter 2, the layered architecture of the OSI model is introduced, as it provides the framework for the study of the different telematic services, being followed by an overview of the main activities on standards development. In chapters 3 to 7, Electronic mail, Document interchange, the Directory, Group communication (including Computer conferencing) and Videotex are respectively explained. Finally, chapter 8 presents the main concepts and state of evolution of the emerging Integrated Services Digital Network, which will integrate data, voice and image communication in the same network, and in chapter 9 some conclusions will be drawn.

## 2. COMPUTER NETWORKS AND THE OSI MODEL

### 2.1 - The OSI concept

The Open Systems Interconnection (OSI) concept is fundamental for the description of the telematic services. The aim of OSI is to provide communication - based user services that operate between computer systems, which may be located in different countries and be supplied by

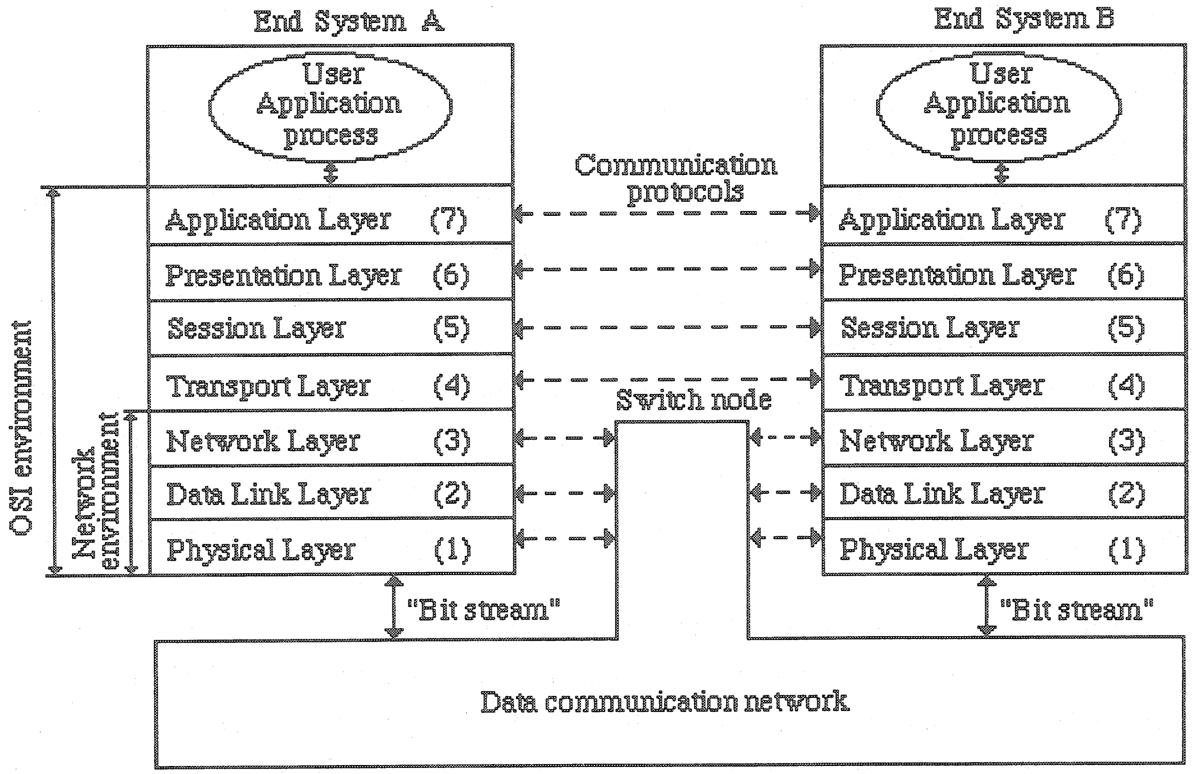


Fig. 2 - Computer communication according to the OSI model

different manufacturers [7] [8].

The communication between two computers, called end systems in the OSI nomenclature, may be modelled as shown in Fig. 2. The final goal is to provide communication between two user's application processes running on end systems A and B, through a data communication network. This data communication network can be a public or private WAN; it can also be a LAN when both computers operate in a local environment.

Due to the fact that different computers frequently have distinct operating systems and different forms of data representation, the communication between the application processes in the two end systems needs to be standardized. Special purpose hardware and software is also required in both systems to handle the requirements of establishing a communication channel across the network and of having flow and error control in the channel during the communication.

The International Standards Organization (ISO) has introduced a reference model for OSI (OSI Basic Reference Model) that provides a basis for the development of standards. In this model, every end system is structured into seven layers each of which performs a well defined function. Peer layers in two distinct systems communicate through a communication protocol.

The basic functions of each layer are :

Application layer (7) -it provides access to the OSI environment for user application processes running on the end system;

Presentation layer (6) - it provides a common representation of the application information for the communication between the two systems;

Session layer (5) - it manages the dialogue between the two end systems during the communication;

Transport layer (4) - it provides the session layer with a reliable message transfer facility, independently of the network type;

Network layer (3) - it establishes and clears a network connection between the two systems, including the network routing facility;

Data link layer (2) - it provides the network layer with a reliable information transfer facility, including error control and flow control;

Physical layer (1) - it provides the data link layer with a means of transmitting a bit-stream between the two systems. It is concerned with the physical and electrical interface between the end system and the network termination.

The lower three layers constitute the network environment. They provide the so-called bearer services, which are application-independent and are only concerned with the provision of a data communication mechanism, independent of the type of network used for the exchange of information. The OSI environment consists of all the seven layers; it includes the network environment and the additional four upper layers that allow the two end systems to communicate at the application level, providing the telematic services.

Each layer has an interface between itself and the adjacent layers. The implementation of a layer functionality is independent of all the other layers, which permits changes to be made in one layer without affecting the others. A layer operates according to a certain communication protocol by exchanging protocol data units (PDU), consisting of user data and additional control information, with a peer layer in the other system. Within an end system, each layer provides a set of services[1] to the layer immediately above it and, in turn, uses the services from the layer immediately below it to carry the protocol data units. Therefore, although conceptually each layer communicates with a peer layer in the other system according to a certain protocol, in practice the protocol data units of the layer are passed by means of the services provided by the next lower layer.

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1) In this case, the term service is used in the context of the OSI model. It is different from the concept of service used in the context of network operation, as are the cases of bearer and telematic services.

## 2.2 - The development of standards

The OSI model is a basis for the development of standards. Standards are defined for each layer and each standard is described in two documents: service definition document and protocol specification document.

The service definition document contains a specification of the OSI services provided by the layer to the layer above it. The protocol specification document contains a precise definition of the protocol used for communication between two layers and also the specification of the OSI services used by the layer to implement the protocol.

A number of standards is associated with each layer. They are sometimes defined by different bodies and may offer different levels of functionality. They are called the base standards.

For a certain OSI environment a selected set of standards has to be defined for use by all systems in that environment to allow an open communication to be established among all the systems. This is called a functional standard or profile. A functional standard states exactly which base standard is to be used in each layer in that environment, explains the less clear points of the base standards to which it refers and establishes the values of the options existing in the base standards, making them ready for implementation [9].

The most important international bodies producing standards for computer networks are the International Standards Organisation (ISO), the Consultative Committee of the International Telegraph and Telephone (CCITT) and the Institute of Electrical and Electronics Engineers (IEEE). Typically, the ISO and IEEE are interested in producing standards for use by computer manufacturers, whereas the CCITT is interested in producing standards, called "recommendations" in the CCITT terminology, for connecting equipment to the different PTT networks.

There are other organizations that are mainly active in defining functional standards. Some of the most well-known organizations working in this field are, the Comité Européen de Normalization (CEN), the Comité Européen de Normalization pour Electrotechnique (CENELEC), the Comité Européen de Postes et Telecommunications (CEPT) and the Standards Promotion and Application Group (SPAG) in Europe, the Corporation for Open Systems (COS) in the United States, and the OSI Promoting Conference (POSI) in Japan.

As an example, Fig. 3 shows a selection of CCITT recommendations (base standards) to be used for Electronic mail. At layer 7, the X. 400 series of recommendations (X. 400, X. 401, X. 410, X. 411, X. 420, X. 430) specify Electronic mail systems at the application level. At layer 6, recommendations X. 408 and X. 409 respectively specify the encoding information for the Electronic mail systems and the communication protocol at the presentation level. At layers 5 and 4, X. 215 and X. 214 define the services provided by the session and transport layer respectively, whereas X. 225 and X. 224 specify the session and the transport protocols respectively.

In this example, the recommendations indicated for the network environment, assume that an X. 25 packet data network is used for the communication. X. 213 specifies the services provided to layer 4, and the other three recommendations, X. 25 (layer 3), X. 25 (layer 2) and X.21 specify the X. 25 protocol.

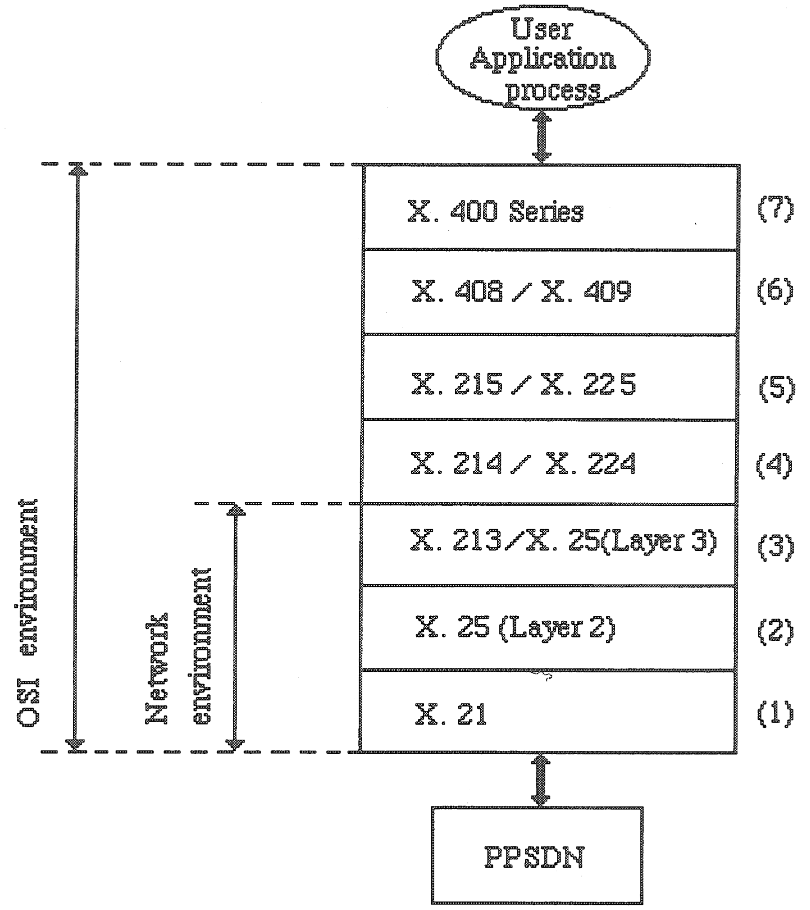


Fig. 3 - CCITT recommendations for Electronic Mail in an X. 25 network

## 3. ELECTRONIC MAIL

### 3.1 - General aspects

An Electronic mail system is a software package that, installed on a computer, provides facilities for the users of this computer to generate, send, read and file messages. In a general sense Electronic mail allows persons to exchange electronically all the information that they would otherwise exchange by conventional mail.

