INTEGRATED VOICE DATA COMMUNICATIONS

INPUT

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Offices

NORTH AMERICA

Headquarters
1943 Landings Drive
Mountain View, CA
94043
(415) 960-3990
Telex 171407

Detroit
220 East Huron
Suite 209
Ann Arbor, MI 48104
(313) 971-0667

New York
Park 80 Plaza West-1
Saddle Brook, NJ 07662
(201) 368-9471
Telex 134630

Washington, D.C.
11820 Parklawn Drive
Suite 201
Rockville, MD 20852
(301) 231-7350

EUROPE

United Kingdom
INPUT, Ltd.
41 Dover Street
London W1X 3RB
England
01-493-9335
Telex 27113

France
La Nacelle
Procedure d'abonnement 1-74
2, rue Campagne Premiere
75014 Paris
France
322.56.46
Telex 220064 X5533

Italy
PGP Sistema SRL
20127 Milano
Via Soperga 36
Italy
Milan 284-2850
Telex 310352

Sweden
Athena Konsult AB
Box 22232
S-104 22 Stockholm
Sweden
08-542025
Telex 17041

ASIA

Japan
ODS Corporation
Shugetsu Building
No. 12-7 Kita Aoyama
3-Chome Minato-ku
Tokyo, 107
Japan
(03) 400-7090
Telex 26487

K.K. Ashisuto
Daini-Suzumaru Bldg., 6th Floor
8-1, Nishi Shimbashi
3-Chome Minato-ku
Tokyo, 105, Japan
(03) 437-0654
Telex 781 26196

Singapore
Cyberware Consultants (PTE) Ltd.
2902 Pangkor
Ardmore Park
Singapore 1025
734-8142

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Planning Services For Management

INTEGRATED VOICE/DATA COMMUNICATIONS

INTEGRATED VOICE/DATA COMMUNICATIONS

CONTENTS

INTEGRATED VOICE/DATA COMMUNICATIONS

EXHIBITS

I INTRODUCTION

I INTRODUCTION

- This report is part of INPUT's Telecommunications Planning Program. Designed to help senior managers and corporate executives evaluate some of the influences associated with voice/data integration, the report assesses opportunities and problems associated with the technology relating to voice/data integration. This report further:

  - Identifies technological voice/data integration requirements.

  - Defines and analyzes the current and projected state of the art of integration.

  - Analyzes some of the market influences associated with voice/data integration.

  - Identifies the thrust and direction of growth and development upon voice/data integration.

  - Defines the term "telecommunications" as including voice, data, video, and any other transmission media, and thus, by definition, is not restricted to voice only.

A. PURPOSE AND SCOPE

- Voice/data integration is hostage to the technology limitations of both voice and data transmissions, as well as to market demands.

- Information systems managers must therefore consider both technological and economic factors as part of the voice/data integration planning and equipment acquisition process.

- To support this process, this report:

  - Examines voice transmission and use in a data environment.

  - Evaluates the problems, possibilities, and costs associated with the voice/data integration process.

  - Describes the role of the Private Branch Exchange (PBX) and its impact.

  - Provides insights on how other users are reacting to the problems and possibilities of voice/data integration.

  - Discusses the standards which might apply in the event of future successful integration and their impact on users.

B. REPORT ORGANIZATION

- This report is organized as follows:

  - Chapter I is an introduction.

- Chapter II is an executive summary. It is formatted as a presentation for group discussion and emphasizes the key points within the report.

- Chapter III examines the problems and techniques associated with voice and voice/data transmission. It also considers some of the market factors influencing such transmission.

- Chapter IV is a technological analysis of voice/data integration and details the requirements and rationale for how integration technology can be applied. Various vendor offerings are also examined and evaluated.

- Chapter VI defines the Integrated Services Digital Network (ISDN) and what it offers the user.

- Chapter VII contains the conclusions and INPUT's recommendations for effective voice/data integration planning.

- The Appendix contains the questionnaire used to conduct the interviews.

C. METHODOLOGY

- The information for this report was gathered as follows:

  - Structured interviews were conducted with personnel from 25 companies currently using or planning to use some form of voice/data integration.

- In-depth interviews took place with leading vendors and suppliers of equipment that might be required in a voice/data integration environment.

- INPUT drew on its own studies into integration technology and the problems associated with voice and data communications.

- Vendor-supplied product literature and other secondary research sources were analyzed.

D. OTHER RELATED INPUT REPORTS

- Network Management and Control Systems (December 1984).

  - Describes various approaches and problems relating to communications network management and control and summarizes future trends and planning issues.

- SNA Networks: Challenges and Opportunities (November 1984).

  - Discusses the requirements and methods associated with installing and implementing SNA networks, and defines some of the problems and opportunities associated with these networks.

- Strategies for New Telecommunications Opportunities (October 1984).

  - This report evaluates the opportunities available in voice, data, and combined networks and is a adjunctive document for network structuring and planning.

- LAN/CBX Trends: Decision Processes for Users (October 1984).

    - This report evaluates the various networking technologies and describes some of the major LAN/CBX vendor offerings, identifies future trends, and defines cost factors for planning purposes.

II EXECUTIVE SUMMARY

II EXECUTIVE SUMMARY

- The executive summary is designed in presentation format in order to:

  - Help the busy reader quickly review key research findings.

  - Provide an executive presentation, complete with script and exhibits, to facilitate group communication.

- The key points of this entire report are summarized in Exhibits II-1 through II-7. On the left-hand page facing each exhibit is a script explaining the exhibit's contents.

A. WHO ARE THE BENEFICIARIES OF INTEGRATION?

- The user community which avails itself of voice/data integration will encompass the entire spectrum of the computer and communications community. These users will be the ones who derive the maximum benefit from integration.

- The specific beneficiaries will be those managers and executives who do the planning of computer systems or communications networks, the technical experts who install and/or maintain computer or communications links, and the staff responsible for the continued operations of the company by control over the computer complex and/or the communications networks.

- The biggest benefit will accrue to the company as a whole, since a properly constructed voice/data integration system should reduce operating costs (but not capital investment), increase throughput of information, and greatly expand flexibility of operations and response to competition.

EXHIBIT II-1

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WHO ARE THE BENEFICIARIES OF INTEGRATION?

