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LOCAL AREA NETWORKS IN PERSPECTIVE

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ABSTRACT

Current scientific and trade literature are flooded with information about local area networks. Details about physical media and their properties, versions of media access methods confusingly called protocols, variations of ARQ protocols, and information about file servers, name servers, gateways and so on proliferate the literature. This review article puts the various aspects of local area networks in perspective and points out some of the important considerations when evaluating such a network.
CR categories — C.2.2, C.2.5, H.4.1
Keywords — Local networks, media access methods, logical link control, protocols, office automation, standards.

1. INTRODUCTION

1.1 Why we need Local Area Networks

During the late 1970's and early 1980's there evolved a need for networks to access computers remotely. Some of the reasons were that the remote machines ran a common application, that the software needed was simply not locally available or that the local computer was not powerful enough. In many cases the need was simply to have access to a computer; any computer.

The proliferation of mini-computers and micro-computers during the last few years has led again to another wave of demand for interconnection. This time, however,the terminals or workstations to be interconnected exist within a single building or group of buildings such as a campus. In addition, access may be via a gateway to a wide area network. Moreover, workstations may use a common network to share files or databases or an expensive resource such as a laser printer.

The objective of this paper is to explain the different approaches to LAN's and to describe the important issues when planning such a network.

1.2 When is a Network a LAN

There is no single defining characteristic of a Local Area Network (LAN), although the product of capacity and the length of the LAN medium in bit-metres per second is sometimes used [3]. When this product is divided by the signal propogation velocity, the number of bits potentially in transit on the network at any one time is obtained. For a LAN this figure is typically between 10 and 100 bits on a 1 kilometer link. A conventional wide area network, for example, may have hundreds or thousands of bits in transit at any instant over that same distance.

Another consideration is that the maximum distance between any two workstations in a LAN is at most a few kilometers and more likely only tens of metres. A practical limit to a LAN is often the boundary within which cables can be privately installed without resorting to common-carrier facilities.

It is moreover usually expected that a LAN should allow the attachments of several types of workstations such as synchronous terminals, personal computers, file storage devices and host computers from different vendors. Ideally this should be so,but at the current stage of technological development, it is often the case that different vendors' software is mutually incompatible.

It is also envisaged that at some time in the future a LAN should be able to carry some or all of, coded and non coded information, data, text, voice and images. Such Integrated Services Data Networks (IS-DN) will, however, not be restricted to LAN's only. Fig. 1 illustrates what a LAN of the future may well look like.