Several Electronic mail systems can be interconnected via an Electronic mail network which provides means to transfer the messages. An Electronic mail network has a set of rules that specify how the messages are to be transferred; these rules are the Electronic mail protocols.

A number of different Electronic mail systems have been in existence for some time. Examples are the VMS Mail over Decnet, RFC 822 over EARN and the Grey Book implementation over JANET. However, all these systems are incompatible, and gateways are needed for the different systems to communicate between themselves [10] [11].

The X. 400 series of recommendations launched by the CCITT in 1984, specify a complete application service based on the OSI model and opens the way to a uniform Electronic mail service to be provided [12] [13]. The CCITT will issue a new series of recommendations in 1988, which adds some extensions to the 1984 recommendations.

The first X. 400 interconnection was established between the University of British Columbia in Canada and KDD in Japan, in 1985. Since then, many manufacturers started developing X. 400 products and a number of PTTs committed already themselves to offer the service soon. As most of the X. 400 implementations appearing in the near future will still be made according to the 1984 recommendations, the following X. 400 description is primarily based on them.

### 3.2 - X. 400 functional model

Electronic mail systems are known as Message Handling Systems (MHS) in the X. 400 nomenclature. The X. 400 functional model for MHS is shown in Fig. 4 and embodies two levels of service. At the lowest level, the Message Transfer System (MTS) operates as a general purpose carrier of messages across the network. At the higher level, the MHS uses the MTS as the underlying carrier. It provides the users with facilities to use the MTS and also assists them in constructing and interpreting messages.

In X. 400, a user is referred as an originator when it is sending a message, and as a recipient when it is receiving a message. A message can be sent to more than one recipient. An MHS is a store-and-forward system, and to send a message from the originator to the recipient(s) there are five phases involved: message preparation, submission interaction, relaying interaction, delivery interaction and message reading.

In the first phase, the user prepares the message in an agreed structure and syntax with the support of the User Agent (UA). A UA is a set of processes in a computer that are used to create,

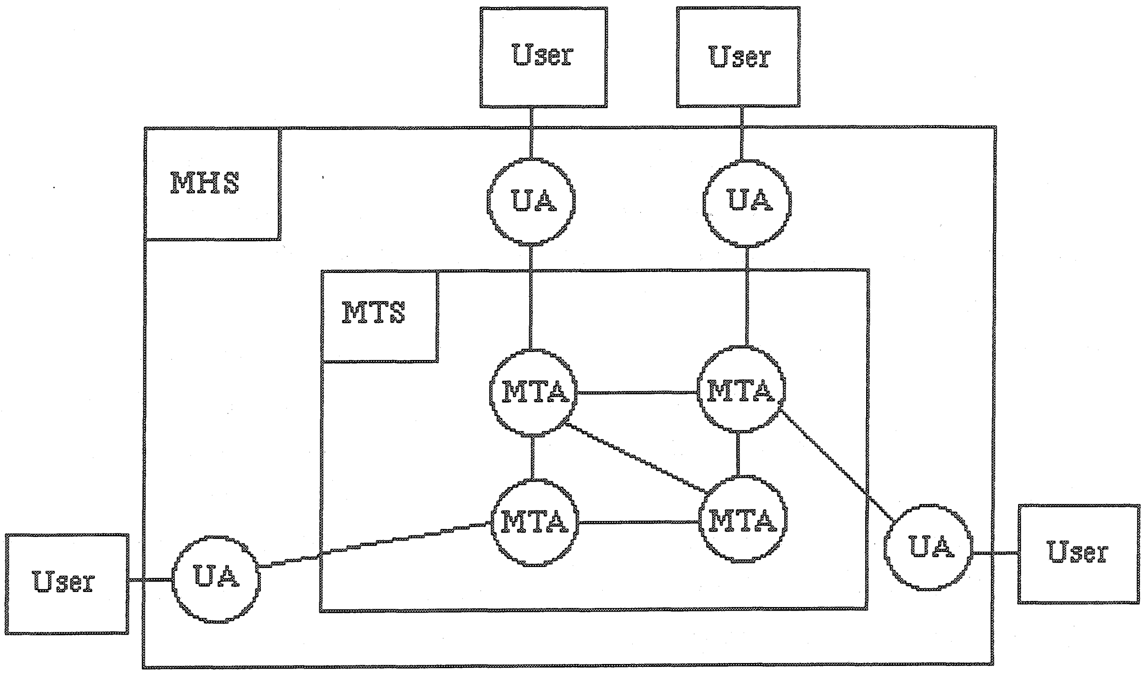


Fig. 4 - Functional model of a Message Handling System

inspect and manage the storage of messages; there is one user per UA. In the second phase, the message is then passed to the attached Message Transfer Agent (MTA). An MTA is also a set of processes that are used to carry the message along the network. In the third phase, the linked set of MTAs operate together, according to a defined protocol, to convey the submitted message to the specified recipient MTA. The latter then delivers the message to the recipient UA, in the fourth phase. The message is typically stored in the recipient mailbox until the recipient requests to read it, to complete the operation. If a message cannot be delivered, the originating UA is notified.

The structure of the message exchanged in the MTS is well-defined. It is composed of an envelope and a content, as shown symbolically in Fig. 5.

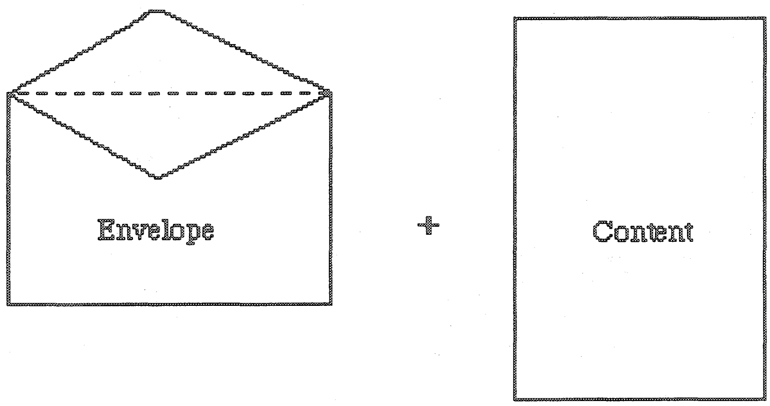


Fig. 5 - Basic message structure

The envelope contains the address information used for transferring the message within the MTS. The content is the actual message to be delivered to the recipient.

### 3.3 - Interpersonal Messaging System

According to the type of message content that they can handle, the UAs are grouped in classes, and those that belong to the same class are called "Cooperating UAs".

To satisfy the need for communicating messages from person to person, the CCITT defined in X. 400, a set of rules for a class of cooperating UAs, the Interpersonal Messaging System (IPMS). This is the only class of cooperating UAs defined until now, but others may be defined in the future, for instance, for electronic funds transfer, library services and office applications.

The IPMS comprises the MTS and a specific class of UAs, as shown in Fig. 6; in addition, to make the IPMS accessible also to users of other services, access protocols have been defined for teletex terminals (X. 430) and the access to telex and other telematic services is under study. The UAs represented in the figure with an asterisk, are examples of UAs that use the MTS, but do not support the IPMS.

The content of an interpersonal message is structured into a heading and a body as shown in Fig. 7. The heading contains the IPMS indicators and the body the actual information. In addition, the body can be composed of a sequence of body parts, each encoded according to any one of a certain set of encoded information types, such as text, voice, facsimile and graphics. The type of the encoded information of each body part is conveyed along with the body part itself.

