BASIC PRINCIPLES OF COMPUTER NETWORKING

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ABSTRACT. The basic principles of networks, the terminology used and the features offered by the most commonly used systems are summarized.

If you ask one hundred computer experts what is the key point now and in the near future of all computer systems, at least ninety of them will answer "telecommunications". As a matter of fact, computer installations have evolved from centralized resources shared by many people, in the early 70's, to distributed processing, in which each user has his own computer, in the early 80's, to network processing, in which each user has access to more than one computer, some local, some remote, each running specialized applications. Consequently, the need to exchange information between computers has evolved over these years, and is in fact the key to this new kind of processing. However, most of us use the services provided without having a clear idea of what is involved. Although this is probably an indication that network computing has reached its goal, it is also evident that a minimum understanding of the terminology and corresponding concepts may help improving the quality of usage of such systems. It is with this aim, following a request from Dr. Wilkins, that I am writing these short notes, which will therefore not be very technical, but only explicative of terms and concepts.

First of all, it should be evident that the physical location of computers plays a major role in determining the services provided: the technology used to connect computers within a single building, for example, cannot be the same as the one used to connect computers hundreds of miles away from each other. Computers connected within short distances are usually referred to as Local Area Networks (LAN), as opposite to Wide Area Networks (WAN), which imply a wide geographic distribution. Among the several possible implementations of LANs, the most successful one has been Ethernet, jointly developed by DEC, Intel and Xerox in the 70's, but now used by most manufacturers of mini computers, personal computers and workstations, including Sun, Apollo, HP, etc. Ethernet allows for a 10 Mbit/sec (nominal) transfer rate, and can extend, by means of repeaters, up to 10 km in length, connec-

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ting up to about one hundred computers. The physical medium may be a special cable (the 'base' Ethernet) as well as the normal coaxial cable used for TV or even the sinmpe twisted pair of telephone connections. Fibre optics are also allowed, to travel long distances without loss of signal. One key feature of Ethernet is its capability of accommodating different domains at the same time, so that a single Ethernet installation may have DECnet as well as TCP/IP running simultaneously. DECnet is the communication software used on all DEC machines, in particular on the VAX/VMS family of computers, but it is also available on workstations from other vendors (e.g. Sun and Apollo) as an option. TCP/IP is the standard communication software on all machines running the UNIX operating system. Each computer may also have both methods of communication installed, so a user may have the need to know when to use each of them. The 10 Mbit/sec transfer rate of Ethernet is, as already said, nominal: the overhead is often such that only 30-40% of such a transfer rate is attained by the end user application. However, it is still high enough to allow basically all services, including file transfer of any size, remote inter-process communication, remote procedure call, and of course e-mail (user-to-user). Of particular interest is the possibility of having "file-servers": computers with a lot of disk space on-line, which serve the requirements of diskless stations over the Ethernet. In this way, workstations with their own CPU and video can stay in the office environment, while disks (and tapes) stay in a central location, where particular environmental conditions can be maintained. This also allows to add workstations to the LAN without need of reconfiguration, and at the cost of a base system only. Servers could also maintain special devices to be shared by users, e.g. an optical disk archive in order to make available to all users huge amounts of information, which could not otherwise be duplicated easily. The conclusion is that not the resources of a single, personal computer, but that of all the LAN, are made available to all users. But this is not enough, because users have to communicate over distances well over those allowed by LANs. One of the services provided by the LAN - or, better, by a specialized computer over the LAN - is that of a communication processor, which connects the system to one or more distant services, which, in turn, could be the communication processor of another LAN. It is the set of these remotely connected computers that forms the WAN. This can be either homogeneous or heterogeneous. In a homogeneous network, all computers talk the same protocol and therefore allow - at least in principle - the same kind of capabilites offered by LANs; however, the connection to different computers is done using lines provided by the PTT's, at a speed which is generally 9600 bits per second or - in the best cases - 56 Kbits per second, not even comparable with the 10 Mbits per second offered by Ethernet for example. As a consequence, file transfer (of moderate size), remote login and e-mail are the only services provided by such kinds of networks. In Europe, examples of homogeneous WANs are the STARLINK in UK and ASTRONET in Italy, with VAX computers, and EARN, with IBM computers. A heterogeneous WAN has the purpose of connecting different brands of computers to provide a minimal service, which often is only e-mail. The advantage is in the

number of computers connected, which is often very high: an example is the U.S. Arpanet, which connects something like 5000 computers. In a homogeneous network, connection to other networks is possible through the use of "gateways", which are hardware/software systems installed on a single node, and allow forwarding of e-mail and file transfer. As an example, ASTRONET uses a gateway in ESRIN to communicate with SPAN, and another in Pisa (or Bologna; both owned by INFN) to communicate with EARN/BITNET. We will not go into details of each network, and how to use a gateway to send e-mail messages, since this is covered by the paper of Chris Benn in these Proceedings.

As we said, remote login is not always offered as a service, and to overcome the deficiency, it is now possible to use the services of PPSN (Public Packet Switching Networks), like Telnet in USA, Datex-P in Germany, etc. These are PTT-supplied services, of easy installation on any computer that allows direct connection for remote login (and in some cases for mail) to any other computer with the same connection, all over the world. The service - usually referred to as X.25 connection - has the only drawback of the cost, particularly high if crossing borders, but is very popular among scientific users because of its easiness and for the acceptable speed.

We will conclude this short discussion on computer networks by looking at the future: this is - by no doubt - given by the ISO/OSI standard, a seven-layer communication standard agreed upon by all PTT's, and which is only now becoming available on the market (and not yet to its full extent). It will provide a unique way of exhanging information between computers of different manufacturers, supporting e-mail, file transfer and remote login. We anticipate its full diffusion in the early 90's.

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