Communications Networks and Services: Vendor Offerings and Their Applications

(Report 2 of 3)

by

Centre for the Evaluation of Communications and Information Technologies (CECIT)

University of Waterloo

Prepared for
Department of Communications
Government Telecommunications Agency
Division of Development and Engineering

Under contract no: OSU81-00496
"The Development of a Methodology to
Evaluate Office Communications
Networks and Services in the
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Under this contract, the following three reports have been provided:

Report 1: An Annotated Review of the Literature on the Specification and Evaluation of Office Communications Information Systems

Report 2: Communication Networks and Services Vendor Offerings and Their Applications

Report 3: Methods, Guidelines and Procedures for the Specification and Evaluation of Office Communication Networks and Services (OCNS)

COMMUNICATION NETWORKS AND SERVICES:

VENDOR OFFERINGS AND THEIR APPLICATIONS

AUGUST 1982

The Centre for the Evaluation of
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University of Waterloo
Waterloo, Ontario
N2L 3G1

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Chapter 1

INTRODUCTION

This report fulfills the objectives listed under Ai) of the proposal submitted by The Centre for the Evaluation of Communication-Information Technologies to the Government Telecommunications Agency, Department of Communications, Government of Canada. These were to "Evaluate the availability and constraints of various existing and planned communication services and networks for use in automating federal offices."

The only deviation of note from the procedures proposed to achieve the stated objectives concerns the taxonomy of office tasks that were to be used to help define office communication needs. As explained in Chapter 6, the existing taxonomies, which we had intended to use, proved to be unsuitable. Thus, we developed another approach to the measurement of user needs, one which focused specifically on the requirements for office communication systems.

The report evolves as follows: Chapter 2 presents certain communication service considerations which are used throughout the report as a basis for making comparisons between alternative systems. Chapters 3, 4 and 5 cover the offerings in Local Area Networks, Private Branch Exchanges and Common Carrier Services respectively. Chapter 6 details our approach to the determination of organizational user needs, and the concluding Chapter 7, indicates how these are to be related to existing and potential offerings.

Chapter 2

COMMUNICATIONS SERVICES CONSIDERATIONS

This section presents a number of properties of communications networks and services, which form a framework with which the specific communications offerings of vendors and common carriers can be compared and judged. Unfortunately, not all of the properties can be described in quantitative terms so no single figure of merit can be determined for each offering. However, if an office automation communications requirement is characterized in terms of these properties, they can be used as useful guidelines for the selection of a particular network or communications service.

This section also provides a general architecture for all communications networks to facilitate the discussion of individual vendor offerings in later sections. This general architecture is presented largely through the use of generic models for a local area network, PBX network and a public data network.

2.1 IMPORTANT ASPECTS OF COMMUNICATIONS SERVICES

A comprehensive set of characteristics of communications networks and services are discussed below.

Cost

For LAN and PBX networks, cost includes the cost of purchase and maintenance of the network equipment, or the cost of rental. The tariffs for common carrier service offerings may include one or more of the following cost components: usage tariffs based on data volume, connection fees, connection holding time fees and dedicated circuit rental fees. Usage tariffs and dedicated circuit rental fees are likely to be distance dependent.

The costs of alternative systems may be compared either in terms of average cost per user terminal (or user connection) or in terms of total system cost for a given configuration. Both types of comparison are complicated by the fact that alternative systems exhibit different costs associated with growth.

Distance

The distance requirement is an important parameter in the selection of a network. Depending on the type of network service, two types of distances must be examined: the maximum distance between adjacent users and the maximum total network length. For ring LANs, for instance, the distinction between these two types of distances is important. The ring may have almost any total length, but the maximum distance between consecutive users is determined by the drive capabilities of each user station.

Availability

Availability includes the ubiquity of a service (is connection possible anywhere?), the likelihood of a service to be not blocked by another user, and the time required to obtain a useful connection using the service at the initiation of each session. It may be necessary to trade off among these aspects of availability. For example, dial up access to a common carrier public data network service (eg. Datapac) may involve a relatively long connection time at the initiation of each session when compared with dedicated line access to the network. However, the dial-up service provides more ubiquity since the network service is available from any telephone.

Interface with respect to Standardization

This issue of standardization in interfaces arises at a number of levels. For instance, at the electrical and physical level, does the user equipment interface to the network using RS-232-C, CCITT X.21, the IEEE 488 bus or the bus structure for a particular microcomputer? At a higher level, in the case of public packet- switched networks, Datapac uses the international standard CCITT X.25 network access protocol, while the CNCP Infoswitch network uses a non-standard access protocol.

The degree of user equipment multiple vendor support for a given network or communications service is generally related to the degree of standardization of the interfaces to that network.

Interface with respect to Cost

Some networks or services may offer interfaces which are more costly for the user provided equipment to implement than other networks which can support the same application.

On public packet-switched networks, for example, the X.25 protocol interface is used for the attachment of computers. The user is required to purchase or implement X.25 software, or obtain an X.25 "front-end" computer. All of these alternatives cost approximately $5000 to $10,000, but X.25 permits the computer to multiplex several virtual circuits simultaneously over its line to the network. However, if the computer requires only a few simultaneous virtual calls, it would be less expensive to connect to the network via a few dedicated terminal attachment lines (to Datapac 3101 ITHI* service) and avoid the cost of X.25.

For a LAN or PBX, certain interfaces chosen for the connection of user equipment may be less expensive for the user to obtain for his equipment than others. If a local net provides interface boxes which connect directly to the processor bus of a small DEC mini computer, for example, it may be very expensive (or impossible) to connect a Data General mini or IBM Personal Computer to the net.

Data Capabilities

The throughput, delay and speed of a network are all important parameters dictated by particular user requirements. For example, network throughput is important in image applications such as facsimile picture transmission, and network delay is critical in digitized voice applications.

In dedicated data circuits and circuit switching networks (eg. Datalink, Infoexchange and most data- carrying PBXs) the circuit is wholly available for data transmission at the rated speed, so the throughput and delay are known. However, packet switched public data networks and most LANs are based on the dynamic allocation of shared transmission resources so that the available throughput and average delay are dependent on the total offered traffic load.

Expandability of Capacity

Ideally, the architecture of a network should be designed for modular growth so that the incremental expansion of both data capacity and user

* ITHI - interactive terminal host interface

connectivity is possible. If it is necessary to replace a network component, such as a switch, with a larger model, hopefully some sort of downwards compatibility will protect the users from wholesale changes in the user interface.

Expandability in Features

Ideally, networks and services should be designed so that the user can obtain a basic network initially, and then can add more sophisticated features as his requirements increase and his experience with office automation accumulates. For example, a purchaser may choose a particular bus LAN because it offers optional features he can add on later, such as a message store-and-forward server, interconnection to a PBX and a gateway to public data networks.

Reliability

Some applications may be much more sensitive to failure than others. Reliability is affected by the architecture of the network (centralized vs. distributed) and also by the availability of remedial services, such as back-up switches and alternative network services.

Degree of System Comprehensiveness

It is possible for a system to be comprehensive in terms of the range of applications which it supports (eg. voice plus data plus messages plus mail, etc.) Comprehensiveness may also mean the degree to which the system or network has complied with the Open Systems Interconnection architecture by including a number of layers of communications protocols.

Chapter 3

LOCAL AREA NETWORKS

Local Area Networks (LANs) are high speed networks which can be used to interconnect computers and terminals located within a geographically restricted area, such as a building or office complex. In the past, terminal-to-computer communications have typically been at low data speeds using telephone lines and modems, unless a terminal was positioned within about 50 feet of the computer and could be directly connected. Similarly, computer-to-computer communications were inhibited by low data rate connections or by the expense of leasing dedicated digital lines from common carriers. However, with the advent of local area networks, both terminal work and computer-to-computer communications can be accomplished at effective data rates in the range of several tens or hundreds of Kilobits per second.

Numerous office automation applications, which are impractical or cumbersome at 300 and 1200 b.p.s., are made feasible by LANs. For example, the transfer of large documents among communicating word processors at telephone data speeds using modems would require such long time periods that one might only consider such a transfer infrequently or if it is absolutely necessary. Documents distributed this way would be sent only when in their final form. However, at local area network speeds, document transfer among communicating word processors is much more appealing, and a document might be distributed several times during its evolution.

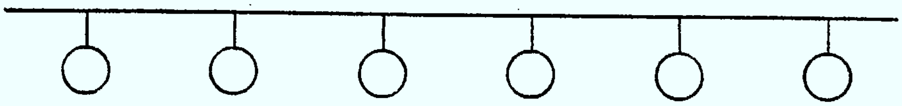
Local Area Networks can be classified, by topology, into one of three types: bus, ring and star. The first two are generally based on data packet transmission. Star networks may use either circuit switching or packet switching techniques. In the following sections, the general characteristics of the three types of LANs are discussed. Then a classification of the local nets which are currently available as stand-alone or bundled products is presented. Finally, local networks are discussed in terms of the properties presented in section 2.1.

3.1 BUS NETWORKS

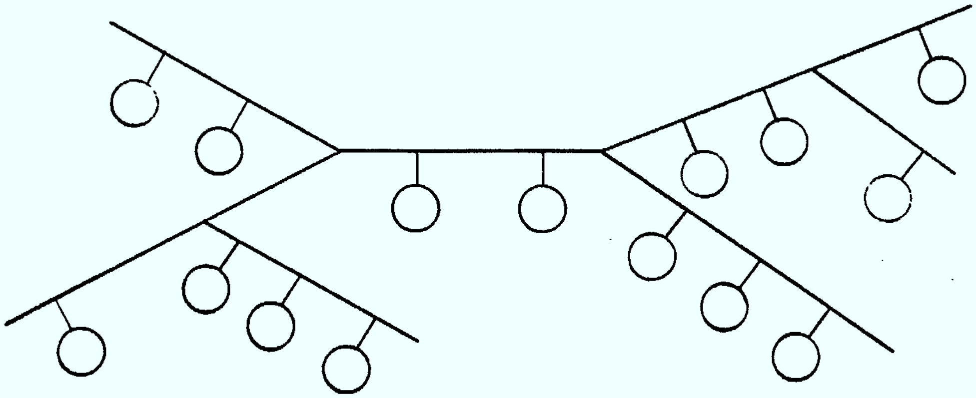
In a bus LAN, each subscriber terminal or computer interfaces with a network node which is actually a data transceiver. The transceiver broadcasts the data on a bidirectional transmission medium, such as coaxial cable. Logically, the transmission medium connects the nodes in a linear series fashion, as shown in figure 3.1(a). However, they may actually be connected by a random unrooted tree of cable, shown in figure 3.1(b), as long as a broadcast by any node can reach all other nodes. In certain types of broadband bus networks a rooted tree, like that used in CATV systems, may be used if a repeater is incorporated in the head-end equipment at the root. This is depicted in figure 3.1(c).