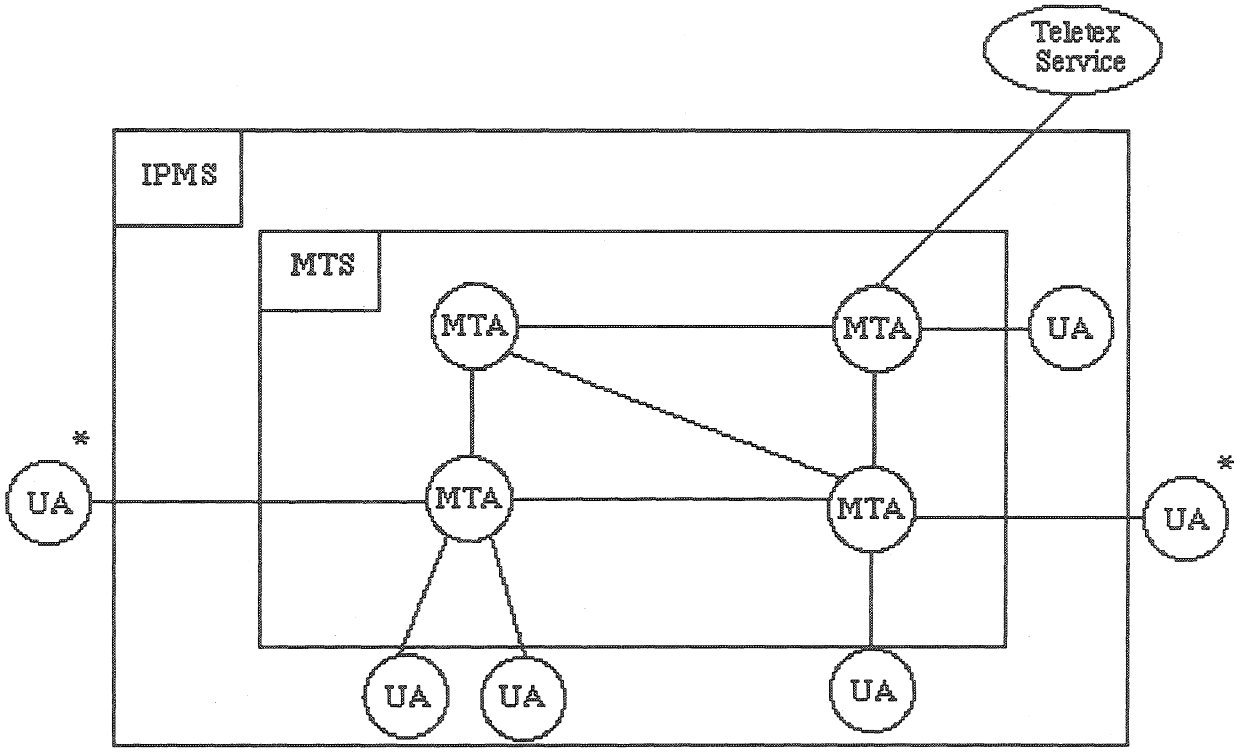


Fig. 6 - The Interpersonal Messaging System model

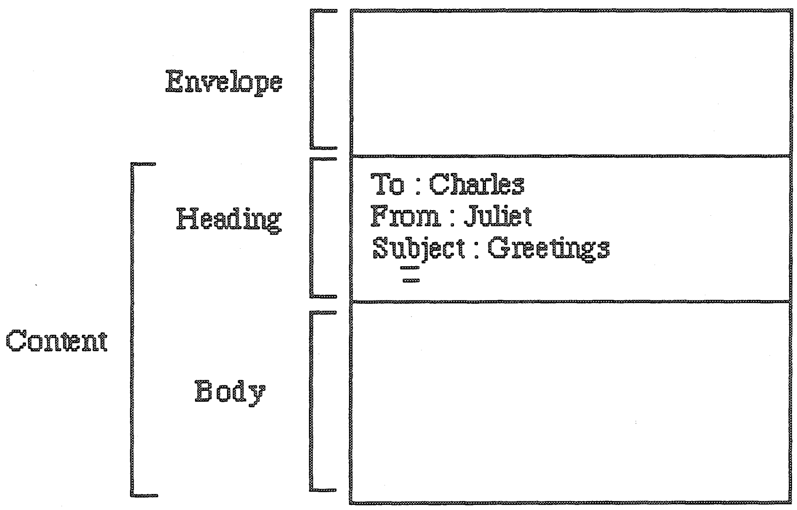


Fig. 7 - The structure of an interpersonal message

3.4 - Physical and organizational mapping

In general, UA implementations will provide storage in which users can manage incoming and outcoming messages. While processing messages, the user interacts with the UA via on I/O device. A UA can be physically implemented as a set of application processes in a multi-access computer system or in a personal computer.

A UA and an MTA may be implemented in the same system (co-resident) or in physically independent systems. Both cases are documented in the two systems represented in Fig. 8 a. On the right hand side of the figure there is no standard protocol for the interaction between the UA and the co-resident MTA. On the left hand side, the communication between the UA and the MTA is done via a standard protocol, called P3. A more complex configuration is given as an example in Fig. 8 b.

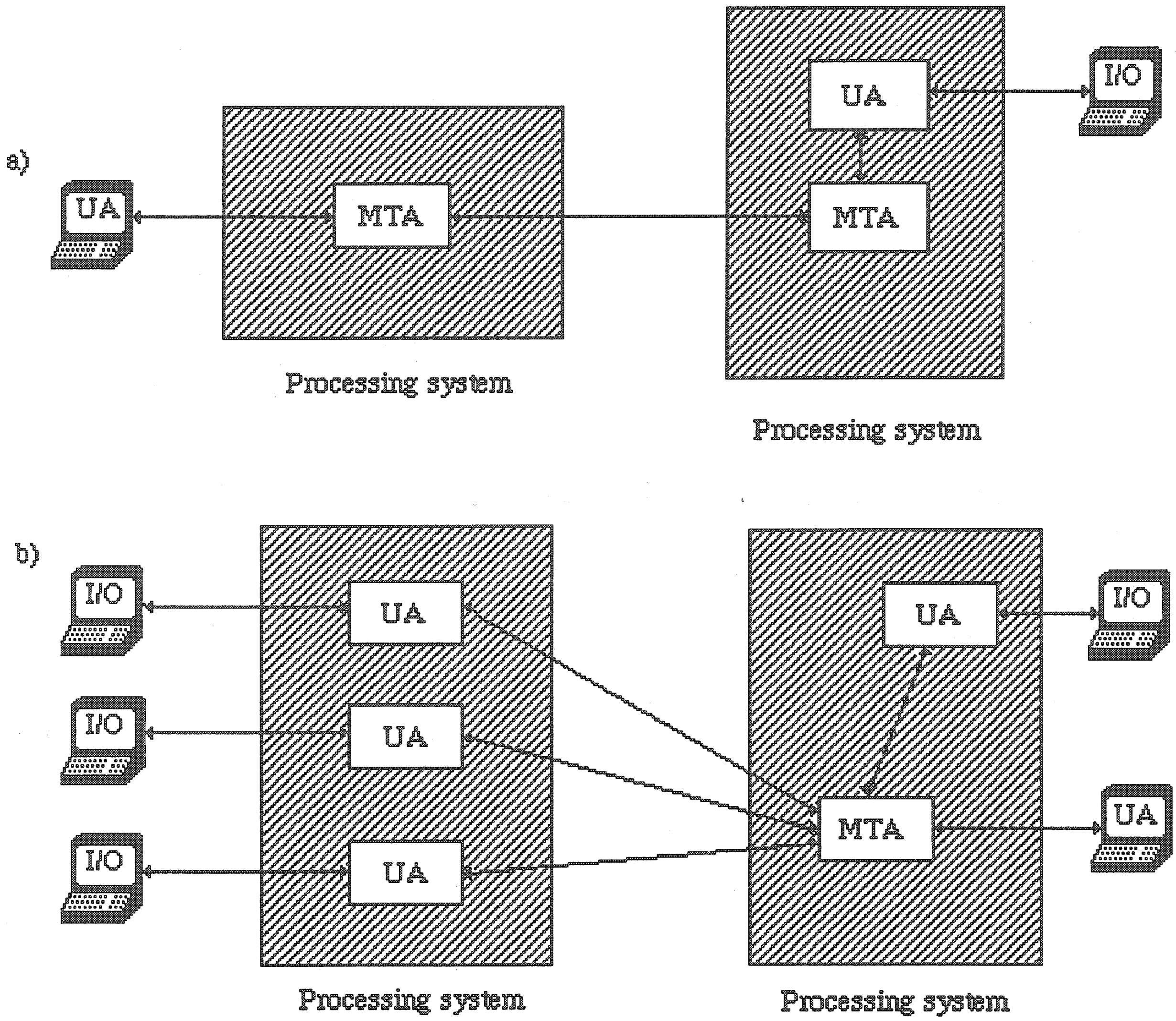


Fig. 8 - Physical mapping of the MHS

The organizational mapping of the MHS is centered around the concept of Management Domain. A Management Domain is a collection of at least one MTA and zero or more UAs owned by a PTT Administration or an organization. In the first case, we have an Administration Management Domain (ADMD) and in the second one we have a Private Management Domain (PRMD). The interconnection between Administration and Private Management Domains is shown in Fig. 9.

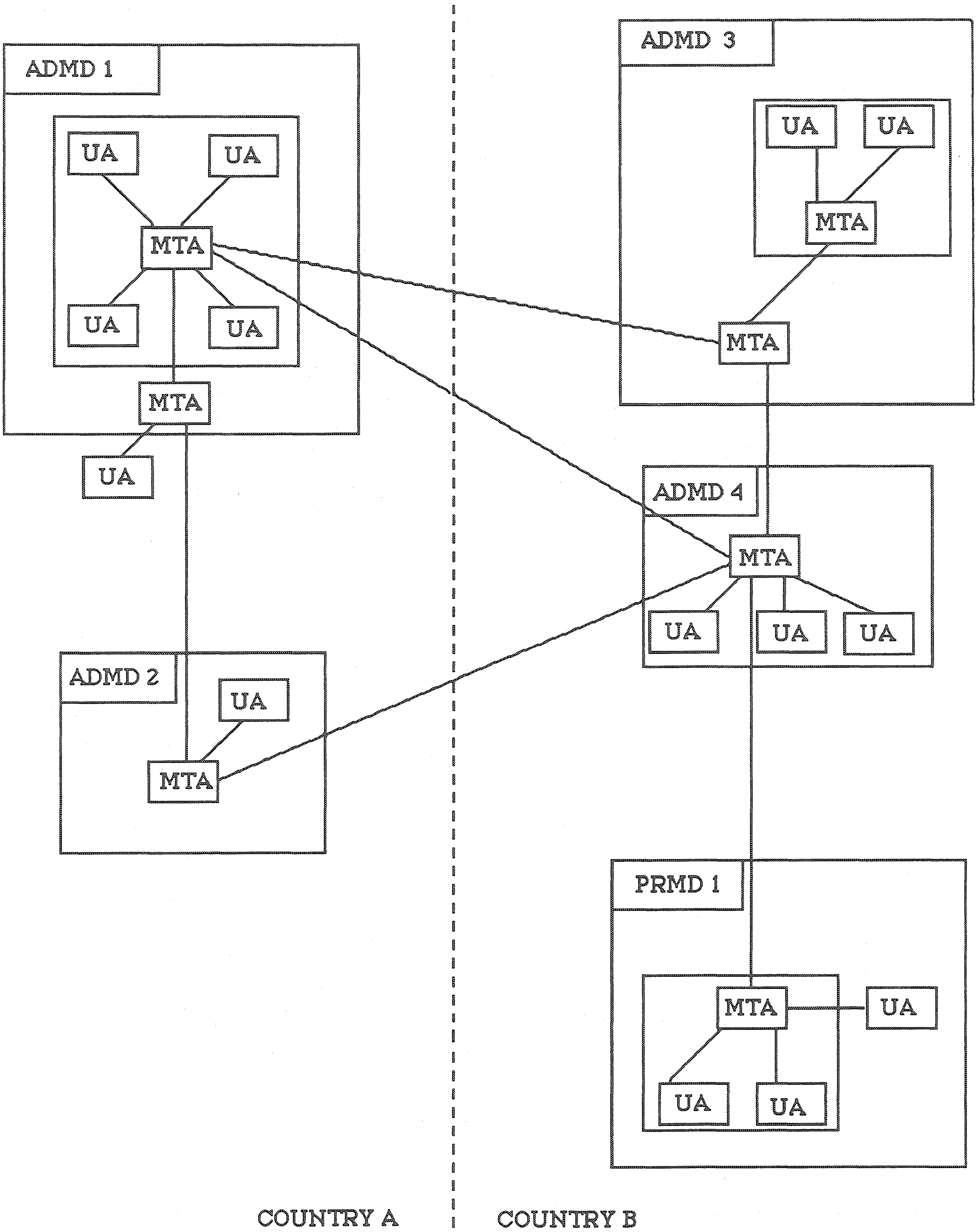


Fig. 9 - Administration and Private Management Domains

A PTT Administration may provide access for its subscribers to the ADMD at one or more of the following boundaries: i) user I/O device to Administration supplied UA, ii) private UA to Administration MTA, iii) private MTA to Administration MTA. An important role of the ADMD is to act as naming authority for all the organizations which are within its region of authority. The ADMD is concerned only with administering the top level of names; the responsability for the naming in the PRMDs is normally allocated to the organization itself.

### 3.5 - Protocols

The message handling protocols are located at the level of the application layer in the OSI model. This layer, in the case of MHS is considered to be divided into two sublayers with different message handling functions. The higher sublayer is the User Agent sublayer (UAL), which contains the UA functionality associated with the contents of messages. The lower layer is the Message Transfer sublayer (MTL), which contains the MTA functionality and provides the message transfer service. The division into sub-layers and the MHS communication protocols are depicted in Fig. 10.