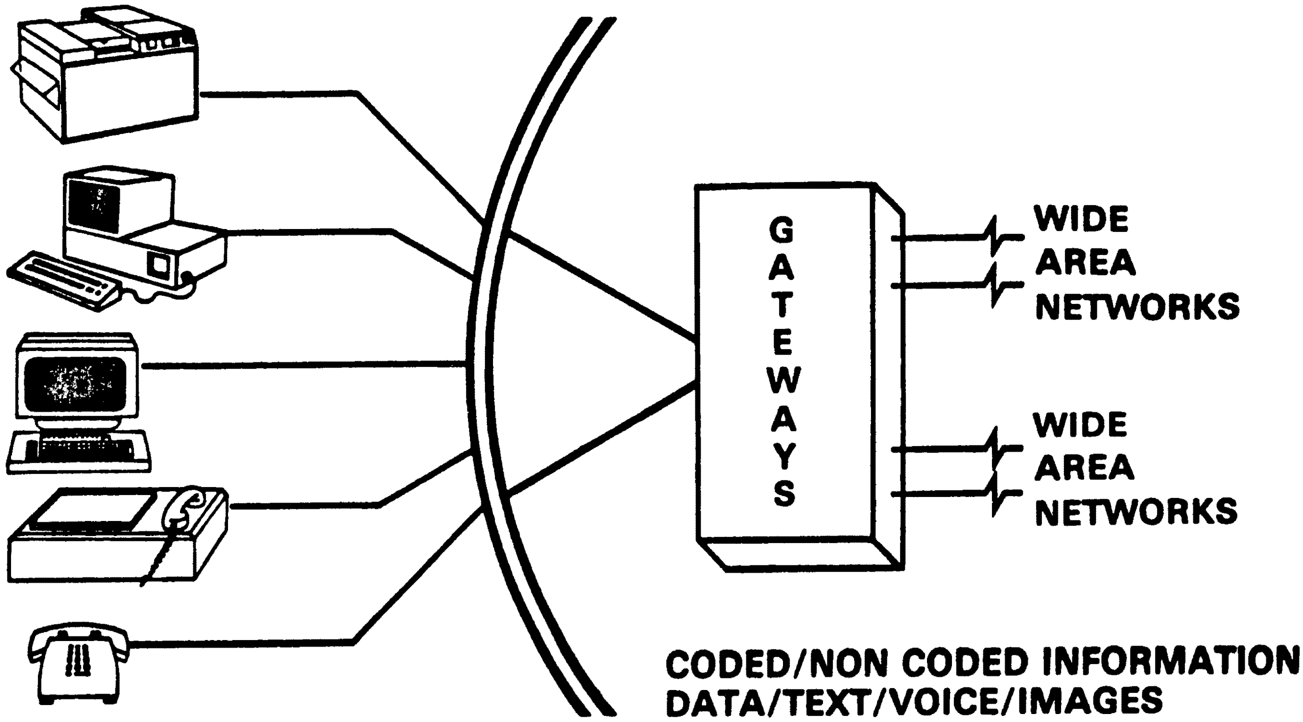

figure 1

A LAN — as it may appear in the future

1.3 LAN Topologies

The pattern in which the various workstations on a LAN are to be connected to one another is referred to as the topology of the network. There are mainly two topologies, namely a ring and as bus topology.