- **Those Who:**
  - **Plan**
  - **Install**
  - **Operate**
  - **Maintain**

Voice or Data Communications Systems

B. IMPORTANT QUESTIONS SHOULD BE RAISED

- What impact will integration have on existing telecommunications networks and systems? If this basic issue is not addressed, organizational chaos will result from any attempt to tie voice and data activities together.

- How does the user prepare for voice/data integration? What specifically does he need to do? What information will he need access to in order to plan properly and ensure a smooth transition from single-purpose systems to multiple-purpose systems?

- When and at what phase should voice/data integration be implemented? Over what time frame should implementation occur? What milestones should the user look for and when should they appear? When does the user begin planning for them and how does he react?

- How much will integration cost, who will pay for it, and how will costs be allocated? How much will the user expect to contribute?

- Is voice/data integration really possible, and if so, when will it happen and how?

- If it is not possible, what are the current technology options? How can efficiencies be produced within existing or soon-to-be-announced technologies, and what are the trade-offs for each type of technological innovation?

EXHIBIT II-2

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IMPORTANT QUESTIONS NEED TO RAISED

- **What Is the Impact?**
- **How to Prepare?**
- **When and for how Long?**
- **What will it Cost - - Who Pays?**
- **IS IT POSSIBLE?**

C. HOW DO YOU GET THERE?

- There has been a significant increase in the integration of voice and data communications in the last several years, in both transmission networks and customer equipment. Local computer networks that handle voice as well as data communications, and digital PBX's that handle data as well as voice, are increasing in number.

- Although substantial efficiencies are predicted for a single integrated voice/data network, there may still be instances where two separate and distinct networks (one for voice and one for data) should continue to exist.

- Many of the new technologies use multiplex and/or compress data streams, thereby creating potential opportunities.

- The replacement of analog by digital networks contributes to the growth of digital networks by making available low-cost, high-reliability digital equipment and facilities.

- Integrated Services Digital Networks (ISDN) are still evolving from continued increases in the digitization of existing public networks.

  - Standardization still has to be established for global linkage.

  - There is a need to create a transport capability for various voice and data services, using a wide range of telecommunications modes.

  - Interfaces permitting disparate types of terminals and networks need to be developed.

EXHIBIT II-3

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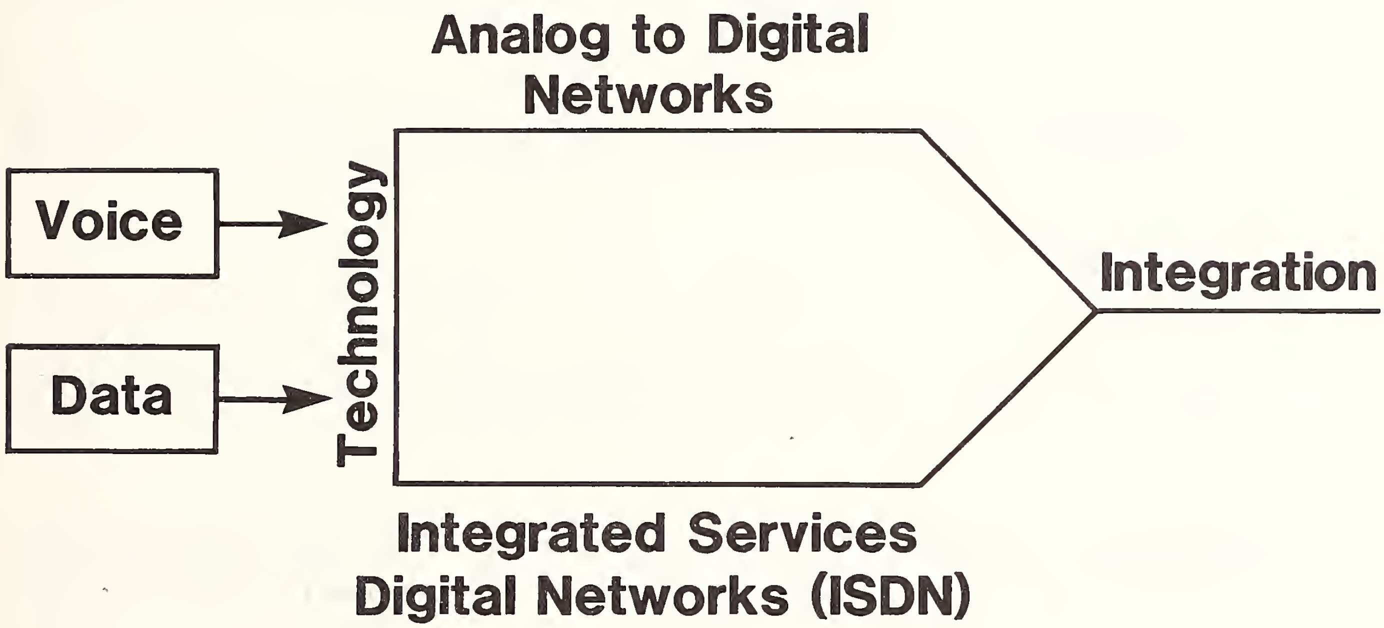
HOW DO YOU GET THERE?



D. TRENDS IN NETWORK SERVICES

- Many companies are marketing LANs designed to support resource sharing on the IBM PC line. Some, such as Ungerman-Bass, even offer direct channel attachment to the PC.

- An increasing number of LAN OEM's means greater pressure to develop voice/data integration capabilities.

- Protocol packages to provide network interfaces with the required high level protocol are becoming more readily available. This adds flexibility to the communications network.

- New developments, such as baseband and broadband chips, and high speed optimized switches, all add push to resolving the voice/data integration problems.

- Bridges and gateways linking dissimilar networks are growing in sophistication and popularity, thus providing public and private wideband network interconnection.

- The requisite software is rapidly being developed and marketed.

EXHIBIT II-4

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TRENDS IN NETWORK SERVICES

- Resource Sharing on LAN PCs
- More OEMs add more Pressure to Integrate
- Improved Protocol Packages for Interfacing
- New Developments Speed Resolution of Problem
- Bridges and Gateways Link Dissimilar Systems
- Software Is Being Developed

E. TRENDS IN PBX DEVELOPMENT

- Major PBX design efforts are focused on providing greater PBX throughput along with LAN interface capability.