There are three distinct MHS protocols : P1, P2 and P3. The P1 protocol basically defines the operations undertaken by the MTAs in relaying the messages along the MTS (X. 411). The P1 units of exchange are called Message Protocol Data Units (MPDU). There are two types of MPDU; the User MPDU, which carry messages submitted by a UA for transfer and delivery and the Service MPDU, which carry information about the messages that are exchanged between MTAs.

The P2 protocol defines the syntax and semantics of the interpersonal messages content being transferred (X. 420). The units exchanged in P2 are called User Agent Protocol Data Units (UAPDU), and they comprise the contents of the messages exchanged between UAs.

The P3 protocol enables a UA that is remote from its MTA to obtain access to the services of the MTL, through a special entity called Submission and Delivery Entity (SDE), which is co-resident with the UA (X. 411). The access includes the transfer of messages from the SDE to the MTA during submission and from the MTA to the SDE during delivery. Operational Protocol Data Units (OPDU) are the units of exchange between an SDE and an MTA. They contain the information needed to require an operation or report the result of that requirement.

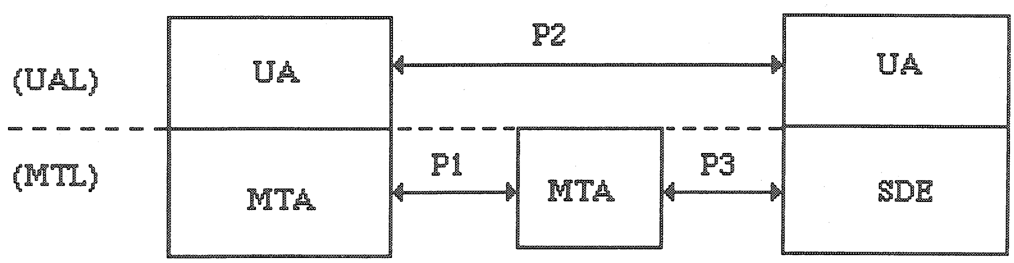


Fig. 10 - MHS application layer model

3.6 - Naming and addressing

When a user submits a message, the MTS must be informed of the identity of the recipients. This identification is done by a name, called Originator/Recipient (O/R) name.

An O/R name has two components, at least one of which must be present : i) O/R address and ii) directory name.

The O/R address contains information that an MTA can use for routing a message to its destination. The directory name is intended to be a more user-friendly and more stable form of name than the O/R address, as it will be independent of the physical configuration of the MHS.

If a user originates a message addressed to an O/R name which consists only of a directory name, then the MTS has to consult the Directory to discover the corresponding O/R address. However, if the originator supplies an O/R address in the O/R name, the MTS will use it directly to route the message to the recipient. For the time being, as the Directory recommendations have not yet been issued, every O/R name consists only of an O/R address.

An O/R address is structured as an ordered list of attributes, each of which consists of a type and a value. A typical set of attribute types that form an O/R address is the following :

| Attribute type | |
|---|---|
| Country name (C) | mandatory |
| Administration domain name (A) | |
| Private domain name (P) | optional (at least one attribute must be selected) |
| Organization name (O) | |
| Organizational unit name (OU) | |
| Personal name (S) | |

For example, the following is my complete X.400 O/R address:

C = pt; A = ctt; P = utl ; O = ist; OU = deec; S = ajc

meaning that the user 'ajc', belongs to the Department 'deec', in the Faculty 'ist', in the University 'utl', in the region of authority of the Administration named 'ctt', situated in the Country 'pt' (Portugal).

3.7 - X. 400 implementations

One of the first implementations of X.400 was the EAN (Electronic Access Network) developed at the University of British Columbia, Canada [14]. It is the mail system used at CDNet, the Canadian academic network. There is also a Europe-wide EAN network for the academic and research community, which is connected to EAN networks existing in other parts of the world. There are gateways between EAN and older mail systems. For this purpose a set of gateways at CERN allow the flow of mail between EAN and EARN, EUNET and DECnet [15]. A gateway between EAN and JANET exists in London. Some of these networks have already plans to migrate their mail systems into X. 400 in the near future, therefore eliminating the need of gateways.

Other known implementations of X. 400 are the GIPSI [16], developed at INRIA, France, in 1985, running on Bull machines and the KOMEX [17], developed at GMD, Germany, running on Siemens machines.

A large number of computer manufacturers have already announced X. 400 products to run on their machines, and some Administrations started already offering an X. 400 public service, such as the recently announced ATLAS 400 [18] in France.

## 4. DOCUMENT INTERCHANGE

### 4.1 - General aspects

The interchange of documents by means of data communication plays an important role in office automation. Documents are items such as memoranda, letters and reports, and they may include text, tables and graphics. Documents which are interchanged in electronic form should not only be printable at the receiver's site, but it should also be possible to edit and reformat the received documents in the same way as at the sender's site.

In order to facilitate such an interchange a document architecture needs to be defined. The document architecture should allow different types of contents to exist in the same document and also permit that the intentions of the document originator with respect to editing, formatting and presentation can be communicated to the receiver.

For this purpose a model has been developed which describes how documents are structured. This model is called Open Document Architecture (ODA) and is being standardized in a combined effort by CCITT (series of recom. T. 410) and ISO (DIS 8613) [19] [20]. Associated to ODA, it is also defined the Open Document Interchange Format (ODIF), which indicates the format of the data stream used to transmit ODA documents.

### 4.2 - Open Document Architecture

ODA describes a document in terms of a document profile and a document body.

The document profile is used for the document management. It specifies the characteristics of the document that apply to it as a whole. The profile includes the title of the document, the date, the name of the author and an indication of the main architecture features that are used in the document, such as the specification of the character sets, character fonts and types of contents.

The document body consists of the logical structure and the layout structure. The structure of a document consists of the division of the contents of the document into a number of parts, called objects. The logical structure associates the contents of the document with the document's logical elements, such as, chapters, sections, paragraphs and figures. The layout structure associates the contents of the document with elements related to the presentation media, such as pages, columns and blocks.

The logical and layout structures provide alternative but complementary views of the same document. Both these structures are shown applied to a simple document, a business letter, in Figs. 11 and 12 respectively.

In the logical structure of the business letter, the header and the main part of the letter can be distinguished at a first level. The header is considered to be subdivided in the date, subject, addressee and summary of the letter. The main part consists of a set of paragraphs and probably figures, and at the end there will be a formula for greetings and the signature.

The layout structure of the same letter would consist of the front page which would be divided into blocks, where the items of the header would be written, and of a number of other pages, each of them divided into blocks, where the text and figures would be inserted.

The logical structure and the layout structures of a document are defined in different ways. The logical structure is determined by the author during the editing process and the layout structure is determined by a formatting process, which is controlled by some directives associated with the logical structure, such as the requirement for a chapter to start on a new page, the requirement to underline the section title or the indication of the indentation for the start of paragraphs.

Depending on the application, either one or both structures can be transferred. If only the logical structure is transferred, although the contents of the document can be subsequently altered, its layout will be determined by the recipient's system. If only the layout structure is transferred, the layout of the document will be as intended by the originator, but the contents will be in image form, which inhibits further logical processing at the recipient's system.

An MHS can be used as the support for the interchange of ODA documents. An ODA document, encoded as indicated in O DIF, may constitute a body part in an interpersonal message in X. 400, and then be transmitted by using the X. 400 protocols.

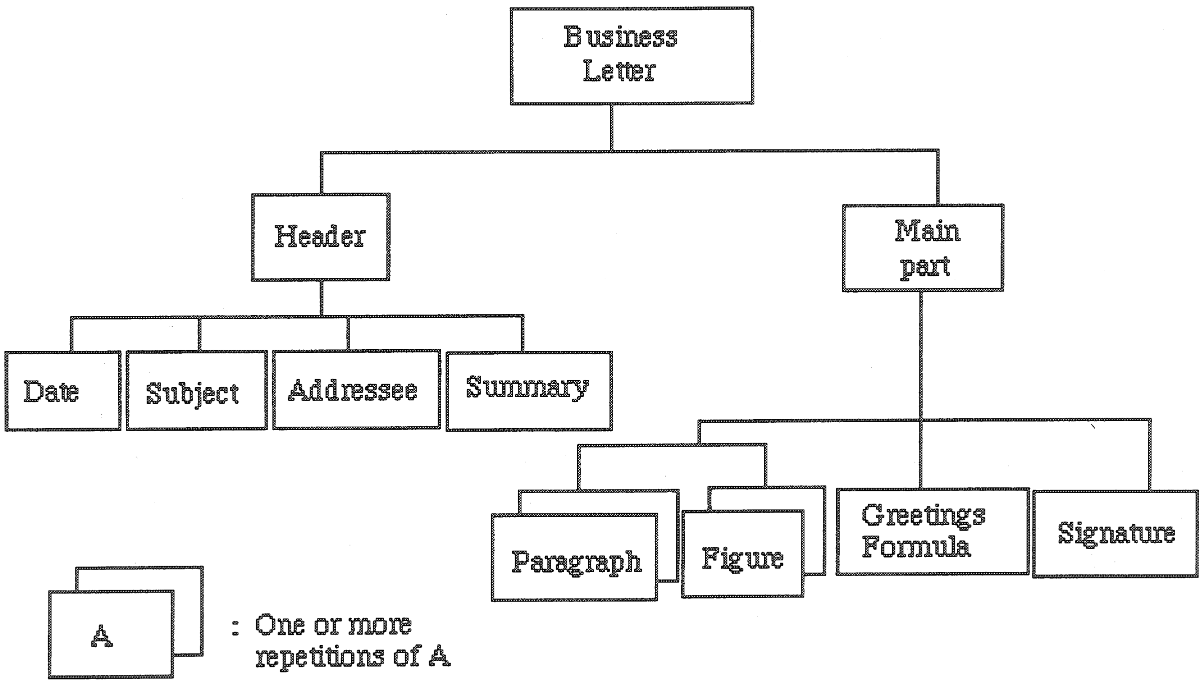


Fig. 11 - Example of the logical structure of a document

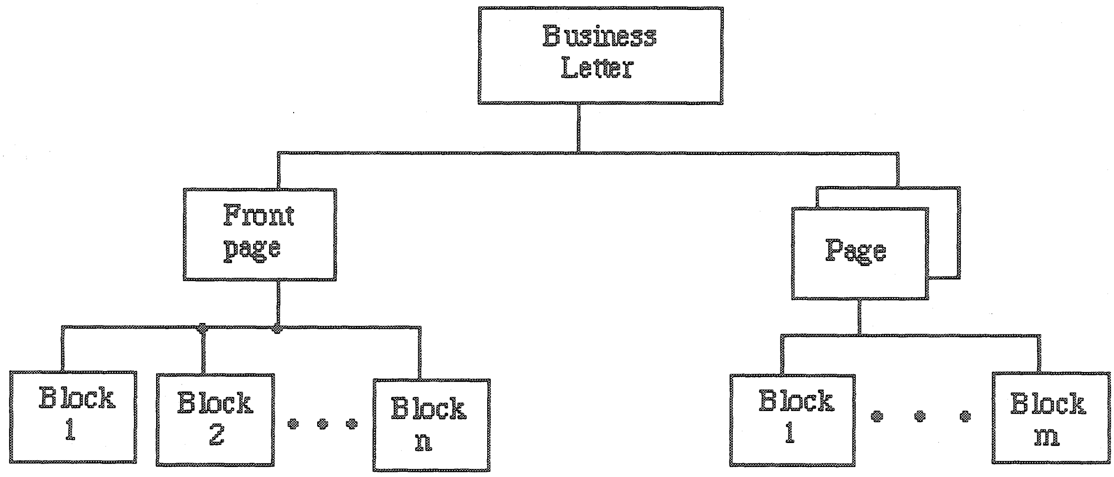


Fig. 12 - Example of the layout structure of a document

4.3 - ODA implementations

The first ODA products are expected within the next couple of years. In the meantime some pre-competitive implementations of ODA have been tried. One of the most relevant occurred in the ESPRIT PODA (Pilot ODA) project [21]. The partners of this project designed a generalised ODA software architecture for their systems and demonstrated the interchangeability of ODA documents among the different proprietary systems in the CeBIT 87 exhibition, in Hannover. In the continuation of this project a demonstration for the interchange of ODA documents containing text and graphics using X. 400 is foreseen.