In bus LANs the transceivers attach to the cable by taps and are passive except when transmitting. For this reason, if a transceiver fails, the network can continue to operate. Fibre optic cable has not yet been used for a bus LAN since successful fibre optics taps have not yet been developed. (There are some fibre optics LAN designs similar to buses using pairs of fibres with repeaters.)

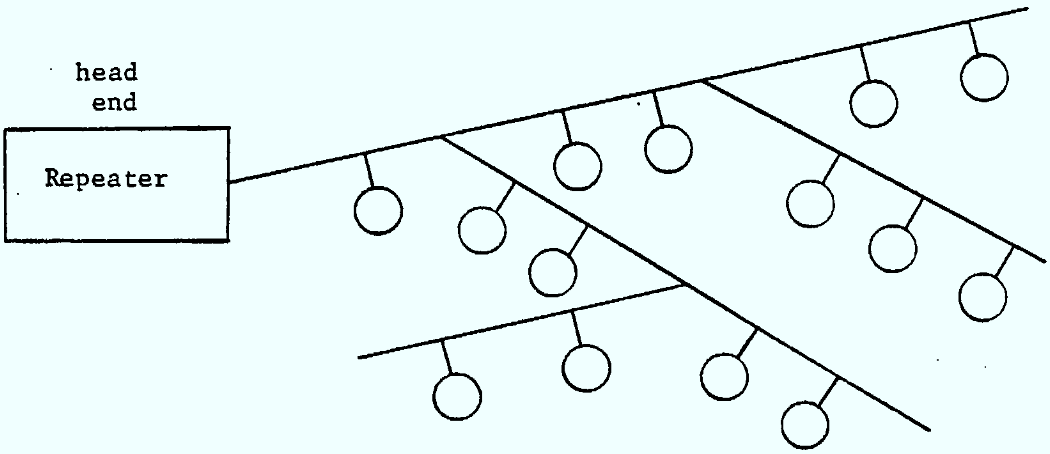
FIGURE 3.1: Three Topologies for Bus LANs



(a) Linear Bus LAN



(b) Random Unrooted Tree Bus LAN



(c) Rooted Tree LAN

In most bus networks, no provision is made for passing transmission control among the nodes in a deterministic way according to a schedule. Since all transceivers connect to a common bus, only one transceiver can transmit at any given time in a successful data transfer. The transceivers transmit data in packets with a finite maximum length of typically 128 data bytes. All transceivers examine the destination addresses of all data packets on the bus and, if the destination address matches the address of a transceiver, it will copy the data packet into its receive buffer.

Since there is no master node to control the access to the transmission medium by the transceivers, a contention strategy is adopted, such as Carrier Sense Multiple Access with Collision Detection (CSMA-CD). CSMA-CD is used in Ethernet [Metcalfe, 1976] and the SYTEK network [SYTEK, 1981].

CSMA-CD networks operate in the following way: Each node is equipped with a full duplex transceiver. If a node has a packet to transmit, it first waits for the bus to become idle, and then transmits. However, due to the propagation delay of the cable, it cannot know whether another node has already commenced transmission. As the node transmits the packet, it continuously compares the received data to the data being transmitted. If they are identical, the node continues to transmit. If they are not identical, then another node has also been transmitting and a data collision has occured. Each node ceases transmission upon detection of the collision and waits a random period of time before restarting the transmission. There are various schemes for determining the wait time, each of which attempts to minimize the chance of re-collision and maximize the throughput.

Mark and Todd have developed and implemented a Distributed Scheduling Multiple Access (DSMA) technique for a bus local net called WELNET [Mark, 1980; Todd, 1980]. Unlike CSMA-CD, which relies on locally derived scheduling information to control each station's contention for the bus, DSMA provides complete scheduling information to each transceiver on the network. In WELNET, a ring which is separate from the data bus is used to pass tokens to reserve slots on the bus for data transmission. As a result, the bus is totally conflict free and exhibits a delay/throughput performance very close to a perfect scheduling system.

Bus LANs are usually classified as either baseband or broadband. Baseband networks, such as Ethernet and WELNET have a single channel of data traffic, usually transmitted at rates of 1 to 10 Mbps, which is signalled at baseband without modulating an RF carrier.

Broadband networks, such as SYTEK and WangNet, use Frequency Division Multiplexing to permit multiple channels of data transmission on the cable by modulating RF carriers at various frequencies. The SYTEK LocalNet System 20 provides 120 channels of CSMA-CD transmission, each of which occupies a bandwidth of 300 KHz and supports a transmission rate of 128 Kbps.

Wang has adopted a different philosophy for their broadband LAN offering, called WangNet. WangNet supports only a single CSMA-CD channel (called the WANGBAND); other frequencies on the cable are used to support other services. The Interconnect Band supports both dedicated channels and circuit switching for RS-232 traffic at speeds up to 9600 bps, and RS449 devices at speeds up to 64 kbps. The Utility Band accommodates broadcast video channels and environmental sensors - rather like a closed circuit television distribution system.

Unfortunately, WangNet has some significant drawbacks. The Wang Band transceivers can only interface with Wang computers, therefore any non-Wang equipment is automatically relegated to the circuit-oriented Interconnect Band. Because the Interconnect Band relies on FDMA to provide multiple circuits on a single bus, the number of circuits is not large, nor is it infinitely expandable.

Because broadband networks use multiple channels separated by frequency, the transceiver for a broadband LAN frequently includes a Frequency Agile Modem. This represents an additional cost at each transceiver which is not required in a baseband system.

Two Important Standardization Activities

Two important standardization activities, which offer a real promise for compatibility among many vendors' workstations and network equipment, were undertaken in 1980. Both activities pertain to bus LANs of the baseband type. These are: the DEC, Intel and Xerox Ethernet project and the IEEE 802 Standards Committee.

The DEC, Intel and Xerox effort on Ethernet resulted in a document in September 1980 which describes the Data Link Layer (level 2) and Physical Layer (level 1) specifications for the 10 Mbps commercial Ethernet system. Details of interface specifications are provided so that other vendors can develop and market plug compatible equipment. As discussed in section 3.4, many already have.

The IEEE 802 standards committee has developed three draft standards for level 1 and the lower part of level 2. These are: a CSMA-CD bus running on cable, a virtual token ring running on a cable bus, and a token ring running on a ring. (More about rings in section 3.2.) Also, the 802 committee has proposed a very carefully designed Link Level protocol (level 2) for use between transceivers. Representatives from semiconductor manufacturers who are active in the committee are sanguine about the possibility of implementing most of the IEEE 802 level 1 and 2 standards on a VLSI chip or chip set.

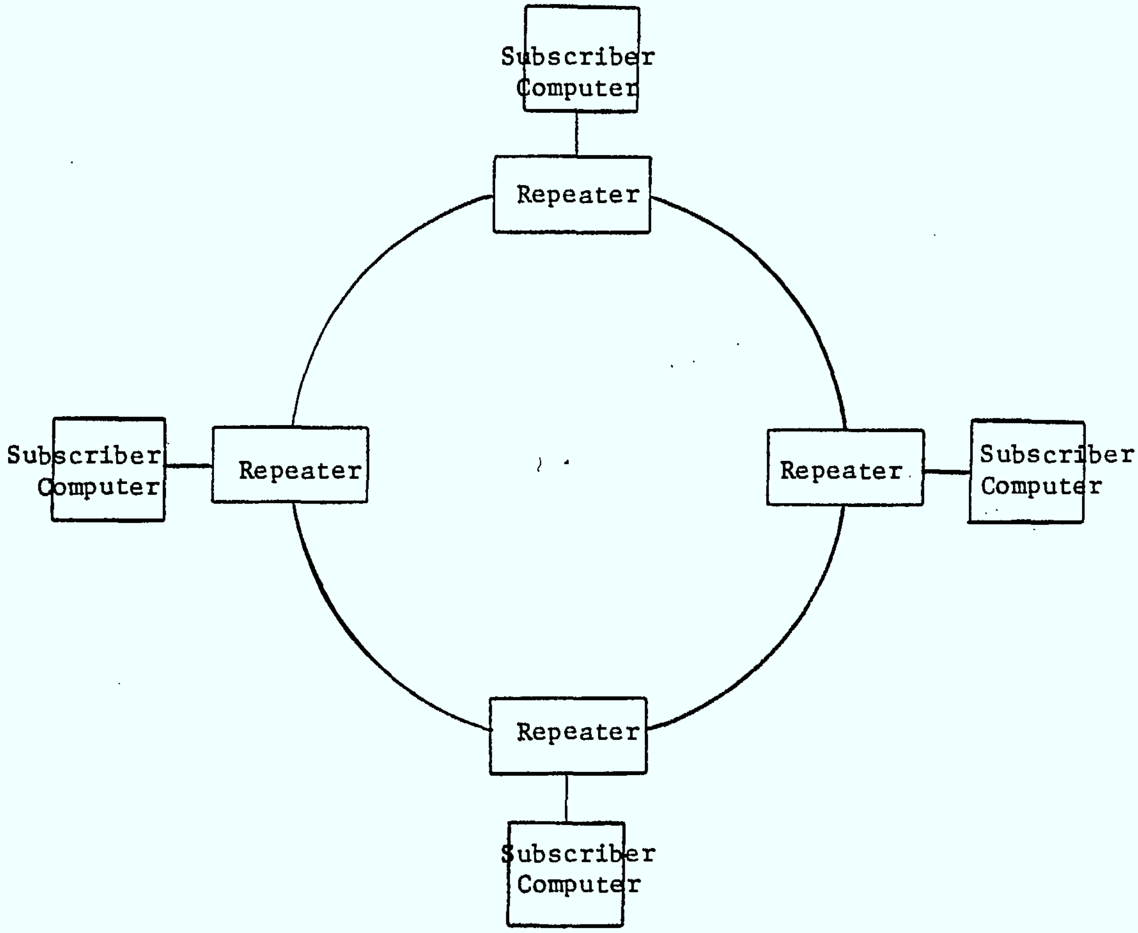
3.2 RING NETWORKS

In a ring network, the user's terminal or computer is connected to a node, and the nodes are connected by unidirectional links to form a closed ring, as shown in figure 3.2. Each node receives messages or packets on its incoming link, checks their address field to determine whether they are directed to that particular node and, if not, merely retransmits them on the outgoing link. Therefore, each node acts as a repeater. The delay at each node may be as low as one or a few bit times.