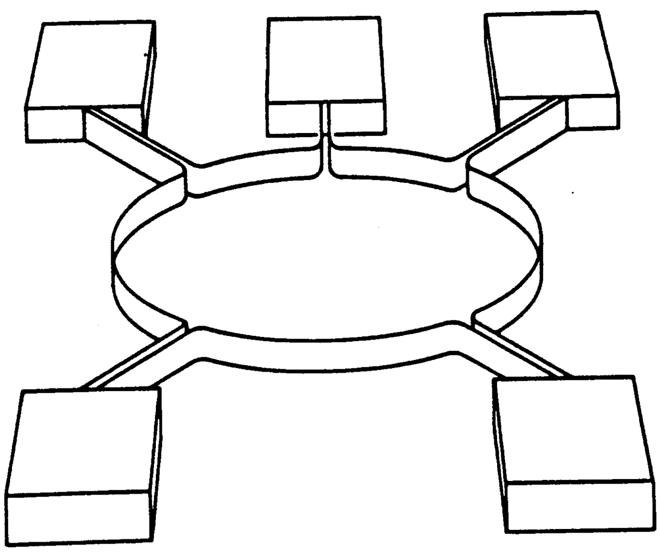

figure 2a

LAN Topologies: Ring

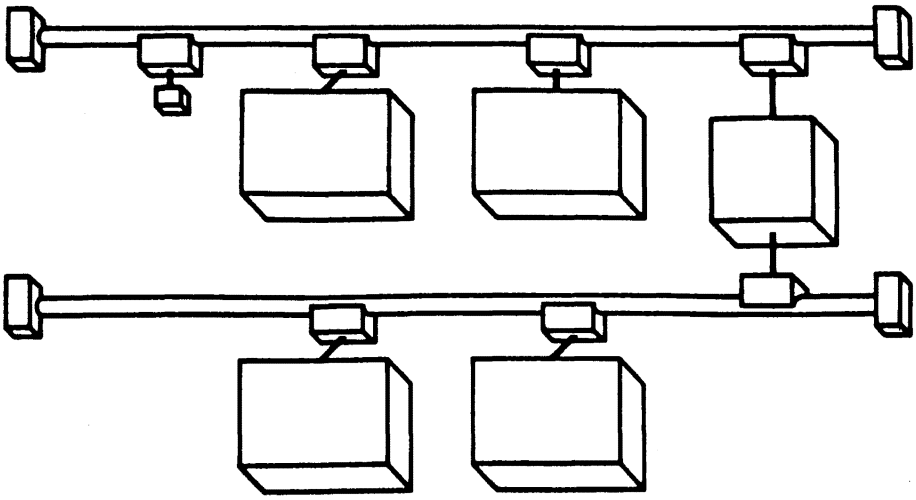

figure 2b

LAN Topologies: Bus

A ring topology is illustrated in Fig. 2(a) and as the name indicates, the various workstations are connected in a closed ring and the direction of signal travel is always unidirectional by design. In the bus topology, illustrated in Fig 2(b), the ring does not close up on itself and for any station to reach any other, the signal transmission must be bidirectional. Although many manufacturers supply networks which have a logical star topology, such networks are not LAN's in the true sense of the word and are often simply a network connecting a set of personal computers.

A ring or bus can be connected to other rings or buses (as for example in Fig. 2(b)) via a bridge, as opposed to a gateway, by which is usually understood a link between the LAN and a wide area network. In the case of a bridge the protocols in the LAN being connected have to be the same. The functions of a gateway, on the other hand, are basically threefold: translating the protocols of one network to those of the next network, ensuring that the destination network does not become flooded with data as well as translating addresses between networks if required.

2. THE PHYSICAL INTERFACE

2.1. The Physical Medium

Transmission media for local area networks include twisted-pair wires, coaxial cable and fibre-optic cables. In addition cables designed specifically as a transmission medium for LAN's are now commonly available. In Fig. 3 some typical cabling media are illustrated.

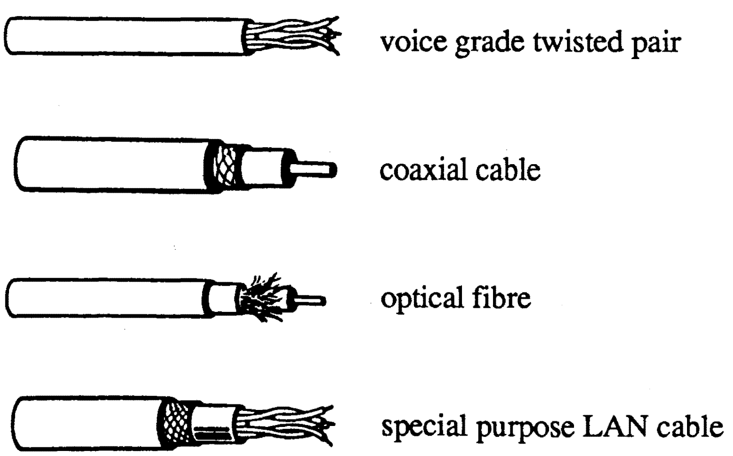

figure 3

Some Typical Cabling Media

Although inexpensive and easy to install, the physical characteristics of voice-grade twisted-pair copper wires are such that practical data rates achievable are in the order of 64 Kbps or less, although rates as high as 1 Mbps can be achieved over short distances. At the same time, the medium is very susceptible to electromagnetic interference.

Fibre-optic cable has the potential to be the superior medium for use in local area network; it offers the very high bandwidth needed to support high data transfer rates; it is not suceptible to electromagnetic interference nor does it generate such interference. The technology for joining fibre-optic cables and providing the physical interface between the cable and workstation has, however, not yet been perfected.

The most popular LAN transmission media at the moment are based and broadband coaxial cable. The cable is physically similar in both implementations, but the electrical characteristics are different.

On a baseband coaxial cable a single message is transmitted in one direction at a time (half-duplex mode) only. No modulation of a radio frequency carrier wave takes place as in broadband transmission, but the raw data bit stream is usually encoded before transmission using techniques such as Manchester encoding. Depending on the electrical properties of the medium, data rates as high as 16 Mbps can be achieved. Baseband cable is considered to be a "passive" medium in that all electrical power used to drive the network is supplied by the user workstation.

Using broadband coaxial cables as a medium, a radio-frequency carrier wave is modulated using cable television technology to provide multiple channels, if required. Broadband techniques can support data rates as high as 150-200 Mbps on simultaneous bi-directional transmissions (full-duplex mode) using different frequencies. Broadband cable is considered an "active" medium, in that the electric power used to drive the network is based in the network components.