## 5. THE DIRECTORY

### 5.1 - General aspects

The Directory is a collection of cooperating open systems that hold a database of information about a set of objects in the real world.

The main need for a Directory service arises from the desire to isolate the user from changes in the network, which implies the designation of a recipient by symbolic name (e.g. the O/R directory name in X. 400), rather than address ; the utilization of symbolic names gives also to the user a more friendly view of the network.

There are three main Directory functions:

i) Name to attribute binding - it binds a name to an attribute related to the object referred by the name, as it is the case of name to address binding (white pages directory).

ii) Name to list of names binding - it binds a name to a list of names, which permits to designate a group of recipients by a single common name, as it happens in the distribution lists of Electronic mail.

iii) Attribute to set of names binding - it lists the names of objects which have a given attribute (yellow pages directory).

The Directory service is in the process of standardization; many of its characteristics are already established, and it will be defined in the X. 500 series of recommendations of the CCITT [22].

### 5.2 - Functional model

X. 500 adopts the approach of having a distributed Directory model; this model has the advantage that each address resolution request can, many times, be carried out locally, thereby increasing the speed of response to requests and reducing the amount of network traffic. The Directory functional model is depicted in Fig. 13.

The component blocks of the Directory are the Directory User Agent (DUA), the Directory System Agent (DSA) and the Directory Information Base (DIB). The DUA is an application process that accesses the Directory and interacts with it to obtain the service on behalf of a user; each DUA serves a user. The DSA is an application process whose role is to provide access to the collection of information to DUAs and/or other DSAs. The DIB is a data base which holds the collection of information to which the Directory provides access. As we are in presence of a distributed Directory, each DSA holds a local data base ('DIB'), which is part of the DIB.

All services are provided by the Directory in response to requests from DUAs. The DUA interacts with the Directory by communicating with one or more DSAs, which may use information stored in its local database, or alternatively it can interact with other DSAs to carry

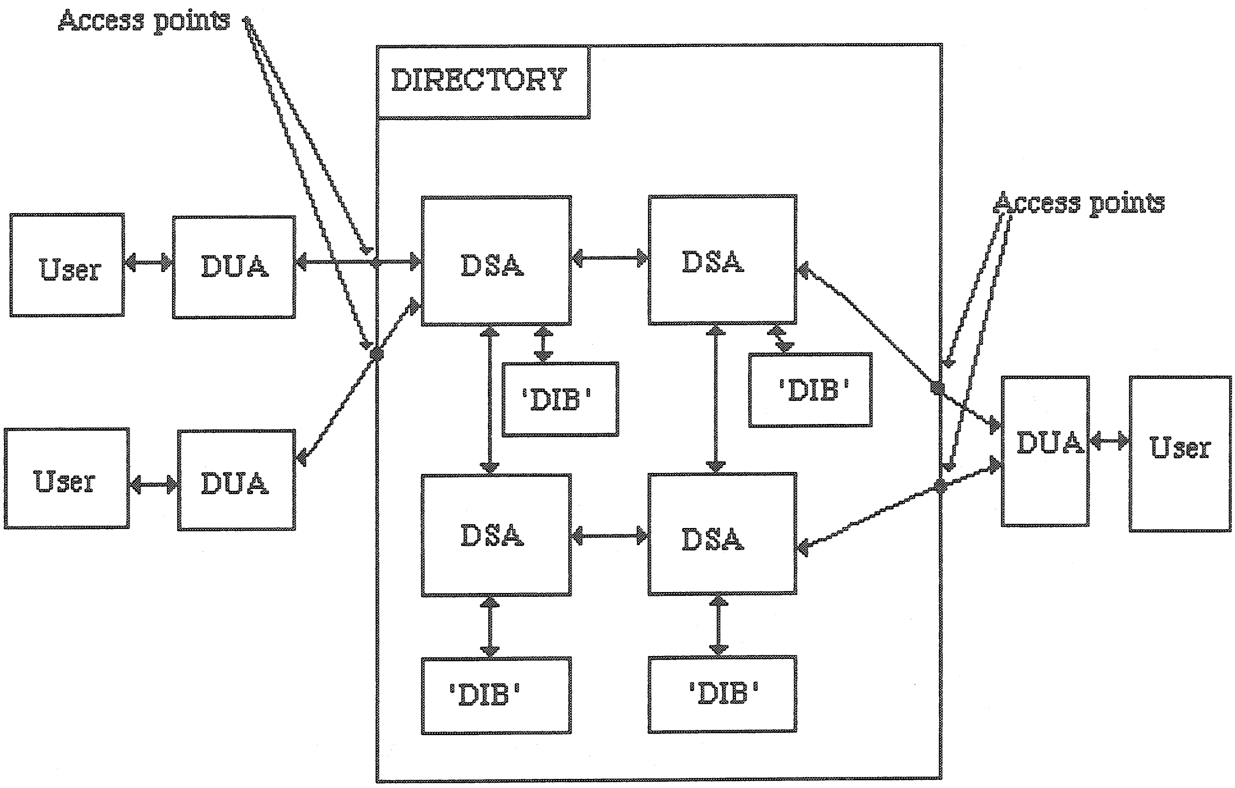


Fig. 13 - The Directory functional model

out the requests. The requests may be for Directory interrogation, such as read, compare and search operations, and for Directory modification, such as the operations of adding, removing and modifying entries in the DIB. The Directory must always report the result of each request that is made to it.

### 5.3 - Protocols

The Directory communication protocols are required to provide cooperation between the DUAs and the DSAs, and between the DSAs themselves; these protocols are located in the application layer of the OSI model, and they use the underlying layers to establish reliable connections between the individual systems independently of the network type.

There are two Directory communication protocols: Directory Access Protocol (DAP) and Directory System Protocol (DSP), as represented in Fig. 14.

The DAP defines the exchange of requests and responses between a DUA and a DSA. It contains protocol elements associated with interrogating and modifying the Directory. The DSP defines the exchange of requests and responses between cooperating DSAs.

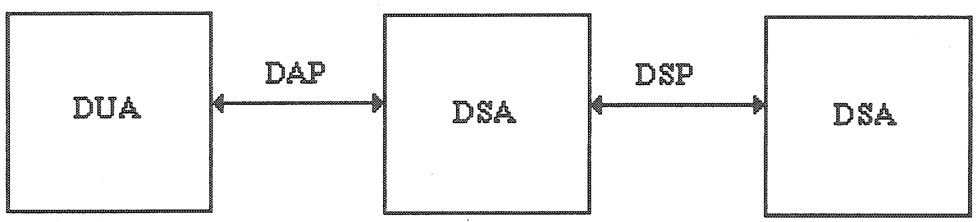


Fig. 14 - The Directory protocols

### 5.4 - MHS and Directory interworking

The Directory service has a key role in the support of MHS. The way through which both systems will interwork, is shown in the functional diagram of Fig. 15.

Both UAs and MTAs may use the Directory. For example, one UA may submit the directory name of a recipient to the Directory and obtain from it the recipient's O/R address. The UA may then supply both the directory name and O/R address to the MTS. Another possibility is that a UA submits a directory name directly to the MTS. In this case the MTS itself asks the Directory for the recipient's O/R address and adds it to the envelope.

Each UA or MTA accesses the Directory via a DUA, which is, in many cases, physically co-resident with the corresponding UA or MTA. In any case, the communication protocol between a DUA and its user is not standardized, being dependent on the implementation.

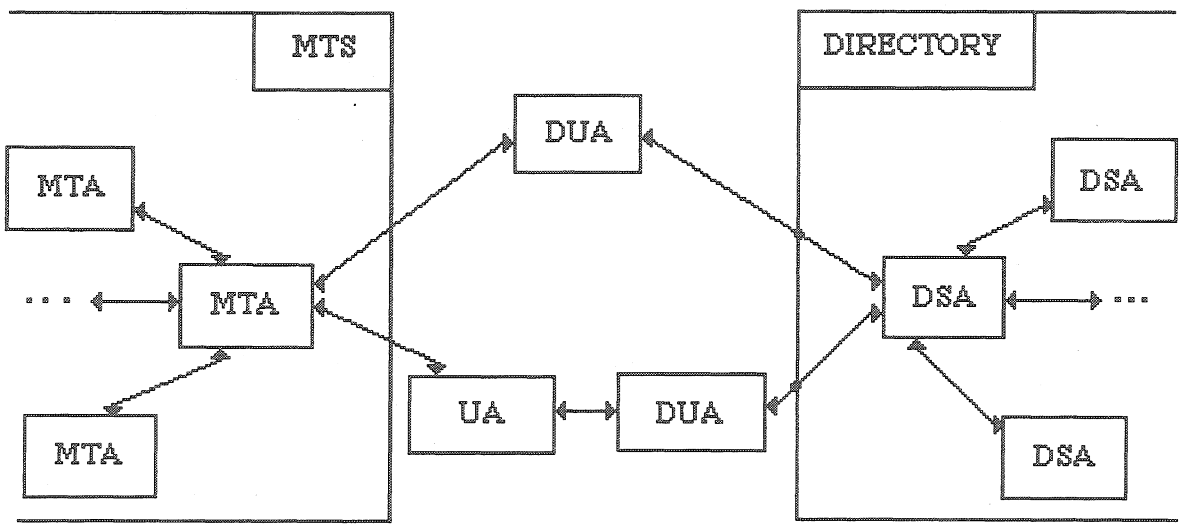


Fig. 15 - Functional model of MHS and Directory interworking

5.5 - Directory implementations

The standardization work on the Directory is still in progress and therefore, there is a small number of Directory implementations. The most relevant one is being done in the ESPRIT THORN (THe Obviously Required Nameserver) project [23]. This project was launched in 1985, and it had as an overall objective to build a Directory service in line with the emerging standards, to be adequate for the Information Exchange Service used by the ESPRIT project teams. The work is in progress and a migration of THORN to the X. 500 recommendations is under way.