Various control strategies have been developed for determining which node may transmit at a given time. These include: control tokens, message slots (as used in the Cambridge [Wilkes, 1979]) and register insertion (as used in the Distributed Loop Computer Network at Ohio State and in Tornet at the University of Toronto [Loucks, 1982].

Because of the simplicity of the ring architecture and transmission control strategies, it is possible to build rings which are highly immune to data errors. Each station acts as a repeater attached as a receiver to one point-to-point link and as a sender to another point-to-

FIGURE 3.2: Typical Ring Topology



point link. No multiple access control procedures are required. Therefore, rings typically do not have as great a requirement for error control, flow control and message sequencing between nodes as bus LANs and packet switched networks do. Most rings leave these aspects of data transport for the user equipment to handle.

On the other hand, rings are more vulnerable to failures of single stations than are bus LANs. The failure of a transceiver on a bus LAN does not adversely affect the rest of the stations, nor are they inhibited from communicating, unless the failed transceiver begins transmitting continuously. However, on a ring network, a repeater failure opens the ring, so that no stations can transmit.

When the details of network implementation and troubleshooting are examined carefully, however, the reliability of ring and bus networks may actually be comparable. Engineering realities for both rings and buses are discussed in a paper by Saltzer and Clark [Saltzer and Clark, 1981], and some strategies for improving ring reliabilities are described.

3.3 STAR NETWORK

In a star network, each user terminal, workstation or computer is individually connected to a central node which performs the switching of data or circuits among the subscribers. It is difficult to generalize about the switch in this topology, since it may switch circuits, packets or bytes.

Examples of two local area networks organized as stars include the Gandalf PACX network and the Hubnet network developed by the Computer Systems Research Group at the University of Toronto.

The Gandalf PACX network provides low speed circuit switched connections between pairs of digital loop extenders (baseband signalling boxes) through a central switch (Private Automatic Computer Exchange). The user equipment is classified into two groups: connection originators which are generally terminals, and connection destinations which are usually computer ports. Since an originator cannot call another originator, nor can a destination call another destination, the network is really only useful for terminal to computer communications.

Hubnet is a high data rate network (approx. 50 Mbps) based on a central switch (the hub) which, when idle, senses incoming data, then broadcasts them to all users while simultaneously blocking all other users with data to send. Fibre optics cables are used to interconnect microprocessor-based interface units to the hub in a star topology, although in a sense this network behaves as a kind of single-point collapsed bus. Hubs may be organized in a hierarchical structure to support larger user populations and to provide multiplexing to reduce the amount of fibre cable required, however, only a single user may transmit on the network at any time.

3.4 A SURVEY OF VENDOR OFFERINGS

The following subsections present the results of a survey of vendor offerings. Much of the information on individual vendors' products was obtained in a collection of vendor product literature done by Shotwell and Associates [Shotwell, 1982].

3.4.1 Ethernet Compatible Network Equipment

Eight vendors of Ethernet-compatible transceivers and additional equipment have been identified. Most of this network equipment is sold for attachment to user equipment which is already in place or purchased separately. Two exceptions, Three Rivers Computer Corp. and Xerox, sell Ethernet-compatible transceivers as a part of a total office automation system including workstations.

Details of the Ethernet-compatible equipment sold by these eight vendors are presented in Table 3.1.

3.4.2 Non-Ethernet Baseband Bus LANs

Ten sources of baseband bus LANs which are not compatible with the DEC-Intel-XEROX 10 Mbps Ethernet specification have been identified. All except two are designed for attachment to existing user equipment; the Nestar Cluster/One net and Prolink Proloop net are sold as part of a total system including applications workstations. None of these ten networks are described by their manufacturers as compatible with each other or with any standard.

The ten networks are listed in Table 3.2.

3.4.3 Broadband Bus LANs

Five vendors offer broadband bus local nets, none of which are compatible. These are described in Table 3.3.

3.4.4 Ring LANs

Three vendors who offer ring local area networks were identified; two of these, IBM and Prime, offer networks for use with their own computers. Logica sells Polynet, based on the Cambridge Ring, for use with multivendor user equipment. Additional details are provided in Table 3.4.

3.4.5 Star or Centralized Equipment LANs

Eight vendors of star networks or central switching systems have been identified. Details on the interfaces and capacities of these networks are given in Table 3.5.

3.4.6 High Speed Interprocessor Communications

There are several products, usually parallel buses, which provide interprocessor communications over a short distance, but do not actually fall under the classification of LANs. Typically these buses interconnect only a homogenous set of processors. Four of these products are described in Table 3.6.

TABLE 3.1: Ethernet-compatible Equipment (10 Mbps Ethernet)

VENDOR	BRIEF EQUIPMENT DESCRIPTION
Bridge	Plans the announcement of Ethernet support products and inter-networking products in 1982.
Intel	Intellec Development System is a tool for the development of applications equipment which will use Ethernet.
Intel	ISBC 550 is a multibus compatible Ethernet transceiver.
Interlan	NM10 Ethernet transceivers include models which interface with DEC Q-bus or DEC Unibus computers.
TCL	2010E transceiver for Ethernet.
3Com	Ethernet controllers for both DEC Q-bus and Unibus computers. Ethernet transceivers and Ethernet cables and terminators.
Three Rivers Computer Corp.	10 MHZ compatible Ethernet option for communications among Three Rivers PERQ workstations.
Ungermann-Bass	NetOne is a fully Ethernet-compatible network. Ungermann-Bass sells coax cable, transceivers and flexible Network Interface Units for a variety of user equipment.
Xerox	Xerox 8000 Network System (including workstations) uses Ethernet.

TABLE 3.2: Non-Ethernet Baseband Bus Local Nets

VENDOR	BRIEF DESCRIPTION	DATA RATE
Corvus	Omninet uses CSMA and RS-422 signalling on twisted pair	1 Mbps
Destek	Destek network runs on coax or twisted pair and is available as standalone or board-level product	2 Mbps
Nestar	Cluster/One Model A uses CSMA-CD	unknown
Prolink	Proloop is a slotted 10 MHZ net with reserved voice channels and contention access data channels. It includes PROCENTER work stations and PROLINK PBXs	unknown
Scientific Data Systems (SDS)	SDSNET runs on coax with 255 users per network segment	1 Mbps
Tandy	TRS-80 interface boards are available for connecting up to 255 TRS-80s to Datapoint's ARCNET	unknown
TCL	Ethernet-like transceivers for coax	
	2004E: 4 Mbps over 1200 metres	4 Mbps
	2001E: 1 Mbps over 2400 metres	1 Mbps
Valmet, Inc.	Dataway System network on coax. Transceivers have serial or parallel data links to user equipment (up to 9600 bps serial)	250 Kbps
Zeda Computers	InfiNet runs on two conductor cable using CSMA and modified RS-422 drivers at the transceivers	25 Kbps
Computer Communications Networks Group (CCNG) Univ. of Waterloo	WELNET offers perfect scheduling (no collisions) by passing tokens on an auxilliary ring	1 Mbps

TABLE 3.3: Broadband Bus Local Networks

VENDOR	BRIEF DESCRIPTION
Amdax	Amdax CableNet offers simultaneous data, video and audio. Data at 14 Mbps
Digital Communications Corp	DCC Cable Access Processor (CAP) runs on a conventional CATV system using CSMA-CD at 1 Mbps
Interactive Systems	IS/3M's Time Shared Channel runs at up to 100 Kbps
SYTEK, Inc.	LocalNet System 20 provides 120 channels of CSMA-CD at 128 Kbps per channel. Each user site tranceiver has a pair of RS-232 interfaces up to 19.2 Kbps and a Frequency Agile Modem LocalNet System 40 will provide computer-style transceiver interfaces and will use 2 Mbps data rate on CSMA-CD channels.
Wang	WangNet offers three different facilities on one net: WangBand provides a CSMA-CD channel with 12 Mbps signalling for Wang computers <u>only</u> Interconnect Band provides: 16 64 Kbps dedicated circuits 32 9.6 Kbps dedicated circuits 256 9.6 Kbps switched circuits (using Freq. Agile Modems at each site) Utility Band: up to 7 TV channels

TABLE 3.4: Ring Local Area Networks

VENDOR	BRIEF DESCRIPTION	SPEED
IBM	the local Communications Controller can be used to build a ring of up to 16 Series 1 IBM computers	2 Mbps
Logica	Polynet consists of Cambridge slotted ring trans-ceivers run on twisted pair	10 Mbps
Prime	the Primenet Node Controller forms a high speed ring of Prime computers	unknown

TABLE 3.5: Star Local Networks and Centralized Equipment

VENDOR	BRIEF DESCRIPTION	USER EQUIPMENT INTERFACES
Amtel	Central message switching system based on a central microcomputer and power line data transmission	several typical terminal interfaces, also Telex interface
BBN	C/30 central packet switch	up to 6 X.21 interfaces 64 terminal interfaces Arpanet host ports
Corvus	Constellation star net for common microcomputers	
Develcon	Dataswitch circuit switch	up to 1000 2400 bps ports or 100 19.6 Kbps ports
Gandalf	PACX Terminal speed circuit switch	approx 400 connections
ITT	fibre optics star net with transceivers at 100 Kbps	up to 64 ports
Protex	Starnet II terminal data circuit switch	16 ports up to 19.2 Kbps
Timeplex	Distributed data switching system (data PABX)	48 ports up to 9600 bps

TABLE 3.6: High Speed Interprocessor Communications

VENDOR	BRIEF DESCRIPTION	SPEED
Computrol	DMA Megalink for DEC Q-bus computers. Uses coax and provides point-to-point or party line communications	1 Mbps
Data General	Multiprocessor Communications System bus connecting up to 15 Nova/Eclipse computers	up to 1 Mbps
Datapoint	ARC (Attached Resource Computer) System provides an interprocessor bus for Datapoint and IBM processors	unknown
Digital Microsystems	HiNet interprocessor bus with one master station polling up to 31 slave stations	500 Kbps

3.5 PROPERTIES OF LOCAL AREA NETS

This section discusses local nets in terms of the properties of communications services presented in section 2.