- Fourth generation PBX's are more sophisticated and are being developed by new entrants into the field who hope to take advantage of the latest technological advances.

- Voice/data workstations, sophisticated software enhancements, and new office automation (OA) applications provide additional revenues to PBX suppliers.

- Close OEM/joint development between PBX and computer manufacturers is adding leverage to the integration problem. Computer manufacturers now have access to voice applications, and PBX suppliers have entree to information processing environments and new channels of distribution.

- Extensive software is being developed for distribution and integration of voice/data capabilities.

- Certification and development of high-speed PBX-to-computer interfaces (and vice versa), as well as high-speed PBX links to microwave and satellite are extending the open system interconnection.

EXHIBIT II-5

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TRENDS IN PBX DEVELOPMENT

- Greater Throughput
- New PBX Technology
- Voice/Data OA Provides Additional Revenues
- PBX and Computer Manufacturers Are Now Working Together
- New Software Is Being Developed
- Data/Voice Links Extend System Interconnection

F. AN AXIOM FOR TOMORROW'S WORLD

- Just because voice and data are simultaneously resident in the same device, e.g., an executive workstation or terminal, that does not mean that voice/data integration really exists in either that device or in that environment.

- True voice/data integration may not be possible for many years or at all, unless there is some dramatic, unforeseen shift in our understanding of the technology, or in the economics of doing business via voice and/or data communication links.

- Technological advances are usually evolutionary, in that, each progressive step is built upon previous technological successes. It is serendipitious where unplanned breakthroughs occur; that means it's revolutionary in the sense that change comes in dramatic jumps or leaps, rather than the slower, less dramatic evolutionary process. And that distinction of change is usually due to neither science nor technology; rather, perhaps just plain luck.

- The point being stressed here is that our understanding of what we call "voice/data integration" will require either a change in the definition of the term, or a different perspective of what constitutes "integration." The mere fact that an analog (voice) signal is handled by a device that is basically digital (data) oriented, e.g., on-line terminals, does not mean that true integration has been achieved. Rather, it means that both signals (analog and data or digital) are co-resident in the same device. And cohabitation (or co-residence) is not integration.

EXHIBIT II-6

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AN AXIOM FOR TOMORROW'S WORLD

COHABITATION IS NOT INTEGRATION!!

G. FOURTH GENERATION PBX: THE VOICE/DATA MANAGER OF THE FUTURE

- As a result of the emergence of local area network (LAN) technologies with higher transmission speeds, and of the need to integrate Private Branch exchanges (PBXs) with LANs, major PBX design efforts are being focused on providing for LAN interfaces and greater PBX system throughput.

- New companies are developing fourth generation PBXs to take advantage of the latest technologies and wresting significant market share from the established PBX suppliers.

- Several important technological directions are being pursued by the major PBX vendors:

  - Extensive applications systems software for the "true" distribution and integration of voice/data features.

  - Further extensions of open systems interconnections, including the development and certification of high-speed computer-to-PBX interfaces and high-speed PBX links to microwave and satellite facilities.

- These current technological developments, however, are emphasizing cohabitation of voice and data, not integration; whether this evolves into true voice/data integration remains to be seen.

EXHIBIT II-7

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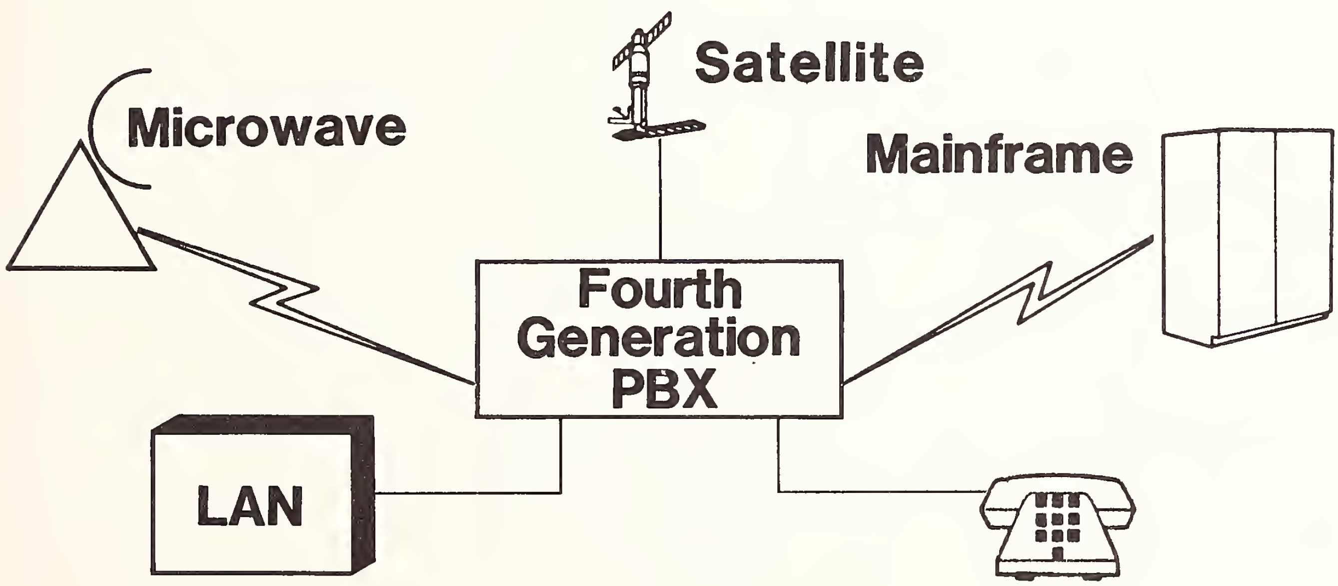
FOURTH GENERATION PBX: THE VOICE/DATA MANAGER OF THE FUTURE



III TECHNOLOGICAL ANALYSIS

III TECHNOLOGICAL ANALYSIS

A. INTRODUCTION

- In order to achieve voice/data integration, some sort of networking (which implies a switch somewhere in the network), or a plain digital switch (without the network) will be required. Which is more appropriate in a given situation is one of the issues that this report will explore.