6. GROUP COMMUNICATION

Group communication is concerned with the provision of facilities to support the communication needs among groups of people. Two main systems for group communication may be presently considered : i) Distribution Lists in MHS and ii) Computer conferencing. Both these systems are explained in the following sections.

6.1 - Distribution Lists

X. 400 is mainly concerned with the Electronic mail among individuals, i.e., an individual user sends a message to one or more individual users by explicity specifying all the recipients of the message. However, the 1988 version of X.400 has already a limited capability for group communication, which is the Distribution List (DL) concept [24].

DLs allow an originator to transmit a message to a group of recipients by using the O/R name of the group instead of having to enumerate each of the final recipients. More formally, a DL is a set of elements, called the DL members, each of which is an MHS user, a collection of such users, or another DL. In the latter case we are in presence of a nested DL.

The use of DLs requires the existence of a Directory, which will store the identification of the members of the DL, the names of the users that have permission to submit a DL name and the identification of the DL owner.

When an originator addresses a message to a DL, the MHS with the aid of the Directory must expand the DL, i.e, replace its name with the names of the users referred in the DL. If the DL contains nested DLs, the expansion may be performed incrementally, for example, each of the MTAs involved in conveying the message may carry out only part of the expansion. To avoid the possible looping of messages in the case of nested DLs an expansion history field must be added to the envelope in the P1 protocol, tracing the various lists that were expanded in the distribution process. By inspecting this field, an MTA can check whether the expansion of the DL has already been performed and in the affirmative case, abandons the expansion.

An example of a DL expansion is given in Fig. 16. A DL O/R address specifies the MTA at which expansion occurs. A message that contains a DL recipient name is carried to the expansion point, where the set of member names of the DL are added to the list of recipients of the message. In the case of a member of the DL being itself another DL with a distinct O/R address, the message is routed to the next expansion point.

### 6.2 - Computer conferencing

The only use of Electronic mail with DLs is a rudimentary capability for Group communication. An efficient Group communication system would require besides that facility, other ones that would allow an organized presentation of the messages to the recipients, control the access of the different users to the information and give the possibility of forming special interest groups. MHS which support all these facilities as an addition to Electronic mail are called Computer conferencing systems [25].

The basic properties of a Computer conferencing system are then the following:

i) the messages are organized into a number of distinct communicating groups, called "Computer Conferences" or "Bulletin Boards", and the originator of the message needs only to indicate the name of the Bulletin Board to make the message available to all the members of that Bulletin Board;

ii) the messages after being read must be stored by the system for some time, in order that new members of the Bulletin Board can read them;

iii) there must be the possibility of controlling the access to the information, therefore two classes of Bulletin Boards exist, the open Bulletin Board where new members can join without restrictions and the closed Bulletin Board, where participation is restrained to a selected group of people;

iv) users can establish interpersonal communication, through the Electronic mail facility, whenever they wish.

Besides these basic properties, Computer conferencing systems may include some other additional features. Two examples of these extra features are the existence of a moderator to control the information displayed in the Bulletin Boards, and the occurence of information retrieval facilities for the acquisition of stored messages according to certain search criteria, such as the author, number or date.

Although no standard exists yet for Computer conferencing, there are a few systems already working such as QZCOM, EUROKOM, FORUM and USENET NEWS. However, most of them are centralized, requiring that all the users log in a central computer, where all the conferences are organized. An example of a Computer conferencing system working along these lines is the

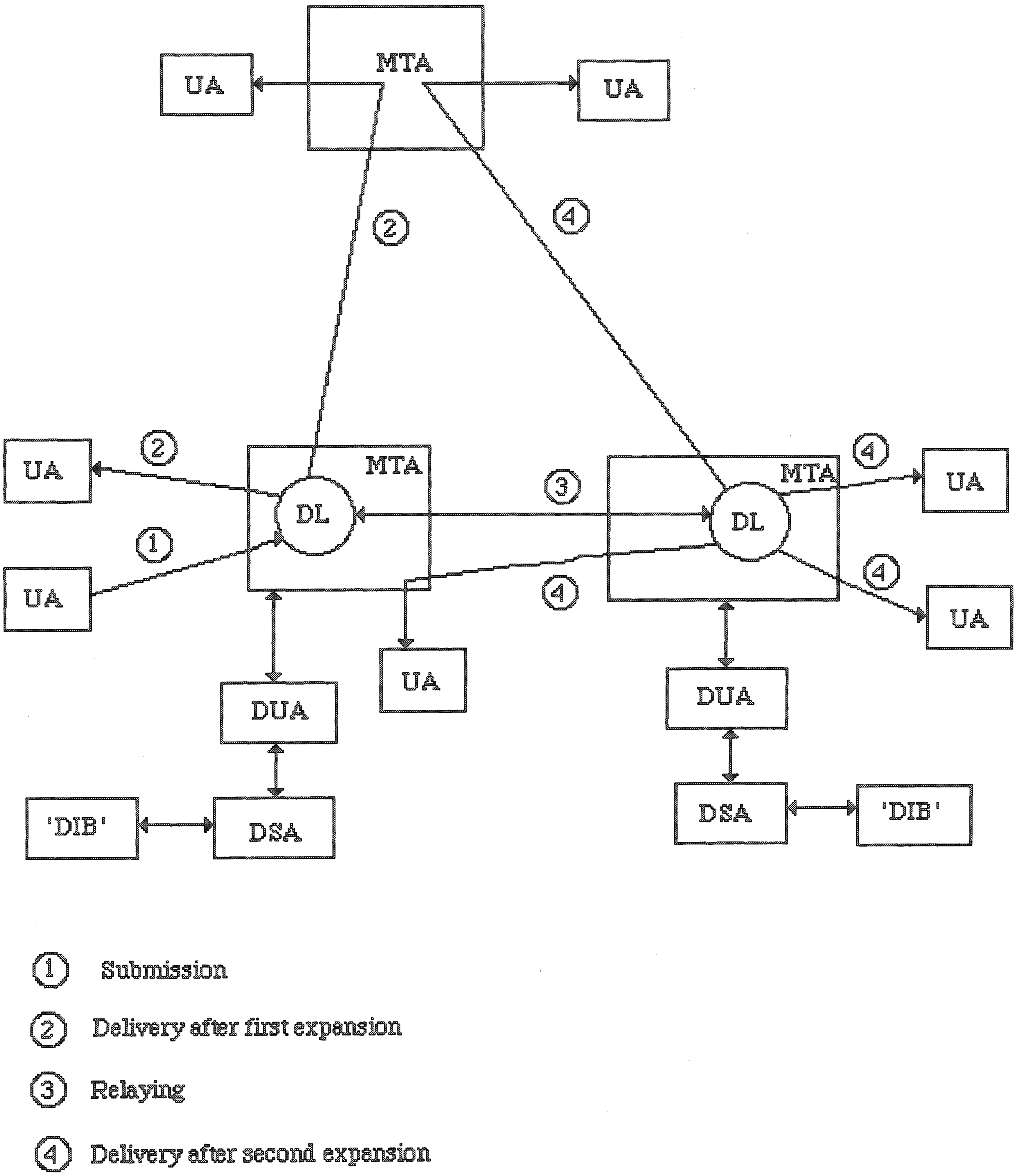


Fig. 16 - Example of DL expansion

EUROKOM. This system is located at the University of Dublin, Ireland, and was established by the EEC as an aid for the communications requirements of participants in the European research programs. It has all the basic facilities of Computer conferencing, and this can be illustrated by the indication of some of the EUROKOM user commands:

- LIST CONFERENCES ; it indicates all the conferences available
- MEMBER <conference> ; to become a member of an open conference
- JOIN <conference> ; to join a conference of which one is a member
- NOTICE ; to send a message to the current conference
- NEXT NOTICE ; to read the next unread notice in the current conference
- REVIEW ; to review entries in the conference
- WITHDRAW <conference> ; to finish being a member of a conference.

A few other Computer conferencing systems may have some support for distributed operations, but with only very limited facilities, like the USENET NEWS. The definition of a fully distributed Computer conferencing system is still at a research stage, and the possibility of extending the X. 400 and X. 500 protocols for that purpose, instead of developing a completely new protocol, is being investigated, namely in the framework of an ESPRIT project [26].

## 7. VIDEOTEX

### 7.1 - The structure and use of videotex

The term videotex may refer to two distinct systems, known as interactive videotex and broadcast videotex, respectively [27].

Interactive videotex is a bidirectional system in which the users can access a remotely located computer from their premises, and display the information retrieved from the computer on a specially adapted visual display unit. The flow of information between the users and the computer occurs in the Public Switched Telephone Network (PSTN) and/or Public Switched Data Network (PSDN).

Broadcast videotex is a broadcasting system which displays selected frames of information as they are being continuously recycled by the originator of the information. The information is prepared and stored digitally and is many times broadcast as part of the regular TV signal. Broadcast videotex is usually known as Teletext.

In this paper, only interactive videotex will be studied, as it is the most relevant system for interpersonal communication and also the one in more widespread use. In the following text, only the single term videotex will be used, meaning always interactive videotex.

The general structure of a videotex system is represented in Fig. 17. The communication infrastructure for the flow of information between the user terminal and the host computers containing data bases is normally the PSDN, but the access to this network can be done through

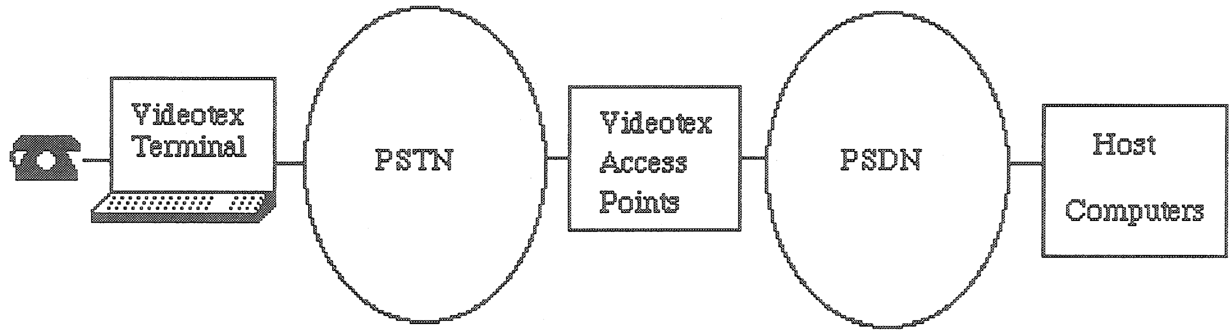


Fig. 17 - Structure of a videotex system

the PSTN, to guarantee a wide availability of the system. The videotex access points are special switching nodes that act as an interface between the two networks.