Cost

For bus and ring LANs, the cost of the transceiver or repeater at each station is in the range of $1000 to $5000. Added to this is the cost of the transmission medium used (coax, twisted pair or fibre). Generally speaking, baseband networks should be less expensive than broadband nets, since many of the latter incorporate a frequency agile modem in the transceiver.

The development of VLSI chips (or small chip sets) for LAN transceivers will cause a great reduction in cost. The IEEE 802 local net standards activities mentioned earlier in this section should culminate in the introduction of standard chips in a few years.

The cost per user of star networks varies considerably depending on the cost and capacity of the central switch. On a Gandalf PACX system, the per user cost is about $300 for the digital signalling box and the central switch. (The cost of the circuit from the user to the central switch is additional.)

Distance

The maximum total length for baseband bus LANs is typically 1 km, and most nets are between 0.5 and 2.5 km.

Broadband bus LANs can frequently support longer distances; they are usually rated in db loss, rather than distance, since they are likely to include CATV bidirectional amplifiers spaced throughout the network to regenerate the signals. Maximum distances may be in the range of 2 to 40 km, although long distances introduce performance problems if CSMA-CD is used, because of the long period required to sense collisions and their increased likelihood.

As a rough rule of thumb, a single baseband bus LAN can be used in a building, while a single broadband bus LAN can be used for a small group of buildings such as a campus or industrial park.

Ring LANs are sensitive to the distance between each pair of adjacent stations, however, additional repeaters can be introduced on inter-station links to provide signal regeneration. The delay of data propagation may be the decisive parameter in determining the maximum length allowable for each link.

The maximum distance allowable between the central switch and users of star LANs is determined by the drivers used at the user stations and central switch. This is usually a few or several kilometers.

Availability

In terms of ubiquity of service, all three types of local area networks have dedicated network equipment at the user station which must be installed before the network can be used. However, a user need only tap onto a bus type LAN via a passive tap. For ring networks, the ring must be temporarily interrupted to add or delete a station. Individual user circuits (similar to telephone subscriber loops) must be installed for new users added to star networks. Therefore, bus LANs are the easiest networks of the three to attach to and detach from.

For LANs, the time involved and complexity of setting up a data connection at the beginning of a session is usually quite small.

It is unlikely that a user could ever be blocked by another user, except in the case of circuit-switched star LANs, or packet-switched or contention-based LANs whose capacity has been exceeded.

Interface with respect to Standardization and Cost

Many bus LANs offer transceivers which interface with the user equipment via RS-232-C or RS-422 terminal interfaces. (Of course, computer terminal ports can also be connected to these.) Other bus LANs offer transceivers which can attach directly to a mini- or microcomputer's bus to perform Direct Memory Access (DMA) transfers. Some LANs will hopefully offer both interfaces; this can be achieved perhaps through the use of transceivers from different manufacturers with different interfaces to user equipment. However, to combine transceivers from different manufacturers, it is necessary that they are designed for a standard bus network using a standard medium access protocol and a standard level 2 link protocol (if one is used). This requirement emphasizes the importance of LAN standards such as DEC-Intel-Xerox Ethernet and IEEE 802, to ensure the flexibility of system configuration which is made possible only by the compatibility of equipment from several vendors.

Ring LANs attach directly to individual vendors' computer equipment, therefore a ring which is sold to interconnect IBM series 1 computers cannot be used to interconnect Prime computers.

Star LANs offer terminal-type interfaces (RS-232-C, RS-422, X.21) at terminal data rates.

The cost of providing the interface required in the user equipment for most LANs is small or negligible.

Data Capabilities

Bus LANs are based on the dynamic allocation of transmission capacity according to a multiple access technique such as CSMA-CD or DSMA. Most bus LANs have a raw data transmission rate (data signalling rate) of 1 to 10 Mbps. However, if the bus uses a contention multiple access technique, such as CSMA-CD, the data collisions, and the time required for their resolution, waste significant fractions of network capacity. Unfortunately, the likelihood of collisions increases proportionally to the amount of data load offered to the network. Therefore, contention buses work best at light loads.

At heavier loads, methods which resolve contention without wastage (i.e. conflict-free systems) provide a greater throughput. These include DSMA, BRAM (Broadcast Recognizing Access Method, used at the University of Minnesota) and Hubnet.

Ring networks can support very high data rates, since the data transmission is from repeater to repeater in a simple point-to-point fashion. The experimental Cambridge Ring, described by Wilkes, runs at 10 Mbps. Because access to transmission is controlled by conflict free techniques on rings (tokens, slots or register insertion), there is no bandwidth wasted in collisions. Therefore, rings can support throughputs close to their maximum capacities, minus some protocol overhead.

Star networks use dedicated circuits to connect users to the central switch. Therefore, the full data capacity of the circuit is available to the user at any time. If the central node is a circuit switch, then the full circuit capacity is available right through the switch to the destination user. The data rates for some currently available star LANs are given in table 3.5; they range from low terminal speeds to maximums of between 19.2 Kbps to 100 Kbps.

Expandability of Capacity

LANs definitely offer incremental expansion of the transceiver or repeater equipment required at each user's station, up to the maximum number which the network or switch can accommodate. When this point is reached, a second bus or switch, which is bridged to the first, can usually be added.

Expandability of Features

Local Net products basically provide data transport services with few advanced features such as message systems, unless a network bundled to the vendor's workstations is purchased. Presumably some advanced feature options will become available as the technology matures.

Reliability

Bus LANs offer excellent immunity to failures in any of the user stations, since each transceiver attaches to the common medium only through a passive tap. A failure in the medium can take down the network, but it is not an active device. It is possible for one transceiver to drastically reduce the effective network capacity by transmitting at its maximum data rate non-stop.

Ring LANs are not as immune to station failures, since each station is a repeater in the ring. However, techniques have been devised for bypassing failed stations.

Star LANs are very vulnerable to failures in the central switch.

Degree of System Comprehensiveness

LANs are fairly comprehensive in terms of the range of data applications which they can support. However, only some of the broadband bus LANs are able to support non-data services such as video.

Most LANs only offer the physical level of the Open System Interconnection protocol; the upper 6 layers have been left for implementation in the user equipment. The exception is the IEEE 802 standard which includes level 2 data link protocol in the transceiver. WELNET has adopted this protocol in its transceivers.

Many networks claim, in their advertising material, to have included the entire OSI model in their transceivers or repeaters; this usually means the transceiver design complies with the first or first and second layers of OSI.

Chapter 4

PRIVATE BRANCH EXCHANGES

The private branch exchange (PBX) has played an important role in communications for many years. It was designed to permit the direct connection of telephone stations on a single premise without having to go through a common carrier central office, the PBX acting as a satellite star local network. Furthermore, it acted as a concentrator, connecting on-premise telephones to any of a group of trunks to a central office, for both outgoing and incoming telephone calls. When machine switching replaced manual operations, the PBX became known as a PABX - private automatic branch exchange.

The service features provided by the PABX did not change greatly until the development of computer controlled electronic PABXs (EPABXs). At first, stored memory and microprocessors were used to provide many features to enhance the value of the telephone as a means of communication. However, even before the advent of the EPABX, there was a need for data communications, linking terminals to computers and computers to each other. Thus, the second generation of EPABXs was presented as a digital switcher which could be used as an integral element of a data network, using PCM links and time division switching to handle bit streams whether they represented voice or data per se.

Despite this advance, one major problem remained. Both voice and data were transmitted to the switcher as an analogue signal. This required that data be converted to an analogue signal by means of a modem for transmission, and then converted back to a bit format before being switched. The process had to be reversed for the data to get to the receiving station, and this greatly limited the data throughput. Hence, Local Area Networks appeared to be the logical solution for the communication of significant volumes of data.

A recognition that a EPABX might be able to handle most data communication, if it could provide adequate throughput rates, has led to the development of the third generation of EPABXs, which is just coming on the market. These switchers have, or will have, electronic telephones and/or other station devices which will permit the direct connection of terminals or computers to the EPABX network, without having to transform the data into an analogue form. Furthermore, the electronic telephone will convert one's voice into a bit stream at the station and not at the interface with the switcher. In other words, the EPABX can now provide a true digital communication network, being able to switch a data signal wherever one wants it to go, whether it be another station on the EPABX network, an attached local area network or a common carrier network. This is a service that no LAN can provide.

As yet the data throughput of current EPABXs is restricted to 64 kbps internal to the system and 56 kbps for transmission elsewhere. The former may still be a constraint for certain types of on-premise traffic, but the latter is a reflection of the fact that the standard T-1 trunks provide 24 56 kbps channels. At present, higher data throughput over long distances would require special dedicated data networks.

Since there is not a great deal to distinguish the third generation EPABXs, there is no reason to discuss them according to type as we did LANs. Nevertheless, there are distinctions to be made among the offerings of the leading vendors, and these will be highlighted during our discussion of the major characteristcs of the current and planned EPABXs. Before doing so, however, we feel that it is appropriate to make some general comparisons between EPABXs and LANs in terms of their likely roles in the office of the future.

4.1 THE EPABX IN THE OFFICE OF THE FUTURE

No matter how automated office tasks become in the future, it is difficult to imagine an office that won't depend heavily on voice communication. Because of this, the EPABX is likely to remain greatly in demand as an economical and effective way to manage on-premises and/or organizational voice traffic. Furthermore, because of the greater reliability of digital transmission and switching facilities, when compared to their electro-mechanical antecedents, speech will be handled in its digital format. Since one's voice will be transmitted, switched and retransmitted as a stream of bits, the marginal effort to handle data in this same form is minimal. Hence, it appears logical to assume that a single communication network will be developed that will handle the bulk of all traffic, whether the originating form is voice, alpha-numerics or pictorial images.

The key advantage of the EPABX over the LAN is that any station which can access the switcher can also access virtually any station on the public switched telephone network throughout the world. The total system is incredibly pervasive, and in most of the western world, connection is rapid and reliable. Furthermore, because the EPABX is a switcher, it can access other networks including LANs and common carrier data services.

The major disadvantage of using the EPABX as the hub of a data network is the limited data throughput it provides. Exactly what this means in terms of its implications for various kinds of data traffic will be detailed in the final section of this report, but to summarize, unless one wishes to transmit rapidly high quality pictorial images or long reports, the 56/64 kbps throughput limitation of the new EPABXs is not very constraining.