- Further, a close look at the principal technologies which have influenced the design of currently available products will set the stage for understanding what constitutes digital switching and how it differs from analog.

- First, it is important to clearly define the functions of a switching system.

  - Private branch exchange (PBX) systems are really scaled-down versions of the large central office (CO) switching systems installed and operated by common carrier telephone companies such as the Bell System and General Telephone. And like them, on-premises switching systems perform three basic tasks:

    - Recognizing a request for service originated by a telephone.

    - Routing the call through its network.

. Maintaining the connections established for the duration of the call, no matter how long.

- The way these jobs are performed differs from one switch to the next, but all are based on a manual model that came about in the early days of telephony.

B. ANALOG AND DIGITAL TECHNIQUES

1. ANALOG TELEPHONE

- Telephony is an inherently analog technology. Specifically, it is an analogous electrical representation of speech which is created by a transmitting instrument and carried over a metallic path to a receiving set, which then converts the electrical current back into an acoustical form that the human ear can hear.

- To perform this conversion, telephone design has not changed much from the carbon element transmitter developed by Thomas Edison as an improvement over Bell's original liquid-base (acid) transmitter.

- Whenever a telephone is lifted from its rest, switch-hook contacts are closed to complete a path for direct current feed by the host switching system to the telephone. Situated in the path is a carbon-granule mouth-piece, or transmitter. As speech waves hit them, the granules are alternately compressed and decompressed, creating a varying resistance to the current. At the receiving station, the varying current drives a small earpiece speaker which reproduces (with moderate fidelity) the original speech.

2. DIGITAL TELEPHONE

- Digital techniques adhere to most of these principles, but incorporate a few new twists.

- Call processing by digital means begins with an analog signal. However, instead of processing the original waveform, a digital Private Automatic Branch Exchange (PABX) converts it into a binary-encoded equivalent.

  - Normally, one of two popular analog-to-digital conversion processes is used, either Pulse Code Modulation (PCM) or Delta Modulation (DM). PCM is more common, but DM is gradually coming into its own with new system introductions. In either case, it's the binary form of the signal that makes a PABX digital, not the network components, or the control mechanisms which may incorporate digital technology.

  - Diagrams for PCM and DM methods are highlighted on Exhibits III-1 and III-2, respectively.

  - The original analog signal appears at a sampling gate in both, and is periodically sampled at a rate determined by the system clock.

  - Normally, a frequency of 8 KHz (kilohertz) will produce a sufficient number of pulses to capture the speech components in the analog signal. If too few samples are made, considerable information can be lost.

  - At any rate, the pulses produced at the gate carry the amplitude of the analog wave at the instant of sampling.

    - One pulse is produced for every gate cycle.

EXHIBIT III-1

PULSE CODE MODULATION (PCM)

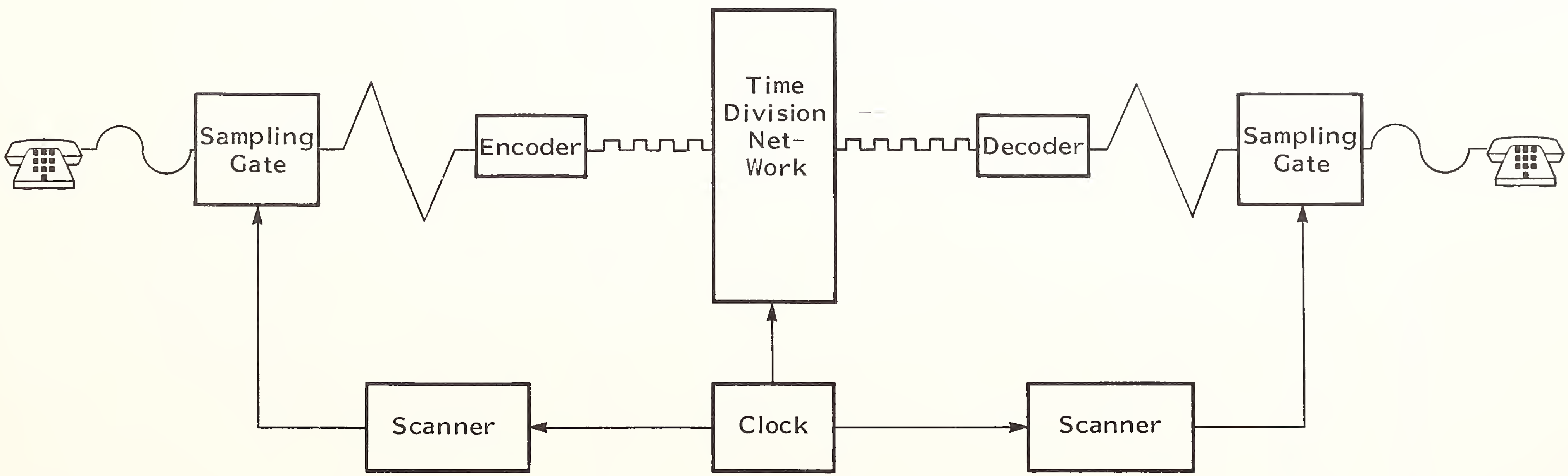
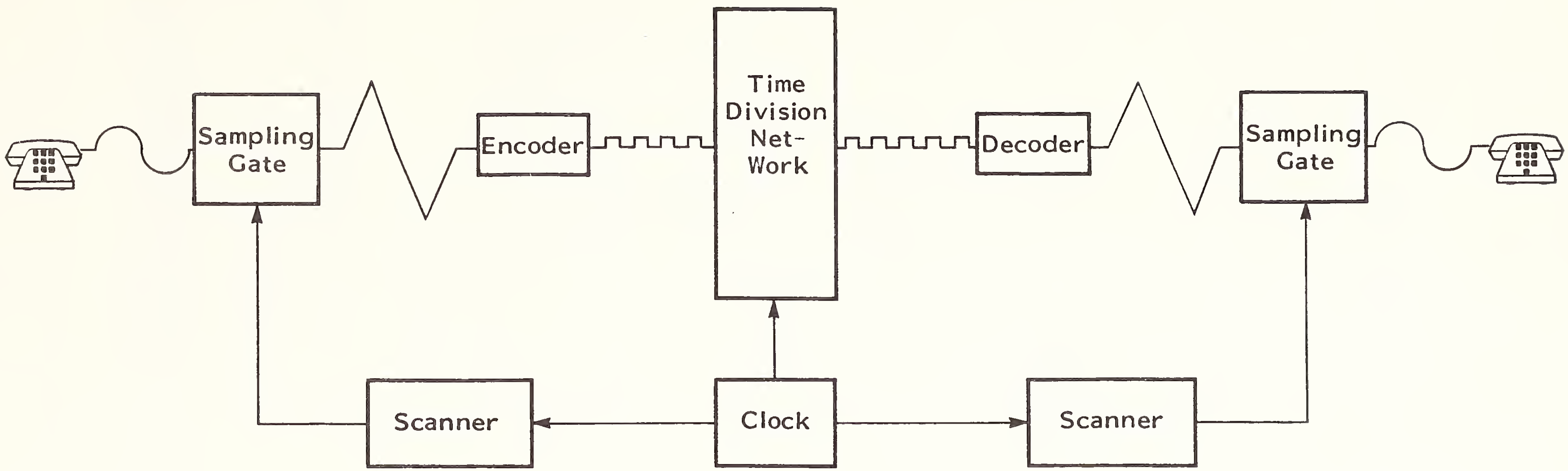