While broadband promises higher performance for the future, more baseband systems are being implemented today. One reason is cost: baseband cable is less expensive and does not required expensive modems. Nor does it require a seperate power source. Future ISDN's which will require the integration of voice and video as well as coded and noncoded data, will most likely require a broadband medium however.

2.2. Media Access Methods

Since in both the ring and bus topologies all workstations make use of a common medium, protocol mechanisms are required to control which workststions may use the medium and for how long. These protocols are usually referred to as media access control protocols or simply media access methods.

The two primary classes of media access methods are contention and token-passing. Ring networks almost exclusively use a token passing method; bus topologies can use either.

Contention access methods are based upon the assumption that if several workstations make infrequent use of the medium, simply starting a transmission when the need arises is more efficient than implementing a complex control method. Although there are several variations, the most common contention protocol labours under the name Carrier Sense Multiple Access with Collision Detection (CSMA/CD). This latter method was developed at the Xerox Park Research Laboratories and has become synonymous with the commercially available Ethernet [1] LAN's.

Since the latter is a baseband network which has no carrier wave the term "carrier sense" is somewhat confusing. The principle, however, is for the interface controller of a workstation which is ready to transmit, to "listen" to the medium. If no transmission is taking place, it starts transmitting. the time taken for the transmission to reach a remote workstation (called the propogation delay) albeit short, is not negligible. It is therefore possible that a remote workstation may, during the the time it takes for the first transmission to reach it, have listened to the medium, detected no transmission, and may thus have started its own transmission, thereby causing a collision.

As soon as workstations realise that a collision has occured, they immediately cease transmissions and try again after some delay which would be different for the respective workstations. There are various algorithms for deciding the length of the delay for each workstation involved in the collision. This princple, although conceptually simple, is one of the main drawbacks of the CSMA/CD access method in that no workstation can be guaranteed a response time by the network. Equally, there is no way of giving priority to any one or a group of workstations. One of the main advantages of Ethernet, however, is that the interface is passive, so that a workstation may simply be switched off without affecting the rest of the network.

The most common ring access control method is the token ring protocol [2]. Typically the "token" is a special 8-bit pattern, which continually circulates from workstation to workstation around the ring. When a workstattion has something to transmit and receives the token, it turns the token into a "connector" by altering the bit-pattern. Immediately after forwarding this connector, the station may start transmitting. During this time, all other workstations may only listen to the network. The process continues until the original source node receives the message from the last upstream workstation and determines whether the intended recipient received the message error free. If so, it places the token back in circulation on the ring.

Token passing therefore guarantess access to the network within a predetermined length of time, making it more suitable than contention methods for command control, process, or other real-time applications. It is also possible to assign a priority to a workstation or a group of workstations. if none of these requirements are important, CSMA/CD may well be the preferred technique, however, particularly at low traffic rates.

Various other access control methods for LAN's have been developed at universities and in research laboratories. Some of these are also available commercially. Most prominent of these are slotted rings and register insertion rings. The standards world is not taking these efforts very seriously however, as will become evident in the next section.

3. LOGICAL LINK CONTROL

In the excitement about the, almost daily developments in LAN technology, it is frequently forgotten that many vendors offer little more than the hardware and the software to achieve the media access control. Beyond the media access control it is still necessary to ensure that a data frame, as a package of data with its accompanying control information is called, arrives error free at its destination. If the message comprises several frames, as it typically may when a large file is being transferred, there has to be a guarantee that the frames will arrive at their destination in the same sequence as when they were dispatched. In addition, it is necessary to ensure that one workstation, such as a terminal, is not flooded by data from another faster workstation, such as a file server. Some flow control mechanism is therefore required.