There is another aspect of the EPABX that deserves mention. Local Area Networks, for the most part, have had to develop contention avoidance procedures to insure that data are received as transmitted. These are required because the LAN is not a switcher per se. Everyone enters the same highway and intended recipients get their messages because their interface units recognize the appropriate addresses. There is no direct connection between the sender and the receiver as there is in the telephone system, even though it is now moving toward similar addressing techniques. As a consequence, local area networks operate well below their stated capacity when they have to handle a large number of small messages. They are ideally suited for a few users with larger volumes of traffic.

Switchers, on the other hand, base their capacity on the fact that they have to handle a large number of rather short connections - the average business phone is assumed to be in use for little more than five minutes of each hour of the working day. There are variations to this assumption, such as that applied to people who sell over the telephone - they are assumed to use the telephone on the average of fifteen minutes per working hour. These figures are used to estimate the telephone traffic handling capacity of a EPABX, and the question is: are these figures relevant for data traffic.

The answer appears to be no. Recent studies indicate that the average data call lasts approximately one-half hour, in contrast to the many short calls one makes on the telephone. Hence, the statistics used to estimate the capacity of a switcher are no longer relevant. Furthermore, many users of terminals or local micro-computers have their stations connected to other stations or computers for the entire day. Therefore, the issue of "non-blocking" is a very important one with respect to a EPABX's ability to handle data as well as telephone communications.

Unfortunately, vendors do not use the term uniformly. Many suggest that their system <u>can</u> <u>be</u> non-blocking, but that often means that they be used well below their stated line capacity. Others are non-blocking within a given module - typically handling 200 to 350 lines - but not across modules. Still other EPABXs appear to be completely non-blocking internally, and whether or not they are externally depends upon the number of trunks which are available.

In addition to the above concept of non-blocking, which concerns how many calls can be carried simultaneously, there is the issue of how many connections can be made within a very short period of time - the speed with which the micro-processors used can connect stations. These figures are very difficult to obtain and verify, and one can only say that most manufacturers design their systems so that this kind of blockage occurs very seldom. Furthermore, this is of less concern for data traffic since the total number of calls to be placed is likely to be less, especially because the duration will be longer, when compared to telephone traffic.

4.2 PROPERTIES OF EPABXS

Table 4.1, attached at the end of this section, outlines the characteristics of eleven different EPABXs, only one of which is not a third generation machine (American Telecom's Focus series). All of them are large, having line capacities of 1000 or more, though most vendors have smaller counterparts that provide similar services. Our intention here is not to discuss the properties of each vendor's offerings. Rather, we intend to discuss EPABXs in general and highlight the differences where they exist, in particular those which might affect the use of a EPABX as an integral element of a data network.

4.2.1 Cost

Vendors will not state a per line cost of their EPABXs. This is because the costs vary considerably depending upon the configuration of lines, trunks and features required for a particular application. Nevertheless, an estimate of between $250 to $1,000 is likely to cover most situations.

Since every organization is going to demand telephone service, the relevant cost for data communication is the increment which must be spent in addition to the amount required for voice communication. Here too cost estimates are difficult to obtain. However, for those systems which already have 4-wire or 6-wire connections in place, and this is likely to be a common practice for future installations, the marginal cost of an electronic set or data service unit appears to be in the $300 to $600 range. This provides access to a data network at only a fraction (1/4 to 1/3) of the cost of LAN interface units. This is one reason why EPABX manufacturers believe that their products will provide the vast majority of the data communication networks for the offices of the future. The other major reason is the extensiveness of the networks to which a EPABX has access.

4.2.2 Control Architecture, Distance and System Reliability

All of the EPABXs in our sample, and we believe that we have covered the most significant ones, are stored program, microprocessor controlled. The typical system is comprised of a central control unit and one or more switching modules, which may or may not be physically separated. Most of the modules are in the 200 to 400 lines plus trunk range, and are internally non-blocking.

The extent to which an EPABX is non-blocking depends upon how these modules are linked to each other and/or to the central control/switching unit. This is usually done by means of T-1 carriers (1.544 mbps each) or coaxial cable (in increments of 2.048 mbps). The major exception is Intecom's IBX which uses a 40 mbps fiber optic link between each switching partition and the controller. The only other machines which appear to be equally non-blocking are the Wescom 580 and Mitel's SX-200. Both provide as many links as there are lines. The remaining switchers covered provide excellent line capacity for voice communication, but only the Datapoint ISX and the Anaconda Ericsson MD 100 can have more than 50 per cent of their lines occupied simultaneously. This aspect of line capacity becomes an issue if the EPABX is to handle a large number of terminals and computers which may remain connected for long periods of time.

All of the EPABXs examined, in fact virtually any large EPABX, can extend service to stations located at least one kilometer from the switcher itself. Many have an operating radius of up to two miles, including connection to remote units. Northern Telecom's SL-100 has an operating radius of 50 miles. This is because it is essentially a third generation central office switcher that can be purchased by large organizations which are dispersed throughout a sizeable geographical area. Note that even the least radius covered by a large EPABX provides substantially greater coverage than a bus type LAN.

System reliability is clearly in a EPABX's favor. Computer users have learned to tolerate periods of down-time which are completely unacceptable to the average telephone user. Even the three minutes required to reload the memory of the first version of the SL-1 was not acceptable to its potential purchasers. As a consequence, all of the EPABXs have redundant memories and microprocessors, and most have redundant processors which operate the various telephone features. All provide various degrees of self-diagnosis, and allow most aspects of the system's operations to be analyzed and maintained remotely. In addition, all manufacturers have the provision for battery packs, should one fear the possible loss of power and not want to have the switcher down even for a moment. Thus, the EPABX is far more likely to be operating than the terminals and the computers attached to it. The only issue across vendors is how many of the reliability features come as standard, and how many cost extra.

4.2.3 Size and Expandability

The maximum number of lines and trunks which can be handled by any given EPABX system varies considerably across those we have reviewed. Four of them have a line capacity in the 1000 to 2500 range. Three have limits between 3500 and 5000 lines, and four can be expanded to more than 10,000 stations. The largest of the latter are Northern Telecom's SL-100 (30,000 lines and 4,500 trunks) and Datapoint's ISX (18,400 lines and 1,600 trunks). It is difficult to imagine a single organization located in a particular area (except, perhaps, for the federal government as a whole) that would require a greater number of lines and trunks on a single system.

As we noted earlier, all of the EPABXs are built on a modular basis and thus are easily expandable. Furthermore, most of the modules are internally expandable, to their limits, at a rate of 4 or 8 per increment.

Another aspect of size is the number of consoles which a EPABX will support. This varies substantially, and although the number has little to do with data communications, organizational telecommunication needs may be affected by this constraint. Most systems have line per console ratios of between 100 and 250. However, at capacity, the ratios for the

Anaconda-Ericsson MD 100 and the Datapoint ISX are 335 and 575 respectively. Northern Telecom's SL-1 can have as many as 480 consoles to cover 5,000 lines; and using the SUPERSET 7 as a console, Mitel's SX-200 can have as many consoles as lines. Note, however, that the SL-1 limit is based on dividing the system into 32 distinct customer/tenant units.

4.2.4 Data Capabilities

The second generation EPABXs, such as American Telecom's Focus series, do not permit direct data connections. Thus, data communication requires the use of a modem. The maximum throughput which one can obtain, even under the best conditions, is usually 9600 bps, synchronous.

All of the third generation EPABXs have, or will soon have, data interface units which provide for 56 or 64 kbps synchronous data throughput. The higher speed is only for intra-system communication, for once the data traffic enters a T-1 carrier channel, 8 kbps are required for the control signals. Asynchronous data flows are typically limited to 19.2 kbps, although both Intecom and Wescom claim that their switchers will be able to handle 56+ kbps asynchronous data as well.

Only two of the EPABXs covered have the capability of multiplexing data with voice over a standard 2-wire connection (Anaconda-Ericsson and Rockwell-Wescom). The Intecom switcher also multiplexes voice and data signals, but over a 144 kbps channel. Rolm provides the capability to submultiplex up to 40 full duplex data connections to a 4-wire line to a capacity rate of 96 kbps. All of the systems, when operating at their data communication limits, dedicate what amounts to 2 wires to the data stream.

Of equal importance to the bit stream capacity is the means of connecting a terminal or computer to the network. All of the third generation machines now provide, or have planned, an RS-232-C interface. Most plan to have RS-449 interfaces and the X.25 interface protocol. Several suggest that they will be able to interface with Ethernet as well. Perhaps the one exception to the large number of interface capabilities (physical and protocols) being planned for the future by most manufacturers is the approach taken by Rockwell-Wescom. They state that they provivde a system which is completely data transparent and that it will be up to the user to supply the interface units.

4.2.5 Telephone Features

Since all of the EPABXs are stored program and microprocessor controlled, most telecommunication service features can be added merely by providing the appropriate software. As a consequence, there is little variation in the feature list presented by the various vendors. If one product line develops a new feature, it is quickly copied by the others who are competing in the same market. All of the EPABXs covered in our survey provide automatic route selection for least cost routing. All make available station message detail recording and provide various degrees of traffic analysis for their systems.

Perhaps the biggest difference between the second and third generation EPABXs is the provision of an electronic telephone set with the latter. Only Rockwell-Wescom has not indicated that they have or soon will have one. Such sets, in addition to the instances where they act as data interface devices, can provide features that are not available from the standard 500 sets. For example, all of the electronic sets can access abbreviated dialing numbers which are unique to the given station. Only the Datapoint ISX has a way to give a similar service to the user of a 500 set.

Conferencing is a feature where one does find some variation. Most of the EPABXs allow a station to add a third party to a telephone call. In addition they can bridge as many as six to eight people either directly or through an attendant. There are limits, however, as to how many such conferences can be conducted simultaneously. Only the Rockwell-Wescom 580 and the Datapoint ISX permit conferences of more than 8 people. The former can handle 24 and the latter 32.

4.2.6 Messaging Services

Vendors have taken two totally different approaches to the provision of messaging services. One group argues that these should be obtained and operated completely apart from the EPABX. The others have now, or will have, electronic messaging and voice store and forward systems. These include the AEL Microtel GTD 1000 (though voice messaging is not yet planned), Anaconda-Ericsson's MD 100, the Mitel SX-2000 and Northern Telecom's SL-1 and SL-100.