EXHIBIT III-2

DELTA MODULATION (DM)



- The characteristic duration of each pulse is determined by the amount of time the gate is kept operating by the scanner.

- This initial process is called Pulse Amplitude Modulation (PAM). Because the pulse amplitudes (heights) vary in time, in a manner similar to analog wave, PAM is considered an inherently analog pulse technology. Many systems don't require further conversion.

  - Perhaps the most well-known analog pulse PABX is the AT&T Dimension system, which uses time-division multiplexing (TDM) to route PAM pulses through its network.

  - Even though pulse and time-division techniques are used, the Dimension system and similar products aren't digital. Further conversion is necessary.

- As shown on Exhibits III-1 and III-2, the next operational element encountered is the encoder.

  - In PCM systems, the encoder examines the PAM pulses for amplitude values. Once determined, the encoder assigns a quantum value which most nearly approaches the sensed voltage of the pulse. The process is called quantization. These quanta are used as the basis for the ultimate binary representation that is subsequently impressed onto the time-division bus.

  - On the opposite side, the conversion process is reversed, leading ultimately to the integration of PAM pulses possessing the qualities of the originating signal.

- DM differs slightly, but significantly, from PCM. At the encoder, only the difference in amplitude between two successive PAM pulses is of interest.

- For every change discovered, either up or down, a single binary digit (pulse) is produced. This pulse alone is what is routed through the system.

- Whereas PCM may use eight bits to encode a quantum value, DM uses only one bit. This simplifies the network's construction.

3. TIME DIVISION MULTIPLEXING

- Traditional switching techniques which use electro-mechanical or electronic network elements are based on space division. That is, every call being processed is provided a separate path through the system. No other call, unless deliberately bridged, can occupy that circuit at that point in time.

  - In time division, on the other hand, all calls share a common circuit, alternately known as the highway or bus (Exhibit III-3). To differentiate between each call, the PBX assigns them a slot in time during which their pulses can traverse the bus.

  - Using the AT&T Dimension PBX as an example, 64 times slots permit only 64 connections at a time. The network controller, operating in conjunction with the scanner, keeps track of all available time slots so that requests for service can be quickly answered.

  - A time-division PBX is not necessarily digital.