The use of a videotex system is better illustrated by a concrete example. The french videotex system, called Teletel, is chosen as the example, as it is probably the most well-known and one of the most widely used videotex systems in the world [28].

Every user has at his premises a special videotex terminal, called Minitel, connected to the PSTN. There is a range of Minitel terminals with different facilities, but every Minitel integrates as a minimum, a keyboard, a CRT display screen and a modem.

When a user wishes to access the Teletel, dials the access code in the telephone set and is then connected through the PSTN to the nearest videotex access point. The line is then transferred from the telephone to the Minitel and the video access point sends an initial menu to the Minitel display. The user can then indicate the wanted Teletel service by typing its name at the Minitel keyboard and access the respective host computer data bases, through Transpac, the french PSDN.

There is a large number of services available in Teletel, and this is one of the reasons for its success. Examples of such services are news reports, classified ads, income tax calculation, comparison of prices in different supermarkets, video games, airline and railway seat reservations and an electronic directory service containing information on the telephone subscribers.

Many other videotex systems are already in use, in a number of countries, however, they are often not compatible, as there are different representations for the text and graphics that can be followed. Examples of relevant videotex systems are Teletel in France, BTX in Fed. Rep. of Germany, Prestel in United Kingdom, Telidon in Canada and Captain in Japan.

### 7.2 - The coding of text and graphics displays

Three different options are usually considered for the representation of text and graphics in videotex systems : alphamosaic, alphageometric and alphaphotografic.

These three options are described in the CCITT recommendation T. 101 [29]. This recommendation is mainly concerned with the description of the Presentation PDUs and data syntaxes used for their coding. Three distinct data syntaxes are indicated in T. 101, which respectively define the alphamosaic, alphageometric and alphaphotografic systems. Alphamosaic is the most rudimentary solution in terms of screen image definition and alphaphotografic the most advanced; in Europe only alphamosaic systems are available as a public service, presently. Recommendation T. 101 also indicates that videotex will use the X. 215/X. 225 in the session layer and X. 214/X. 224 in the transport layer. An application layer protocol for user to data base access is not published yet.

7.2.1 - Alphamosaic systems

In the alphamosaic system the display frame is composed of defined character positions, which may be occupied by any of the characters of the repertoire. The default format of the frame is 24 rows of 40 columns.

The repertoire is composed of the alphanumeric repertoire and mosaic repertoire, in which the mosaic repertoire is formed by dividing the character space into a matrix of 2x3 elements. There is also a set of control characters.

Alphanumeric, mosaic and control characters are represented in different code tables in the terminal. A code table consists of 128 positions arranged in 8 columns and 16 rows. A code table entry is identified by a 7-bit code, in which the 3 msb define the column number and the 4 lsb define the row number.

If we consider, for example, the PLDS (Presentation Layer Data Syntax), which is a CEPT functional standard for the European alphamosaic systems, there are two alphanumeric tables (G0, G2) which include graphics symbols, three mosaic tables (L, G1, G3) and three control tables (C0, C1 series, C1 parallel) altogether. G0 and C0 are the default tables, and the evolution to the use of other tables is done through the occurrence of special control characters. The contents of four of these tables (G0, G2, C0, L) is shown in Fig. 18, as an example. Notice that the use of columns 0 and 1 is reserved for control characters.

The serial and parallel alphamosaic coding forms differ because of the way attributes are handled. Examples of attributes are the colour of a character, the colour of the screen background or the underlining of a sentence. In a terminal using a serial alphamosaic coding, the attribute codes are stored always with and precede in the same memory the characters to be displayed; attributes correspond to a position in the screen and make the cursor move. It is the case of the Prestel system.

In a terminal using a parallel alphamosaic coding, the characters comprising the display and their attributes are stored separately in different parts of the terminal memory : extra memory is required, but the attribute does not interfere with the display of the characters. It is the case of the Teletel system.

### 7.2.2 - Alphageometric systems

In an alphageometric system the display is composed of alphanumeric text and pictorial drawings defined in terms of geometric primitives transmitted to the terminal as drawing commands. This option for text and graphics representation has been adopted in North America and named NAPLPS (North American Presentation Level Protocol Syntax).

NAPLPS has five geometric primitives to draw a point, a line, an arc, a rectangle and a polygon, and a sixth one to draw a line or a polygon in an incremental way. A geometric primitive is composed of an opcode and zero or more parameters, which specify the coordinates needed by the primitive. The opcode is a 1byte character that identifies the primitive or alternatively expresses a control operation. A repertoire of alphanumeric symbols is also available.

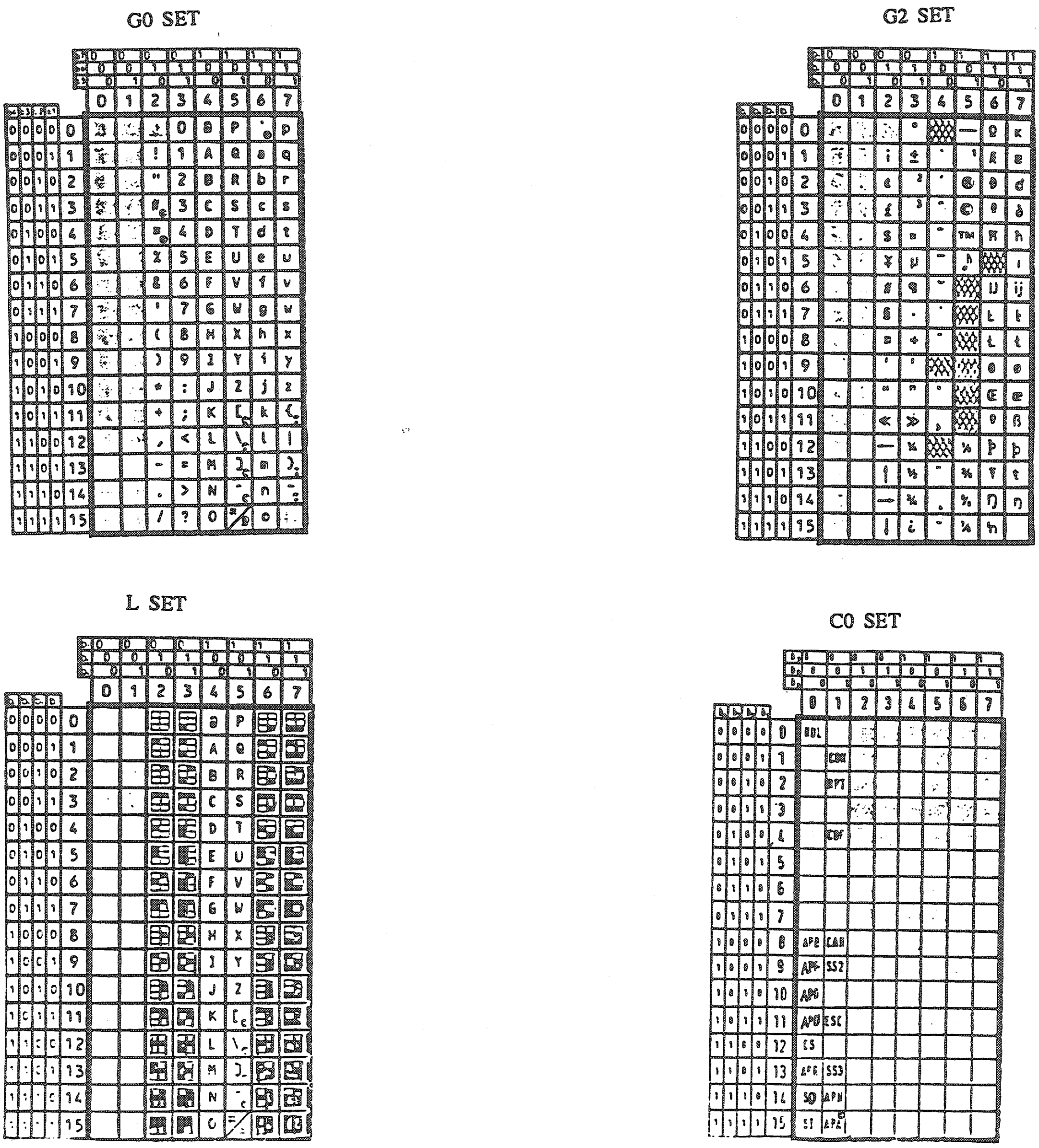


Fig. 18 - Examples of PLDS code tables

7.2.3 - Alphaphotografic systems

An alphaphotografic system is the videotex system that offers the best image resolution. An image is displayed as the result of the transmission of the individual picture elements (pixels).

This videotex system permits the storage and the display of photographs and other high-resolution images. The present limitations for its implementation result from the requirements for a large store in the terminal and high speed communication links. A pilot alphaphotografic videotex system, the CAPTAIN system, is being experimented in Japan.

## 8. INTEGRATED SERVICES DIGITAL NETWORK

### 8.1 - The ISDN concept

The Integrated Services Digital Network (ISDN) is a completely digitized communication network in which the same switches and paths are used to establish connection for the different services. As all the types of information can be digitized and transmitted in this form, the ISDN integrates voice, data, text and image communication in the same network [30]. The ISDN is being implemented by the progressive digitization of the public telephone network.

The physical configuration of the ISDN is shown in Fig. 19, consisting of : i) local exchanges, ii) transit exchanges with routing functions and iii) digital communication links.

The users may have simultaneous access to more than one service, therefore, multifunctional terminals will be typically used; the user access to the network will be done through a standard interface. Service providers, like for example videotex host computers, may connect directly to the network and a set of gateways for the ISDN to interwork with other types of existing networks have to be provided.

The CCITT I-Series of recommendations, published in 1984, define the general configuration of the ISDN, services, user-network interface structures, communication protocols and interworking with data networks [31]. Some pilot implementations have been done and a limited public ISDN service is starting to be offered in some countries. Although, due to its capabilities the ISDN can substitute both telephone and data networks, it will happen that at least in the near future the three types of network will coexist, because of network evolution strategies, rendering necessary the existence of gateways.

### 8.2 - User-network interfaces and protocols

The CCITT I-recommendations specify the types of user - network interfaces that may be used in an ISDN environment. There are two main interface structures specified : basic structure and primary structure.

In the basic structure, there are 2 B-channels plus 1 D-channel simultaneously available to the user. A B-channel is a 64 kbit/s, bidirectional, information carrying channel. A B-channel gives to the user a transparent connection to the network, and it can be used for either circuit-switching or packet-switching at the user criterion. The D-channel is a 16 kbit/s, bidirectional channel, mainly intended for carrying signalling information associated with the B-channels. It always operates in a packet-switched mode, and as the signalling rate is usually less than 16 kbit/s, the channel can be multiplexed to be used as a third information carrying channel available to the user, although at a rate lower than the B-channels.