TABLE 4.1 E P A B X s

PROPERTIES		AEL Microtel GTD 1000	American Telecom Focus series	Anaconda Ericsson MD 100
Control Architecture -- System Design		stored program (distributed) microprocessor controlled partially redundant multiple switching modules (256 lines each) central switching unit required 7.2 ccs/line @ p=.01 (192 simultaneous calls) T1 compatible remote analysis & maintenance	stored program microprocessor controlled ? multiple switching modules (400 lines, 60 trunks each) central control unit required 9.0 ccs/line @ p=.01 at 720 (127 external calls/module) ? remote analysis & maintenance	stored program (distributed) microprocessor controlled partially redundant multiple line interface modules (200 lines, 30 trunks each) group switch required for 4 or more modules 4 2.048 mbps links per module non-blocking within module (90 external links/module) T1 compatible remote analysis & maintenance
Capacity Voice	Lines	104 - 1,024	24 - 1,500	200 - 10,000
	Trunks	256 (64 @ 1,024 lines)	143	1,000
	Modules	4	5	62+
	Consoles	8 (2 per module) 2 per module	8	30
	Expansion	easily expandable	easily expandable	easily expandable
Capacity Data		via Subscriber Data Unit 56 kbps 2-wire voice, separate	via modem 4.8 kbps	via 2-wire connection unit 9.6 kbps data plus 64 kbps voice, <u>or</u> 56 kbps data via 4-wire connection unit both of the above, <u>or</u> 56 kbps data plus analogue voice
Interface Capabilities		via Subscriber Data Unit RS-232-C X.25 (others to come)		via ? RS-232-C Telex, IRC, TWX (RS-366)
Telephone Features		Feature Command phone individual station features 3-8 party conference	Focusphone some station features 3-8 party conference (max. of 5 confs.)	MPX telephone individual station features 3-8 party conference (32 conf. ports per LIM)
Messaging		electronic messaging (1983)		electronic messaging voice store and forward
Other Properties		equivalent to Displayphone coming at end of 1982		advanced phone to use codec chip.

NOTE:

ccs/line = 100 call-seconds/line
P = probability of line being busy

TABLE 4.1 E P A B X s

PROPERTIES		Datapoint ISX	Intecom IBX	Mitel SX 2000
Control Architecture -- System Design		stored program (distributed) microprocessor controlled fully redundant multiple remote switching units (~350 user ports each) central switching unit required 2 4.096 mbps links per unit non-blocking within unit T1 compatible remote analysis & maintenance	stored program (distributed) microprocessor controlled fully redundant multiple switching partitions (256 128-kbps interface ports each) central switching unit required 40 mbps fiber optic link per partition non-blocking T1 compatible remote analysis & maintenance	stored program (distributed) microprocessor controlled fully redundant multiple groups (4 cabinets) (3840 lines, 768 trunks each) controls linked via Ethernet 128 2.048 mbps links per group non-blocking circuit switch and inter-group T1 compatible remote analysis & maintenance
Capacity	Lines	200 - 18,400	1500 - 3,600	250 - 10,000
	Trunks	1,600+	496+	2,000
Voice	Modules	59	16	3+ groups
	Consoles	32 4 per unit	16	no limit if SUPERSET 7 is console
	Expansion	easily expandable	easily expandable	easily expandable
Capacity Data		via Data Service Unit 9.6 kbps async 19.2 kbps sync, term.clock 56 kbps sync, DSU clock 2-wire voice, separate	via 144 kbps line, multiplexed data & voice 57.6 kbps data 64 kbps voice	via SUPERSET 7, 4-wire 256 kbps line 19.2 kbps async 56 kbps sync 2-wire voice, separate
Interface Capabilities		via Data Service Unit RS-232-C RS-449	via integrated voice/data terminal RS-232-C RS-449	(to come in 1983, 1984) RS-232-C RS-449 X.25
Telephone Features		INFOSET II individual station features 3-32 party conference 500 sets can access all features via dialing INFOSET II is full-duplex speakerphone (intra-system)	electronic set individual station features 3-7 party conference no limit to number	SUPERSET 7 individual station features 3-8 party conference traffic recording and recovery via SUPERSET 2000
Messaging				electronic messaging voice store and forward
Other Properties		6-wire line installed INFOSET II transmits analogue signal		bubble memory SUPERSET uses codec chip will act as if VT100 terminal (1983), 3270 terminal (1984)

NOTE:

ccs/line = 100 call-seconds/line

P = probability of line being busy

TABLE 4.1

PROPERTIES		Northern Telecom SL 1	Northern Telecom SL 100	Plessey K 2
Control Architecture — System Design		stored program (distributed) microprocessor controlled fully redundant multiple network units (32 time slots: 160 lines, 80 trunks or 40 VTs each) central control unit required blocking depends on configuration T1 compatible remote analysis & maintenance	stored program (distributed) microprocessor controlled fully redundant multiple network modules (960 two-way voice channels each) central control complex required blocking depends on configuration T1 compatible remote analysis & maintenance	stored program (distributed) microprocessor controlled fully redundant multiple shelves (80 ports, 64 paths each) central switching unit required 320 "highways", outside shelf 10.3 ccs/line @ p=.01 at 960 lines T1 compatible remote analysis & maintenance
Capacity Voice	Lines	100 - 5,000	5000 - 30,000	100 - 1,920
	Trunks	1,000 (600 @ 5,000 lines)	20,000 (4,500 @ 30,000 lines)	255
	Modules	32 customers	32	6 (cabinets)
	Consoles	15/customer	255	8
	Expansion	easily expandable	easily expanable	easily expandable
Capacity Data		via SL-1 Electronic Set data module 19.2 kbps async 56 kbps sync 2-wire voice, separate	via Electronic Set 19.2 kbps async 56 kbps sync (2.7 mile loop length) 2-wire voice, separate	via 4-wire data plug 19.2 kbps async 64 kbps sync (1983) 2-wire voice, separate
Interface Capabilities		via SL-1 Electronic Set data module RS-232-C (to come: X.25, Ethernet,..)	via SL-100 Electronic Set data module RS-232-C X.25, RS-449,...(to come)	RS-232-C RS-449 (1983) X.25, Ethernet (1984)
Telephone Features		SL-1 Electronic Set individual station features 3-6 party conference (6 only with SL-1 set) all features available to data calls	SL-100 Electronic Set individual station features 3 party conf., 500 set 6 party conf., SL-100 set all features available to data calls	K-Phone some station features 3-6 party conference 12 party conf. (1983)
Messaging		electronic messaging voice store and forward	electronic messaging voice store and forward	
Other Properties			can be part of a large Electronic Switched Network can be managed via special Communications Management Center	

NOTE:

ccs/line = 100 call-seconds/line
P = probability of line being busy

E P A B X s

PROPERTIES		Rockwell-Wescom 580	Rolm MCBX - VLCBX
Control Architecture -- System Design		stored program (distributed) microprocessor controlled fully redundand multiple customer groups (288 lines, 48 trunks each) central switching unit required each line has own time slot on T1 link non-blocking T1 compatible remote analysis & maintenance	stored program (distributed) microprocessor controlled fully redundant multiple nodes (~600 lines, 120 trunks each) linked via communication "hubs" 6 ccs/line @ p=.01 at 4000 lines T1 compatible remote analysis & maintenance
Capacity Voice	Lines	100 - 2,304	100 - 4,000
	Trunks	576	800
	Modules	8	10
	Consoles	16	48
	Expansion	easily expandable	easily expandable
Capacity Data		via Data Voice Switching System (4-wire network) Voice port: 9.6 kbps sync 4.8 kbps async Data port: 64 kbps	via Data Terminal Interface (4-wire line) 19.2 kbps async 56 kbps sync 2-wire voice, separate can multiplex 40 data terms to one 96 kbps 4-wire line
Interface Capabilities		via Data Interface Unit RS-232-C system to be data transparent user to supply interfaces	via Data Terminal Interface RS-232-C via Data Network Interface RS-449, X.25, X.3, X.28,..
Telephone Features		some station features 3-24 party conference 48 ports available	ETS 100A individual station features 3-8 party conf. (2 external) 80 8-party confs. capacity
Messaging			electronic messaging
Other Properties		580Ls can be networked to act as a single switcher (at least 3)	VLCBXs can be networked to act as a single switcher (to at least 10,000 lines)

NOTE:

ccs/line = 100 call-seconds/line
P = probability of line being busy

Chapter 5

COMMON CARRIER SERVICE OFFERINGS

Canada's two national common carriers, TCTS and CNCP, provide a range of data communications offerings. These are described in the following subsections.

5.1 DDD NETWORK

The TCTS DDD network, when used with modems, provides circuit-switched data communications at terminal data speeds (typically 300 to 2400 bps with unconditioned lines at up to $1000 modem cost; 9600 bps usually on conditioned lines with $10,000 modems). Free hunt groups permit several circuits to be switched simultaneously to the same destination, so that a computer may have several terminal ports which may all be accessed using the same phone number.

5.2 LEASED LINES

The TCTS CCG Dataroute and the CNCP Infodat are both nation-wide networks of dedicated data circuits supported by trunks interconnecting major centres. Dataroute and Infodat both provide unswitched, dedicated, point-to-point, full-duplex circuits between pairs of subscribers at speeds up to 56 kbps. Either synchronous or asynchronous transmission is available.

Usually subscribers connect to Dataroute or Infodat via local subscriber loops and modems. If the subscriber is not located in a centre with Dataroute or Infodat service, an interexchange data channel can be used between Dataroute/Infodat and the subscriber, or between the subscribers.

Subscribers may also access individual Dataroute/Infodat dedicated circuits via the DDD network.

5.3 TELEX, TWX AND DATATELEX

Telex and TWX are low speed, circuit switched message systems for use with hardcopy terminals provided by the common carriers. In Canada, CNCP operates Telex and TCTS operates TWX. Neither service has any built-in message store-and-forward capability until very recently. Both services are behind the current state of the art but are self-perpetuating because of their large installed terminal base.

Standard Telex uses the 5-level (i.e. five bit) Baudot code and provides a low data rate. The Canadian Telex network connects to other Telex networks internationally, as well as to the U.S. TWX network. There is no direct interconnection between Canadian Telex and Canadian TWX subscribers.

CNCP offers a Telex-based service called Telepost, which allows Telex subscribers to send messages to non-subscribers in the following way. The originator sends a message, by Telex, to the Canada Post Office closest to the destination. The message is then delivered by Canada Post via preferrentially-handled mail.