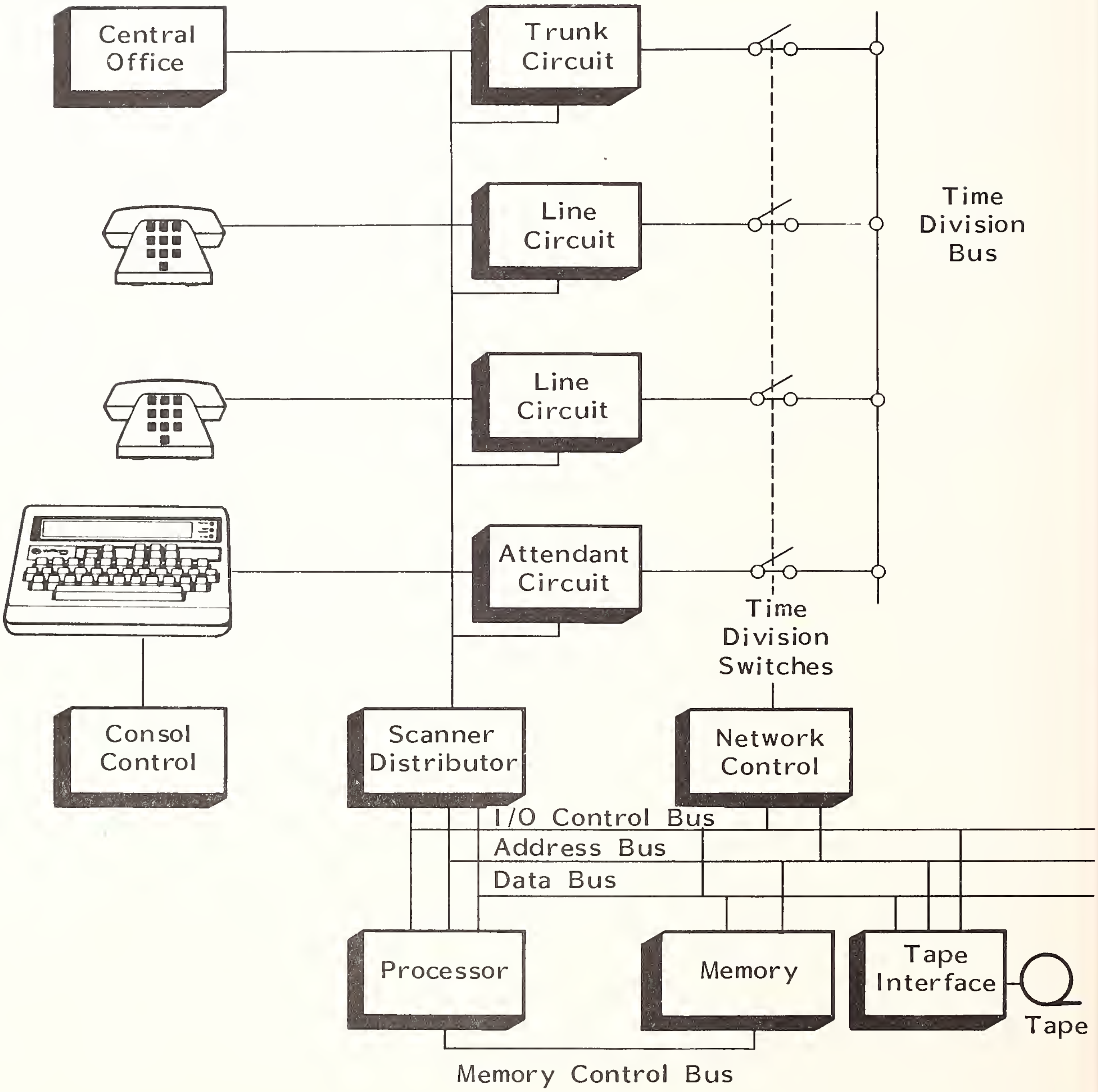
4. ADVANTAGES OF DIGITAL PBX

- There are several reasons for using a digital PBX:

  - The digital PBX improves signal quality.

EXHIBIT III-3

TIME DIVISION MULTIPLEXING (TDM)



- Digitized signals reduce noise and crosstalk, particularly over long loops, or circuits.

- Once the PAM wave is quantized, the possibility of injecting noise into the signal is practically eliminated.

- Whereas an analog signal requires frequent amplification over long hauls, digital pulses only need occasional reshaping due to attenuation (weakening of the signal due to partial signal loss).

- Additionally, when a normal telephone signal is amplified, any extraneous noise is also boosted in amplitude.

- The digital PBX provides direct compatibility with digital networks and devices. The PBX is assuming greater importance in overall business telecommunications. More and more, the telephone switching system routes data channels in-house and provides links to long-haul networks (private or provided by a common carrier).

  - The ability to attach processors and peripherals directly to a digital exchange reduces data processing network costs.

  - PCM-based PBXs are well-equipped for direct interfacing with long-haul carrier services which are heavily PCM-based. For example, several PBX products are built around the 24-channel North American PCM standard developed by the Bell System. It's a simple matter to interface these switches to a T-1 (24-channel, 1.544 Mbps) trunk.

  - With digital techniques and time-division multiplexing making up the backbone of local area networks, using the PBX as centralized control will also be possible.

- It's true that some simultaneous voice/data transmission capabilities can be provided for analog switches, but not without adding considerable hardware, modems in particular.

- The digital PBX can support specialized services such as voice store-and-forwarding. Because the voice signal is already digitized, all that is required are memory and management facilities to get the service running.

- Electronic communications message systems can be created simply by adding terminals, memory, control, etc. and then assigning channels, because digital paths are already in place.

- Secure voice transmission opens an interesting potential area of service for digital PBXs. Scrambling the digital speech data would render it unintelligible to an eavesdropper. This capability could be especially attractive to large corporations, banks, and securities exchanges which have their own sophisticated telephone systems.

- Once a PBX is digitized, it is usually referred to as a Private Automatic Branch Exchange (or PABX).

C. LOCAL AREA NETWORKS (LANs)

I. INTRODUCTION

- The battle of advocates continues between those who favor LANs and those who favor digital PBXs as the ultimate solution for local data communication. A new generation of high-tech products attempts to settle the question by offering the best of both worlds. Two heavily capitalized start-up firms, Ztel and CXC, have announced products that function as PBXs, but are physically token-ring local area networks, or more precisely, LANs with digital voice/data switches as nodes.

- A growing share of attention in the LAN market belongs to the "bridge" and "gateway" vendors.

  - A bridge is a device that links two local area networks of the same type.

  - A gateway is a similar device but one that performs protocol conversion between a local area network and a network of a different type, either a foreign LAN or a long-haul architecture such as SNA or X.25.

  - Many vendors offer such products for their own local area networks. Some vendors, however, specialize, marketing only bridges and gateways.

2. WHAT IS A LOCAL AREA NETWORK?

- A large percentage of the computer and data communications vendors active today have chosen to call at least one of their offerings a local area network, and in some functional sense, most of them are right. However, consensus holds that the term refers quite specifically to a certain class of product. For this report's purposes, the following definition is used.

  - A local area network is a system for the interconnection of two or more communicating devices that is:

    - Intra-company, privately owned, user-administered, and not subject to regulation by the FCC. This definition excludes both traditional local connections over common carrier facilities, such as Bell System tie lines, and public local networks, such as the newly approved Digital Termination Services and local cable television networks.

- Structured, i.e., integrated into a discrete physical entity, with devices interconnected by a continuous structural medium. In a local area network, many types of equipment and applications, such as data processing, word processing, electronic mail, video, and voice can all operate over a single cable.

- Limited in geographical scope, with devices physically separated but not mobile. For example, devices may be on different floors of a building, on the same industrial or university campus, or in several buildings in the same city. The maximum distance limitation, depending on the technology used, is about 50 miles. This excludes co-located computer systems interconnected by a high-speed parallel bus, global network systems designed primarily for use as long-haul networks, and mobile radio networks.

- Supportive of full connectivity. Every user device on the network is able potentially to communicate with every other user device. This characteristic excludes traditional local environments that support only hardwired, point-to-point connections between a host computer and its attached terminals.

- High speed. Because LANs are not subject to the speed limitations imposed by traditional common carrier facilities, they usually support operations in the 1M to 10 Mbps (megabit/sec) range. Minimum and maximum throughput generally ranges from 500 Kbps for low-speed LANs based on twisted pair wiring, up to over one billion bps for experimental optic LANs.

- Commercially available. The LAN market remains somewhat immature. Although in this report we touch upon some possible future trends and some technologies under development, our primary concern is to provide information on the current commercial environment and its capabilities.

- In local area networking, commercial availability is a matter of degree. Only the simplest LANs are true turnkey products.

  - Most local area networks require a great deal of on-site engineering to ensure the efficient location of stations, ease of reconfiguration and expansion, accessibility for testing and repair, and compliance with building and fire codes.