In the primary structure, there are 30 B-channels (23 in North America) plus 1 D-channel. The primary structure is typically utilized by users that have PABXs at their premises and therefore need to have simultaneously available a large number of channels. Each B-channel has the same characteristics as in the basic structure, but the D-channel, in this case, operates at 64 kbit/s.

As the ISDN is only concerned with the provision of communication facilities, it only covers

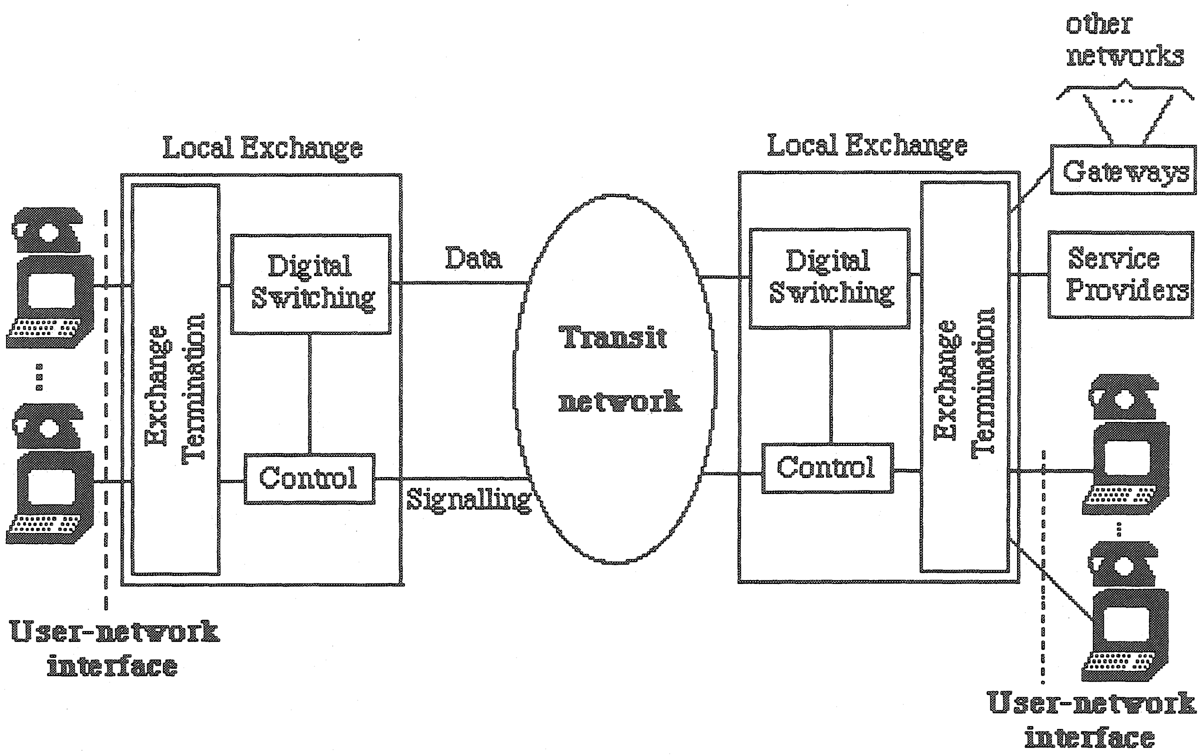


Fig. 19 - The ISDN configuration

the first three layers of the OSI model, respectively the physical, data link and network layers. Assuming the basic interface structure as an example, the use of the different ISDN protocols is indicated in the lower three layers of Fig. 20.

The I-recommendations define the communication protocol to be used at the physical layer (I. 430, I. 431), the data link protocol in the D-channel (I. 440, I. 441) and the network layer protocol for signalling in the D-channel (I. 450, I. 451). The users are free to choose the layer 2 and 3 protocols for the B-channels, and if the D-channel is also used to carry the user information, X. 25 must be used at layer 3 in that case. The data from the distinct B-channels and D-channel are multiplexed at layer 1 into a common frame for transmission to the local exchange.

The teleservices, e. g. Electronic mail, Directory, Videotex, Telephony, Fax, Teletex, Videotelephony, use all the seven layers of the model, as documented in the same figure. End-to-end signalling, i.e., user-to-user signalling is considered a special application that utilizes the ISDN signalling protocol at layer 3.

## 8.3 - ISDN evolution

The introduction of a public ISDN will accomplish a number of strategic objectives, bringing advantages to the users and to the network operators. The user will have a large number of telecommunication services available through a standard interface, at a speed higher than the one generally available in present public data networks. The user may also have some economic advantages, if as a result of factors of economy of scale, the ISDN tariffs reduce the cost of the services provided. A better quality of service is also expected, due to the digitization of the network, and a better planning for the network evolution can be achieved.

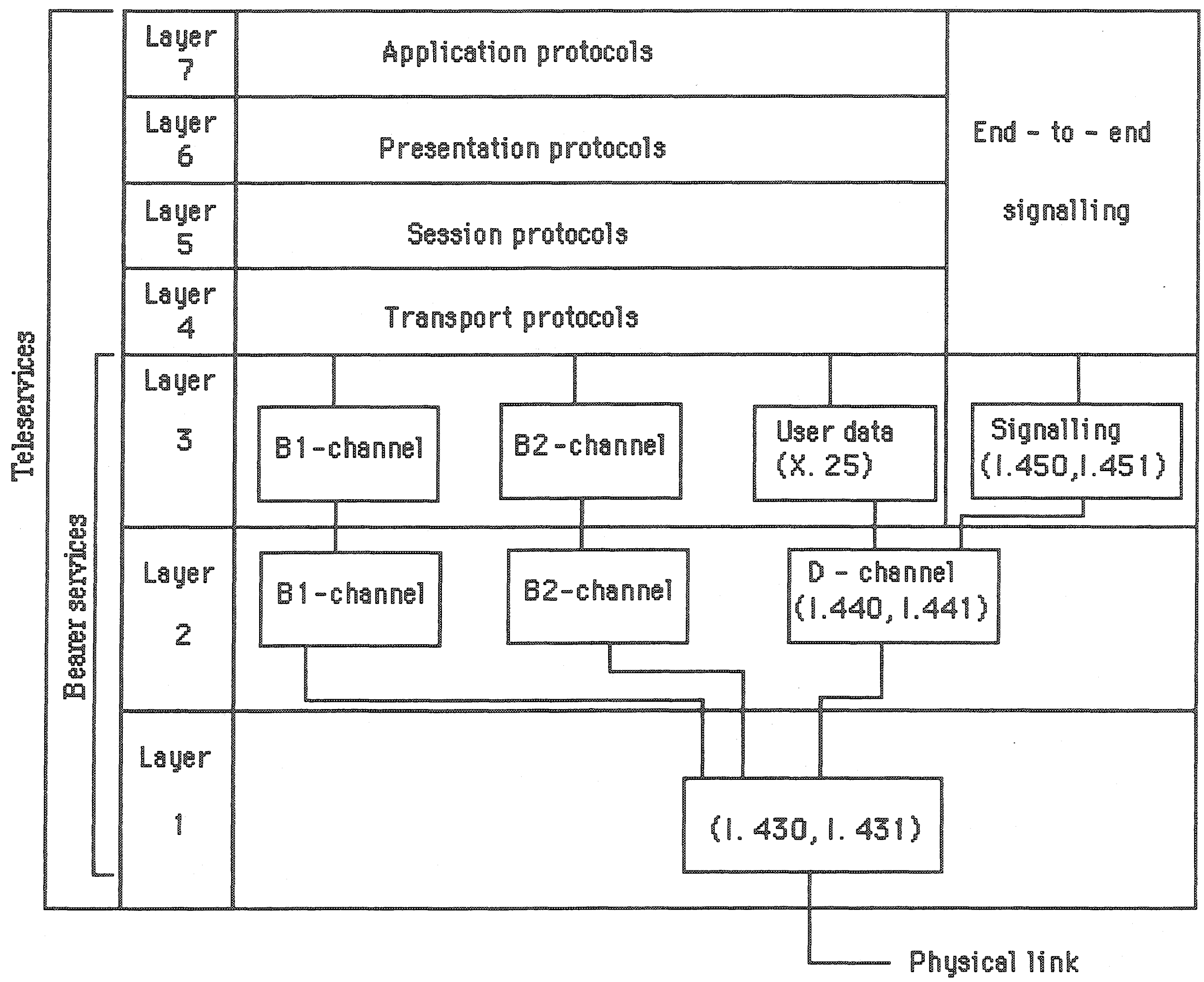


Fig. 20 - Protocol structure at the user-network interface

Despite these advantages, ISDN will only be available in a widespread scale in a few years from now, due to the high investments that are necessary to make and to the need of harmonizing its introduction with the existing telephone and data networks. The sucess of its introduction will be also very dependent on the tariffs charged to the user and on the definition of ISDN functional standards that may guarantee the compatibility of the ISDN implementations in the different countries.

At present, ISDN starts to be available in some European countries, such as France and Germany and in the United States. It is foreseen that many other European countries, Canada and Japan will also start offering ISDN services in the next five years, although at a limited scale.

The evolution of ISDN towards higher speeds is at a research stage, presently. Work is being carried out, in order that speeds in the order of hundreds of Mbit/s can be achieved in a public network with integration of services, taking advantage of the high transmission speeds allowed in optical fibers, which will be more and more used as the transmission infrastructure in communication networks. These high speeds would allow the integration of all the services available in the ISDN and services that require higher speeds, such as, high definition TV distribution, video communication and high-speed file transfer, in the same network, called Broadband ISDN. Special switching and transmission techniques, network structures and new services definition for a Broadband ISDN are being investigated in Europe (RACE project), United States and Japan, being possible that the first pilot networks appear up to 1995 [32].

## 9. CONCLUSIONS

Interpersonal communications using computers is a subject of prime importance for the scientific community, due to the large international collaborations that are set up in many scientific fields, namely in High Energy Physics.

The scientific community is normally a forerunner in the use of new telecommunication facilities and services. This has been exemplified in the latest years through the use of many private academic and research networks, such as EARN, EUNET, DECnet, JANET, EUROKOM and others, which incorporate network-oriented telematic services, not yet available in the public network [33]. Due to the lack of OSI standards, all these networks have their own proprietary protocols. In order to ensure compatibility among the networks, eliminating the need of gateways, there is now an effort to achieve the migration of the protocols existing in the different academic and research networks towards OSI protocols [34] [35]. This effort is being coordinated by the RARE (Réseaux Associés pour la Recherche Européenne) Association [36], which was founded in 1986 and groups more than twenty european countries and international organizations, including CERN.

The use of public telecommunication facilities, whenever available, is also encouraged by RARE, and this is well exemplified in the EAN network, which is running an X. 400 prototype implementation on the public X. 25 network, since 1986. It may be foreseen that, if tariffs are reasonable, the use of the public telecommunication networks by the scientific community may significantly increase in the future, accompanying the gradual introduction of the different network oriented telematic services based on OSI protocols and of ISDN.

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