CNCP has introduced a new, updated version of Telex called DataTelex. This service permits the attachment of user-supplied equipment using either Baudot or ASCII code. It can support data rates of up to 9600 bps.

TWX is a TCTS service similar to Telex. It also uses low-speed, hardcopy terminals provided by the carrier. However, TWX transmits data using the ASCII code.

5.4 TELETEX SERVICES

Teletex is a new internationally-standardized service which allows office machines (e.g. electronic memory typewriters, word processors etc.) which use the Teletex standard alphabet (i.e. an international variant of the ASCII code) to communicate with each other over switched networks on an international basis. Both TCTS and CNCP are introducing Teletex-compatible services, called Teletex and Infotex, respectively.

TCTS Teletex service operates over the telephone network at a speed of 2400 bps. An electronic directory of network addresses of all subscribers will be available. Users are encouraged to obtain their own terminals from what will hopefully be a broad range of equipment which incorporates the Teletex standard. Teletex will interconnect to other Teletex networks internationally, as well as certain Datapac services, Canadian TWX, U.S. Telex and TWX, and international Telex.

CNCP Infotex will offer the international standard 2400 bps Teletex service, as well as other speeds. Infotex services will include mailboxes and message store-and-forward services. CNCP has not yet announced whether or not they intend to allow the connection of user-provided Teletex compatible terminal equipment to Infotex. Infotex will interconnect with Telex in Canada, and both Telex and other Telex networks on a world-wide basis.

5.5 PACKET SWITCHED PUBLIC DATA NETWORKS

Packet switched networks achieve economy by sharing trunks among computer-based packet switches on an asynchronous time division multiplexed basis. Since subscribers effectively share the communications circuits between switches, the communications cost per subscriber is less than if each subscriber leased Dataroute or Infodat circuits to meet his requirements. This economy is passed on to the subscriber since the added cost of the packet switching computers is less than the communications cost saved.

Unlike leased lines, for which the subscriber pays a fixed monthly fee regardless of the amount of data actually sent, the tariffs for the Canadian packet switched networks are based on usage.

Canada has two national public packet switched networks: Datapac, which is operated by TCTS, and Infoswitch, which is operated by CNCP. Both networks provide only virtual call based service; virtual call procedures are similar to those used to make a telephone call. The virtual call must be set up, then data is transferred. Either the source or destination subscriber may terminate the call. There is no virtual call equivalent to the telephone conference call involving more than two subscribers.

Datapac offers a variety of subscriber interfaces at a range of data rates, including the CCITT Recommendation X.25 interface (called Datapac 3000 service). Datapac 3101 service permits the attachment of asynchronous stop/start mode terminals (i.e. "dumb" terminals) using X.28 and X.29 procedures to control the packetization and transmission of terminal data. A computer may also attach a single terminal port to the network via Datapac 3101 service as an alternative to implementing the X.25 network access protocol.

Datapac also offers a few terminal interfaces which are tailored to some of the more common IBM terminals and Remote Job Entry stations.

Datapac network access speeds range up to 56 kbps for 3000 service, and up to 19.2 kbps for other service interfaces in general. Dial-up access is provided to Datapac 3101 service at data rates of 110, 300 and 1200 bps.

Infoswitch provides two basic packet-switched network services - Infocall and Infogram. Infogram provides a multiple virtual call access to the network similar to X.25. Infocall is a terminal-oriented service which packetizes and transmits asynchronous or synchronous data. Infocall and Infogram subscribers may interwork freely.

5.6 CIRCUIT SWITCHED PUBLIC DATA NETWORKS

Both TCTS and CNCP offer circuit switched data services, called Datalink and Infoexchange respectively. Unlike the packet-switched network services, trunks in the network are not shared among subscribers asynchronously as packets arrive. Instead, bandwidth is allocated on trunks using the fixed Time Division Multiple Access (TDMA) strategy. Hence, the delay and throughput for individual data calls is known to the subscriber. The major disadvantage is that the trunks are not shared as economically as when packet switching is used.

Both Datalink and Infoexchange offer a range of data transmission speeds up to 19.2 kbps.

5.7 ENVOY 100

CCG has recently introduced an electronic message switching system, called Envoy 100, which uses Datapac to provide the communications between the users' terminals and the Envoy 100 computers. Envoy 100 provides a range of electronic mail support features and delivery modes.

Users sign on to Envoy by typing a user name and password. They may read unread messages, stored messages, or messages on a bulletin board available to a closed user group. When the user reads a message, he may forward the message to another user, answer it, or store it in his own message files. New messages may be composed and delivered using urgent, timed, or private delivery. The sender may also request registered delivery or a return receipt mode where the sender is advised when the message is read by the recipient. Means for sending messages to prespecified lists of users are also provided.

Envoy 100 charges are based on a fixed monthly amount ($20 per organization and $3 per user name), plus usage and message storage fees. Usage fees are based on a charge of 30 cents per kilocharacter for reading and sending messages, and a charge of 5 cents for each addressee to whom a message is sent. The message storage fee is one-half cent per kilocharacter stored per day.

5.8 INET

Datapac, as it currently appears to a terminal user, lacks many user-friendly features which would enhance its use for business information purposes. Such features include individual user profiles stored by the network and recalled automatically at network access time, an electronic directory of Datapac addresses and services, automatic addressing and automatic login to prespecified host computers, and individual per-user billing. These features are being gradually incorporated in the iNet Gateway field trial which began in 1982. iNet stands for "intelligent network".

Users access the iNet gateway over Datapac, via the DDD network, or by using a dedicated circuit. Standard ASCII terminals, or Telidon alpha-geometric terminals, can be used with the gateway. The iNet gateway can then provide access to computer hosts via Datapac. Access to Envoy 100 is also available.

When users sign on to the iNet gateway, it provides directories of all hosts and services available. Both a public directory and a personal per-user directory of frequently used hosts are available. When a directory item is chosen, the user is automatically connected to the destination host, without requiring any further identification from the user. The user's identity is provided by the gateway. Therefore, a user needs to perform only one sign-on per session.

The iNet gateway also remembers an individual user profile for each user. This profile contains user-specified parameters on the level of language and expertise at which the user will interact with the gateway. Additional parameters determine the level of authority and billing requirements of the user.

Chapter 6

TAXONOMY OF OFFICE COMMUNICATION NEEDS

Our initial intention was to relate existing taxonomies of functions, jobs, tasks (see Appendix) and/or activities to the needs for alternative office communication systems. However, as we attempted to map jobs and tasks to technological support systems, we found that the relationships were difficult to determine and even more difficult to substantiate. For every "normal" case, one could find several exceptions. Thus, the relationships developed were so tenuous that they would be of little use in the planning and specification of office communication systems.

To illustrate, suppose we are presented with the task of production scheduling. While the job seems quite well defined, the communication needs of that task vary substantially depending upon the number of products to be scheduled, the variation in the demand for those products, the volumes involved, the number of different production units, whether or not the scheduling is done by computer, etc. Hence, one has to know much more than the class of task before one is in a position to gauge its communication requirements and the network that would be needed to support them. It would be far more useful to look directly at what takes place, and this is the approach we have decided to take.

Since we found it necessary to take a fresh look at the way we classify user needs, we established two criteria which we felt our scheme should satisfy. First, it should focus on office communication per se, rather than on the broader issues involved with the coverage of all office support systems. Second, the approach taken should be capable of relating needs directly to their technological implications without having to go through contorted and/or abstract reasoning processes.

6.1 KEY PARAMETERS

A review of the literature on the specification of communication networks suggests that one must have knowledge about the values of three traffic parameters: Distance, Distribution and Volume. In addition, there are a number of Characteristics of communication systems which might affect their suitability for a particular application.

That Distance is important should be obvious. It makes a great difference in the supporting technology needed, depending on whether one wants to communicate with the person in the next office or with someone across the country. This is the reason we have noted the Distance that a given communication technology could span.

Distribution concerns the communication network - who communicates and/or needs to communicate with whom. Included in distribution is whether a communication event involves more than two persons.

Knowing the Distances covered and the Distribution of a communication is clearly not sufficient. One must also know the Volume of traffic that is to be carried over any given segment of that network. The technology required to support a five minute telephone call is quite different from that needed to transmit a 100 page report in the same time frame.

Related to the kind of technology one wishes to use to support a given network configuration are a number of issues or system Characteristics. For example, the technology required to transmit a 100 page paper depends upon whether or not the receiver is concerned if it arrives a week later. A system's reliability, expandability and ease of use are other Characteristics which will affect its suitability.

6.2 PARAMETER MEASUREMENT

6.2.1 Distance

An examination of Distance in light of the alternative communication technologies led to the development of four classes:

Intra-facility: this involves service within a given building. The distances spanned can be satisfied by bus LANs and all PBXs.

Intra-campus, Inter-facility: this involves service within a given complex of buildings. The distances spanned can be satisfied by most ring LANs and third generation EPABXs.

Intra-city, Inter-campus: this involves service within a city or well defined region. The distances can be easily spanned by a private hard-wire system or micro-wave link.

Inter-city: this involves long distance service that is most likely to be provided by a common carrier, though a private satellite communication system is a feasible alternative.

6.2.2 Distribution

Developing a measure of Distribution involves the issue of the level of requisite detail. At the extreme, one could detail the complete network, examining every possible link between each and every node. The value of such an approach, however, is highly questionable since the primary concern is to ensure that links which are used on a regular basis are adequate to handle the expected traffic. As a consequence, when one considers the measure of Distribution in light of Volume, it appears adequate to consider just three categories, each of which can be related to a technological alternatives.

Concentrated : one considers the volume involved in point-to-point communication.

Diffuse: the concern is for the volume over many links in a multichannel network, where pervasiveness is an asset.

Conferenced: one is interested in the traffic which is exchanged simultaneously over a number of channels in a network.

6.2.3 Volume

Our measurement of Volume takes two different approaches. One is the direct categorization of the bandwidth required. While this is very useful for determining the service to be provided, usually one has to obtain such data in an indirect manner. Thus, we also present Volume in terms of communication content.

Direct Measure - Bandwidth Requirement

Low: voice grade circuits, data rates to 4.8 kbps (in certain cases 9.6 kbps) via modems.

Medium: high fidelity voice, data rates to 64 kbps (limit of third generation EPABX).