  - To ensure proper design and installation, users may have to deal with a number of secondary suppliers in addition to the primary vendor of LAN equipment. For example, although some LAN vendors provide "complete and comprehensive" configuration and installation services, others require the user to purchase and contract for the installation of all but the intelligent components of the network.

- For a fuller discussion of what Local Area Networks are and what advantages accrue through their use, please refer to INPUT's report entitled LAN/CBX Trends: Decision Processes for Users (October 1984).

3. LAN APPLICATIONS

- A local area network can support any application now served by conventional point-to-point communications. However, the implementation of a local area network can be a radical and expensive step, and hard to justify if its sole purpose is simply to replace an existing cable plant for tried-and-true applications.

  - A radical innovation must offer radical benefits.

- A local area network can simplify and streamline current procedures, of course, but in addition, it can offer benefits not available, or simply too expensive, with conventional local communications. These benefits vary for different applications in different environments. Some of the things that LANs can do best in broad areas of application include:

  - General Business Data Processing.

  - Office Automation.

  - Industrial and Laboratory Automation.

  - Home Utilization and Entertainment.

4. ADVANTAGES AND RESTRICTIONS OF LANS

- Today's local area network has yet to reach a stage where any really elaborate applications are available off-the-shelf. Today's local area network is a fairly sophisticated engine for moving several streams of bits concurrently, rapidly, reliably, and inexpensively from one physical interface to another. Still, every major advantage now offered by a local network balances one or more restrictions.

  - Some of these restrictions are built into the technology, while others will fall as vendors advance the state of the art.

  - A local area network allows a large number of intelligent devices to share resources.

    - Sharing hardware, such as disk space, printers, and connections to outside communications, distributes the cost of such hardware among all participating devices and offers significant savings over installing individual disk drives, printers, and modems at each station on the network.

- Sharing software enhances security, since all attached devices will use not only the same version of a particular program, but also the same master copy of a given program, thus further reducing the need for separate storage hardware. Since only a single program of a particular type is in storage at any one time, security is enhanced by limited access and by strict accountability of usage.

- Sharing data increases the reliability of a data base by ensuring that changes made by one user are available immediately to all other users.

- Resource sharing is perhaps the greatest current advantage offered by local area networking.

5. INTEGRATION OF LAN FUNCTIONS

- The ability to integrate a wide range of functions into a single, harmonious system is another potential advantage that LANs offer.

  - The local area network can provide a rational framework around which management can build everything from office procedures to strategies for planning, purchasing, and growth.

  - Focusing on the LAN, creative managers can establish an orderly hierarchy of job functions, as well as of hardware, thus facilitating the flow of responsibility and information from top to bottom in their organizations.

- The chief restriction is that implementing a management system in hardware is like casting the system in concrete.

- A large investment in a given organizational plan generates a proportional amount of inertia against efforts to change that plan.

- Increasing the efficiency of a good system makes it better; increasing the efficiency of a bad system makes it worse.

• No system or hardware is a panacea, however attractive it may seem. The greater a technology's potential effect on an organization, the more carefully managers must plan its implementation. A local area network is only a tool. Creative management can make it a powerful tool.

6. HIGHER CHANNEL SPEED

• A high rate of data transfer is inherent in any definition of a local area network. Most LANs transfer data at rates from 1 Mbps to 10 Mbps, and high-performance LANs can achieve rates up to 50 Mbps, roughly 900 times faster than the best rates available over conventional switched facilities.

• Such high rates of throughput can be indispensable for such applications as high-resolution, movable color graphics, which need megabits of information to paint a single screen, and bulk data transfer among mainframe computers.

7. SIMPLICITY AND FLEXIBILITY

• Most local area networks use a simple and elegant architecture with control distributed among the participating stations. Since the entire network does not depend on a single polling or switching device, such networks tolerate failures quite well.

  - A hardware or software failure in one station usually affects only that station.

- Distributed control also allows easy reconfiguraion and expansion, since participating devices in most LAN architectures need not be aware of the precise number or arrangement of the other stations.

- Users can move or add stations to such networks with relative ease.

- The LAN's simplicity and flexibility are among its most notable selling points.

8. SECURITY

- By design, most local area networks are easy to tap. Ease of tapping makes the network easy to expand and reconfigure, but also makes it virtually impossible to secure from simple physical intrusion.

  - At the current state of the art, data security is arguably the biggest disadvantage of a local area network.

  - New, easier tapping mechanisms simply exaggerate the problem.

- Some vendors have begun to address the security problem by implementing data encryption as an add-on feature, but encryption can only prevent the interception of data.

  - A relatively unsophisticated vandal can still jam or destroy data with ease.

  - Users should never allow plant security applications, such as card-access locks or security video, to share the same cable plant as every day data applications.

  - Separate networks should be up for secure and open facilities; if necessary, such networks can be interconnected through a secure bridge or gateway that can screen out unwanted signals.

- If possible, redundant cabling should be installed, so that an intentional or unintentional break in the cable will not bring down the network.

9. ALTERNATIVES TO LANS

- Alongside the many applications for which local area networks can provide beneficial, cost-saving solutions are some for which LANs are either too costly or too unsophisticated technologically.

- For simple port selection or port contention among one or more computers and a network of terminals, the installation of a local area network is just plain overkill.

  - Users in such situations usually wish only to gain access to host-resident applications; the host computers handle requests for storage and peripheral service. Their terminals are usually unintelligent, asynchronous devices that have no ability to share software either with the host or with one another and need to communicate with only one computer.

  - Applications requiring simple port selection and contention are most common on university compuses, or in their industrial counterparts, research and development labs.

- For port selection among a small number of computers of similar make and with similar operating systems, a shared front-end processor can do the job more effectively than a local area network. When mutually incompatible computers are involved, a port selection switch or a data PBX is the best choice.

  - Both front-end processors and data switches have been on the scene for years; they offer all the benefits of proven technologies: stable interfaces, time-tested maintenance and control procedures, vendors who have been around awhile and are likely to stay so, and a history of satisfied customers.

- Users should not risk an infant technology for simple applications when a less risky alternative is available.

- The large-scale, fully integrated voice and data network lies at the other end of the spectrum.

  - The LAN has not been built that can handle a full load of voice telephone traffic along with a full load of data.