Simultaneously, it is important that frames and their content will make logical sense from one LAN to the next, or within a network between one device and another which may not be from the same vendor. To this latter end, the Institute for Electrical and Electrical Engineers (IEEE) in the United States have proposed the standard Local Network Logical Link Control (LNLLC) frame format illustrated in Fig. 4.

access control	dest. addr. 8-56 bits	source addr. 8-56 bits	dest. service addr. 8 bits	control 8 bits	information variable length	FCS 16-32 bits

figure 4

IEEE LAN Frame Format

Another issue relates to whether a logical connection is established or not between two communicating workstations before data are exchanged. A logical connection is similar to a telephone call , establishing a permanent logical link between two workstations. The source and destination Service Access Point adresses are therefore required at the time the connection is set up and do not have to be otherwise included in the frame, thus saving bandwidth. This is often referred as a *connection* network service as opposed to a *connectionless* service when no such virtual link is set up between two communicating workstations. There is still some discussion in research circles as to the advantages of the one type of service above the other.

The IEEE and the European Computer Manufacturers Association (ECMA) have also laid down standards for the various control methods referred to above. These are commonly known as the IEEE 802 LAN standards and comprise of the standards described on Fig. 5. Proposal 802.6 concerns itself with so-called Metropolitan Area Networks which will make use of existing physical networks used for cable television. The equivalent ECMA standards are described in Fig. 6.