High: Picturephone circuit, data rates to 1.544 or 2.048 mbps (T-1 carrier and CEPT standard respectively).

Very High: video, data rates to 6.312 mbps and beyond (T-2 carrier,...).

Indirect Measure - Communication Content (Must be Related to Frequency/Volume)

Alpha-numerics - Message: a message or letter, limited to a very few pages at most.

Alpha-numerics - Document: a report, manual or document of several to many pages.

Alpha-numerics - Data Base: a large volume of data to be transferred; may be a computer-to-computer transfer, but it could involve many invoices, accounts, personal files, etc.

Graphics: a simple pictorial presentation which can be drawn by means of a few basic commands (e.g. Telidon graphics).

Images: a pictorial presentation which requires a complete scan to be well represented (e.g. facsimile or slow-scan video).

Video: a pictorial presentation which accurately reflects motion.

Face-to-face: an interactive communication which can appeal to all of the five human senses.

To go from the Indirect to the Direct measure of Volume, one has to have a measure of the throughput required or the permitted delay between the transmission and reception of that which is to be communicated. Note, although we are focusing on the properties of telecommunication technologies, we should not lose sight of other forms of communication, such as the mails, face-to-face interaction and the like. These systems will be with us for a long time to come, and in many instances may be very cost-effective.

Characteristics

The choice of both communication network configuration and a vendor may well depend upon issues which are over and above the actual design of the network. These we list as system Characteristics.

Reliability: the proportion of time a system is expected to be inoperative.

Ease and Method of Maintenance: in particular, can system failures be diagnosed automatically and rectified remotely?

Features Offered: what are they, and are they system or station unique?

Ease of Feature Use: are feature operations simple and easy to learn?

Expandability: can the capacity of the system be easily expanded, and can new features be added to the existing system without requiring major reconfigurations?

Interface Capabilities: what kinds of terminals, stations and the like can be connected to the network, and under what conditions?

Time to Connect: how long does it take one to connect to the network?

Chapter 7

CONCLUSIONS

It should be clear by now that there is little point to develop a matrix with functions, jobs or tasks along one dimension and classes of communication technologies along the other. This does not mean, however, that one cannot say a good deal about the appropriateness of a given office communication system for a particular set of requirements.

First, telephone communication services are going to continue to be in demand in the foreseeable future, and thus they will have to be provided. Because of the pervasiveness and reliability of the public telecommunications network, people will demand to be connected to it. For most organizations the most effective way to do so is by means of a PBX. Whether or not this PBX should carry data is a separate issue, and only the marginal costs of a data EPABX network compared to a voice only network should be considered.

Second, conferencing, and especially video conferencing questions are going to be considered apart from data communication needs. The issue here usually concerns the travel/conference system cost tradeoffs. Since most video conferencing systems are likely to be strictly point-to-point (a diffuse network would be prohibitively expensive), and since much of the data traffic in the future is likely to be diffuse, the use of the video network for data traffic is likely to be limited at best. Furthermore, such uses as the movement of large data bases from one computer to another can probably be examined apart from the day-to-day office communication requirements of most organizations. Hence, it seems appropriate to consider data communication needs in the office of the future as a concern which can be examined separately.

To get a better feel for the telecommunication implications of various data traffic, we have prepared a matrix showing the speed by which a given form or content can be communicated over various bandwidths (Table 7.1). The forms have been selected as representative of the kinds of data one might wish to transmit in the future. At one end of the scale is a page of alpha-numerics, perhaps a letter or a page of a report. We assume that it contains 1500 8-bit characters. At the next level of complexity we have a simple black and white graphic of 300x300 pixels. The third level is a good resolution image that one obtains by means of Colorado Video's slow-scan system. The image is 240x512 pixels, with a 6-bit (64 degree) gray scale. At the extreme, we have a high resolution color image, 600x800 pixels, using 8-bits per pixel for the color.

The bandwidths presented are those which reflect the typical constraints of alternative technologies. A reasonably good modem can provide 1200 bps over most any voice grade line. Specially conditioned lines may yield throughput rates of 9600 bps, relying on modems costing in the neighborhood of $10,000. The new EPABXs and the data channel on the T-1 carrier provide 56 kbps capacities. The largest bandwidth considered is the T-1 carrier itself, which provides twenty-four 56 kbps channels, though it is rated at 1.544 mbps (the rest of the capacity is used for control signals).

TABLE 7.1

Transmission Speed of Communication Content/Line Capacity

Communication Content	Line Capacity			
	1200 bps	9600 bps	56 kbps	1.544mbps
one page alpha-numerics 1500 characters	10 secs	1.25 secs	.21 secs	.0087 secs
graphic image 300x300 pixels, 1 bit each	75 secs	9.4 secs	1.6 secs	.065 secs
slow-scan image 240x512 pixels, 6 bits each	615 secs 10.25 mins	76.8 secs 1.28 mins	13.2 secs	.53 secs
high resolution color image 600x800 pixels, 8 bits each	3200 secs 53.33 mins	400 secs 6.67 mins	68.6 secs 1.14 mins	2.78 secs

7.1 OBSERVATIONS

From strictly a data throughput perspective, it would appear that existing telecommunication systems can handle most low level data traffic. The rate of 10 seconds per page is about as good as the speed of a number of the smaller copiers. Even a 50 page report can be transmitted over a 1200 bps line in little more than 8 minutes; and if one has a 9600 bps capacity available, the transmission time would be only a minute.

Of equal relevance are typical input, printing and reading rates. It is very rare to find someone who can type 120 words a minute. Yet, that rate can be handled in its bit form at 80 bps. A 1200 baud line can transmit approximately 1,500 words per minute, which is about five times the reading rate of most people. Even a printer operating at 600 lines per minute (60 characters per line) requires only 4800 bps. Hence, except for large volumes of data which are already in computer memory, the constraints on communicating alpha-numeric data are far more likely to be those of input and output rather than line capacity.

Existing transmission rates of data might become a bottleneck if there is a substantial increase in the volume of graphic and image communication. As one can see from the table, high resolution, high quality color images take a considerable amount of capacity to transmit in their bit form. Even here, however, unless the number of such items is large, it would appear that the 56 kbps data transmission capacity of the third generation EPABXs would be sufficient for all but very high speed applications. Furthermore, while it is highly likely that there will be an increase in demand for such traffic, a considerable amount of research is being done on data compression techniques. Facsimile has introduced a number of efficient sampling routines, and even better ones are in the works. Very effective color presentations can be made by the appropriate interspersing and spacing of the three primary colors, requiring many fewer bits of information than needed at present. One only needs to look at the art work of the pointillists, painted during the late 19th century, to understand the expected results.

In closing, we should note that the field of data communications has been driven by persons who have a professional interest in the use of computers and who could see the need for the transfer of very large data bases from one machine to another. Such traffic, however, is far removed from that found in the typical office. Furthermore, even though office work is moving rather rapidly toward an increased use of computers, that work does not require the same machine and network capacities used by software and hardware experts who reside in the data processing centers of most large organizations.

What one needs to do is conduct a careful examination of the communications which currently take place in an organization, along with a projection of those which are likely to take place within the next few years (remembering that change in <u>user</u> <u>needs</u> is seldom as rapid as forecast). These can then be put into the context of existing and projected office communication offerings to determine the appropriate system for the future. If one is to have a bias in such an exercise, it is probably better to be conservative. Current office communication technology is probably far more capable of handling the increased demands of the office of the future than most people are willing to recognize.

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TASK TAXONOMY

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TASK CODE	TASK NAME
P	PLANNING
E	EVALUATING
C	COORDINATING
N	NEGOTIATING/BARGAINING
A	AUTHORIZING
S	SUPERVISING
I	GATHERING/DISSEMINATING INFORMATION
R	RECORD KEEPING
T	SECRETARIAL SUPPORT
Z	UNKNOWN/NOT APPLICABLE

TASK CODE	TASK NAME		
P	PLANNING	Financial Planning, Budgeting, Policy Formulating, Production Scheduling, Marketing Strategy	This is a cognitive (thinking) activity and involves the development of a blueprint for action. It may be interactive (multi-person) in nature and has an extended time horizon.
E	EVALUATING	Monitoring, Appraising, Auditing, Reviewing, Analyzing, Controlling.	The purpose of evaluation is to compare actual results of operation against previously established plans and benchmarks. This is a control function.
C	COORDINATING	Liaising, Advising/Assisting, Consulting, Arranging/Organizing (eg. meetings).	This is an interface or liaison activity. Ensuring the smooth operation of the various individuals, groups, and departments is the objective. Seeking concensus rather than imposing unilateral positions characterizes the task of coordination.
N	NEGOTIATING/ BARGAINING	Persuading, Selling (ideas, products, etc)	Attempting to change the opinion or awareness of others is the chief characteristic of this activity.

TASK CODE	TASK NAME		
A	AUTHORIZING	-	Approving, Signing, Exercising Authority. This is the realm of those who have the authority or power to authorize or approve.
S	SUPERVISING	-	Staffing (Hiring/Firing), Motivating, Counselling, Training, Directing. The management of human resources (usually subordinates) is an ongoing activity of those in supervisory positions.
I	GATHERING/DISSEMINATING INFORMATION	-	Requesting (from others), Accessing and retrieving (from files), Investigating, Reporting, Informing, Dictating, Advertising, Representing/ Public Relations. Searching and retrieving information either from storage (eg. files) or from other individuals and distributing information to others either in response to a query or because it is felt that others may need the information is the activity involved. Note that the activity includes the processing of the information after receiving and before transmitting it.
R	RECORD KEEPING	-	Bookkeeping, Calculating, Inventoryin Invoicing, Placing/Receiving Orders. This is a maintenance function and subsumes a great variety of an organization's ongoing activities. The stress is on those activities which are routine and repetitive. Standard operating procedures and programmes or algorithms either exist or could be developed to guide the execution of record keeping activities.

TASK CODE	TASK NAME	
T	SECRETARIAL SUPPORT -	Transcribing dictation, Typing, Inputing, Editing, Filing, Copying, Printing, Sorting, Storing, Handling Mail, Answering Telephone Calls and General Enquiries, Receiving Clients, etc. This is an intermediary or routing function required to facilitate the flow of information from those who generate to those who seek or need the information. The intermediaries usually act on the form rather than on the content of the information.
Z	UNKNOWN/NOT APPLICABLE -	This category is to be used if none of the preceding categories adequately describes the task involved or the task description is too ambiguous.