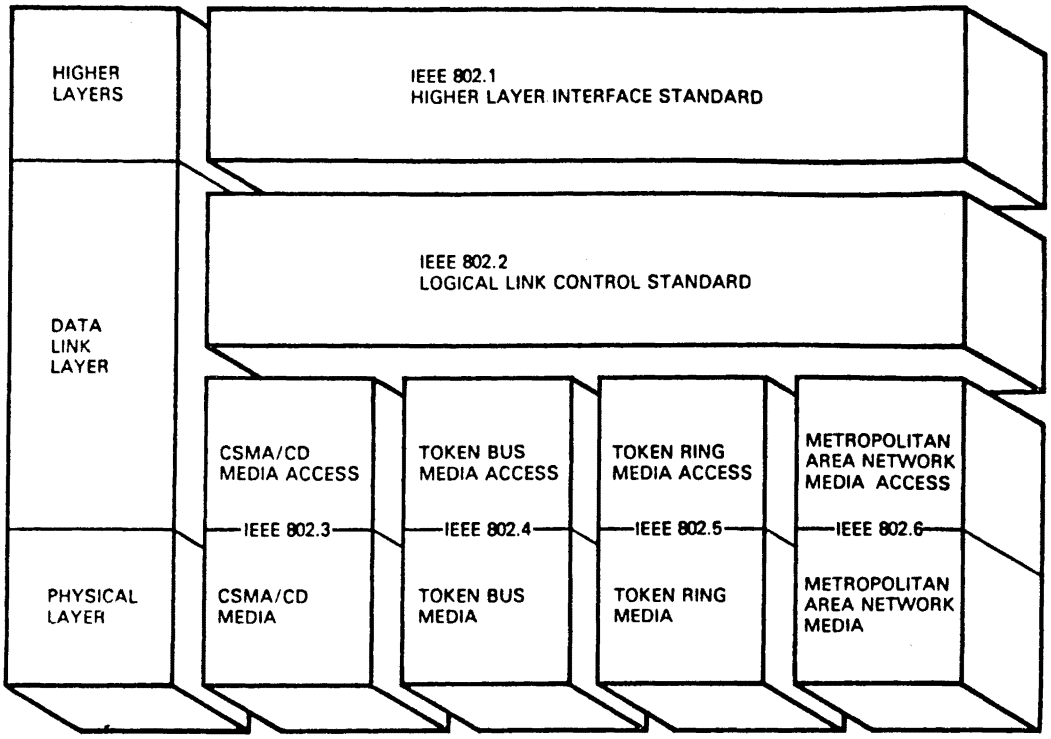

figure 5

The IEEE LAN Standards

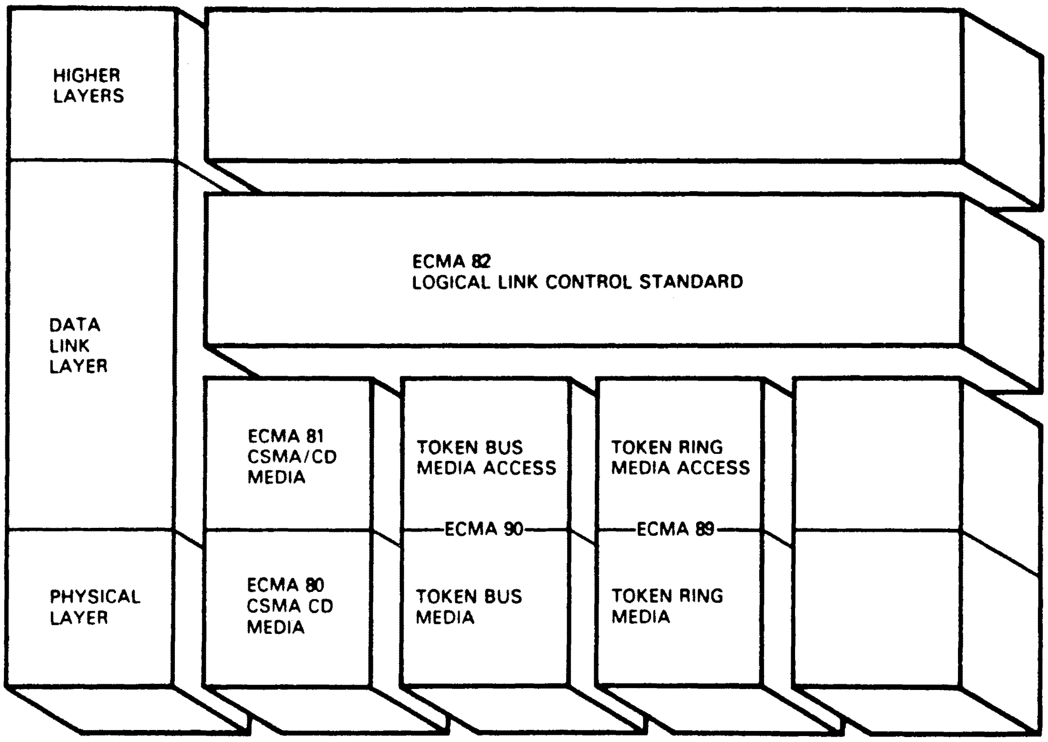

figure 6

The ECMA LAN Standard

The services and functions which exist at the logical link level, including network management functions, are sometimes referred to as the *Establishment Communication System.*

4. THE ESTABLISHMENT INFORMATION SYSTEM

Having mentioned the various physical properties of local networks, it is important to realize that, although it is important for the end user to be aware of those aspects of LAN's, it is mostly irrelevant as far as he is concerned. Being provided with a LAN with the facilities described so far, is similar to being provided with a computer and its operating system without any application software. Much more relevant to user of a LAN are the much more loosely defined services that a LAN should provide. The collection of such services has been variously referred to as an *Electronic Office System* or *Establisment Information System (EIS).* Fig. 7 illustrates where, what is commonly understood to be a LAN, fits into the full picture.

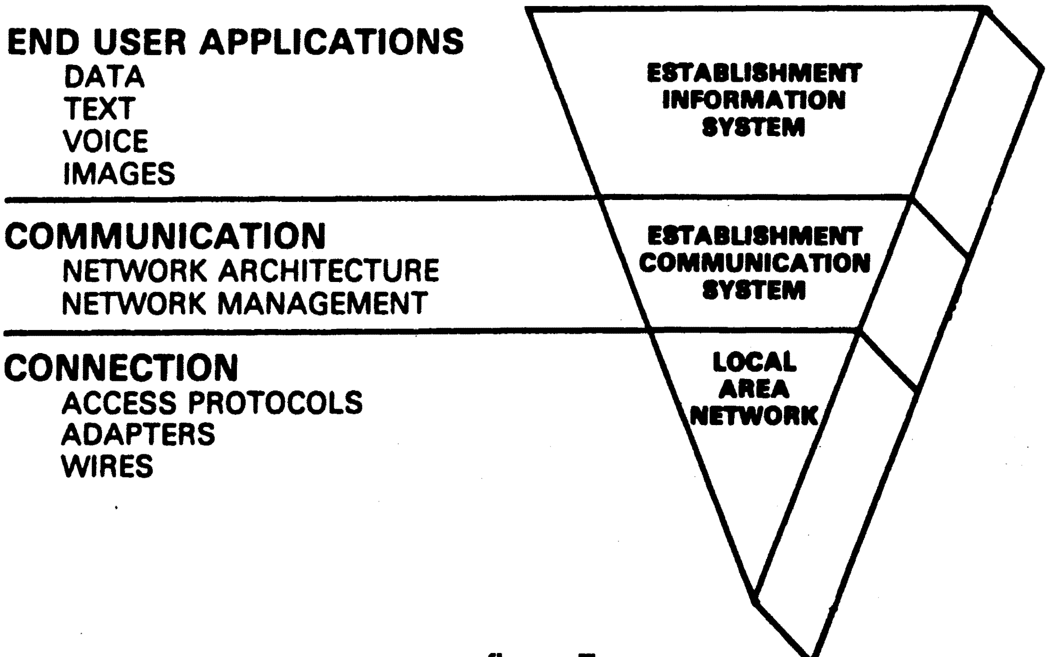

figure 7

Local Area Networks in Perspective

4.1 Typical EIS Services

From the viewpoint of its users, a LAN in a general office environment is therefore a collection of some or all of the following services:

Document creation. This includes preparing correspondence, reports, proposals and manuscripts. This activity may include assembling a document from other documents which already exist. The ability to substantially revise existing documents without having to retype entire contents, improves the productivity of the office workers engaged in that activity.

Document formatting. The user has normally a lot of control over how a document is formatted; that is, how the text is arranged on its pages. For example, the user can specify, independently of the contents, a document's page size and margin areas. The user can specify and respecify the document format without altering the text.

Printing documents. Because documents can be typed and revised using display devices, the user needs to print the document only after being assured that its contents and format are satisfactory. The need for successive printed draft copies is greatly reduced. The office system can usually print the document while it performs other office functions.

Document distribution. Documents can be distributed through office systems networks intead of through the mail.

Filing and retrieving documents. Documents can be filed in, and quickly retrieved from a central library or database. The library may be remote from the site at which the document was created or where it is to be used.

It should be borne in mind that these services may be be required not only on the LAN, but indeed from a remote wide area network or a remote LAN. The complexity of the problem at the EIS level is several orders more than at the other levels. For example, the database on the LAN may have a file format different from that of the workstation accesing it, while simultaneous updates by various users must be prevented.

Very few commercial systems supply the software to provide services such as those referred to above and an organisation often lands up with only the bottom triangle in Fig. 7 when it acquires a "LAN".

4.2 Documentation Format and Interchange Standards

Office systems may differ in several ways, for each offers different capabilities and addresses the needs of different users. Clearly there is a requirement for a uniform structure for information that is interchanged between users of the services provided by a EIS. This structure must have an encoding method that is designed to convey any document regardless of its contents, from one workstation on the same or a different network; and to communicate the intent of the person who sends or creates a document as to how it is to be processed.

The encoding method must also be flexible and extendible to allow it to accomodate new requirements as they arise. Rules must also be established to cause the various office systems to interpret documents uniformly and process them in a consistent manner. Standards such as those referred to in the last paragraph are being established as witnessed by the recent vendor standards [4] for a Document Content Architecture (DCA) and Document Interchange Architecture (DIA).

5. CONCLUSION

Physically a LAN is a combination of interconnected equipment and programs used for moving data between points where it may be generated, processed stored and used. As far as the user is concerned, a LAN is a collection of services. Few systems as yet provide the software to support those services and when they do, a user who leaves the confines of his own LAN finds himself in protocol jungle which will take many years yet to sort out.

ACNOWLEDGEMENT

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3. Tannebaum AS, [1982], *Computer Networks*, Prentice Hall Inc.
4. *Office Information Architectures: Concepts*, [1983], IBM Form G23-0765-0.

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2. Bohm C. and Jacopini G., Flow Diagrams, Turing Machines and Languages with only Two Formation Rules., *Comm. ACM,* **9**, 366-371, 1966.
3. Ginsburg S., Mathematical Theory of Context-free Languages, McGraw Hill, NewYork, 1966.

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