  - Local area networks are a creation of the data processing industry, and their technology has bypassed, not solved, the voice communications problems that the telephone industry has been handling for decades.

- From the telephone industry comes the voice/data PBX, a circuit switch built on a digital matrix and designed to handle both voice and data traffic.

  - For data handling, such systems represent an even younger technology than LAN, and their data transmission capabilities are currently somewhat narrow.

  - Still, they offer a number of advantages for large offices in which management would like to place a terminal, at least potentially, on every desk.

  - Any large office must have a telephone network, and in a large plant, the cost savings from having data applications share that network, rather than having to install a separate cable plant for data, can more than make up for the high initial cost of a voice/data PBX.

- The big switches' present limitations for data handling aren't really an issue; their makers will have ironed the bugs out of data switching long before current LAN vendors have taught their networks to switch voice calls.

• Makers of both data switches and voice/data PBXs are heating up their side of the competition by using LAN technology.

  - The resulting products are hybrids between local area networks and traditional circuit switches in which individual switches handle local communications in their own domains while participating in a network of similar switches based on a LAN technology such as the token-passing ring.

  - Several vendors of data-only switches are now offering such hybrids. One voice/data PBX maker, InteCom, currently offers a semi-hybrid, a PBX that can communicate directly with one or more Ethernet segments.

  - Two vendors, startups CXC and Ztel, have recently announced full hybrid configurations, LANs with voice/data PBXs as nodes.

10. LAN TECHNOLOGY

• In choosing a local area network, four basic issues must be addressed:

  - The network's physical medium and transmission technique.

  - Its topology, the logical arrangement of its stations.

  - Its access method, the way it arbitrates among its stations for the use of the shared medium.

- Any higher-level services the LAN offers, such as potocol or file format conversion, data encryption, or network management.

- Today's market offers three basic choices of medium:

  - Twisted wire pair.

  - Coaxial cable.

  - Optical fiber.

- There are three basic topologies:

  - Linear bus.

  - Ring.

  - Star.

- And three access methods:

  - Carrier sense multiple access (bus and tree networks).

  - Token passing (bus and ring networks).

  - Slotted access (exclusively ring networks).

- The issue of higher-level services is somewhat more complex, since a vendor can offer such services above any practical combination of the other three factors.

- However, right now, such services are only beginning to emerge as commercial offerings, and they depend heavily on specific applications.

D. NETWORK CONSIDERATIONS

- To adequately determine the ability to integrate voice and data, it is necessary to determine which of the following directions will be the most feasible. Thus it is necessary to evaluate:

  - A single network to handle both voice and data as separate entities.

  - Two separate networks, one for each entity (voice and data), with a communication path between the two.

  - A single network, capable of handling both voice and data over a single channel or pipeline.

  - The switching technique to be used for the preferred topology.

- Based upon this evaluation, the user can then determine which network topology is preferable for use in his environment--star, ring, bus, or some form of distributed configuration.

- Consider these alternatives in light of the following observations:

  - Intra-office voice networks are pervasive.

  - Intra-office data networks are becoming more necessary and useful; they will be essential to tie together the currently developing variety of office systems to achieve full automation of office processes.

  - In a typical business office, voice communications predominate; the ratio of data traffic to voice traffic is extremely low even in highly automated offices.

- At present, there are few applications which combine the use of voice and data in a cost-effective way; in the future, however, combined voice/data applications should become cost-effective and hence more prevalent.

I. SEPARATE NETWORKS VERSUS A COMBINED NETWORK

- On the basis of the observations given above, it is apparent that in the near future, there will be strong interest in intra-office data networks and some interest, but perhaps less utility, in unified voice/data networks.

  - There is no single strong argument for a total integrated voice/data office network. However, there certainly are reasons for constructing a network that will provide some connection between voice and data devices.

  - Since voice traffic volume is so much greater than data traffic volume, and since it may be assumed that an intra-office voice network will always exist, the potential for carrying the data on the already-existent voice network is, at least superficially, extremely appealing, but some concrete justifications are clearly required.

- Before outlining the relative merits of separate and combined networks, it is necessary to explore a few thoughts about the traffic patterns in a future office.

  - The data flows in the office will be both for internal and external communications: almost all devices will be involved in some intra-office communications, and many will also utilize some outside communications.

  - Initially, the traffic flows within a newly automated office may be somewhat static, but this will change as the variety of devices and applications grows; then the inter-connections will become quite dynamic, partly because it is anticipated that most communications among terminals will be mediated by a computer or some type of controller (for example, a buffering unit that manages facsimile input/output).

- The future terminal will connect to a variety of hosts or terminals, depending upon which provides the particular specialized service required.

  - For data communications external to an office, with the increased use of distributed processing, an increased fraction of connect time will be devoted to actual communications.

  - In these ways, future data connections will become increasingly similar to current voice connections.

- The relative advantages of separate and combined networks are shown in Exhibit III-4 and are summarized below:

  - Separate networks:

    - There is not much voice/data cross traffic, and the flow patterns of the two are different.

    - Separate networks can each be optimized for its own traffic.

    - Data and voice have different requirements for delay, throughput, error control, and reliability.

  - Combined networks:

    - In the future, there will be more voice/data cross traffic, and the flow patterns of data will become more similar to those of voice.

EXHIBIT III-4

SUMMARY OF ADVANTAGES

1. Separate Networks:

    A. Not Much Voice/Data Cross Traffic

    B. Different Flow Patterns

    C. Separate Networks Optimized

    D. Voice and Data Have Different Requirements

2. Combined Networks

    A. More Cross Traffic

    B. Flow Patterns Similar to Voice

    C. Data Access is More Direct

    D. Single Product Purchase

    E. Modularity Permits Adding On

    F. Less Expensive

- Data access to external resources is more direct with a combined network.

- A customer can begin with a voice network and later add data capabilities at lower incremental cost.

- It may be possible to use existing in-building telephone wiring to carry data traffic.

- Since the volume of data traffic is much less than voice, it is incrementally less expensive to provide the capacity for initial as well as for expanded data requirements on a combined voice/data network.

- In evaluating the potential advantages of separate networks in greater depth, the following counter-arguments can be invoked to the three points given in the exhibit:

  - When designing a network (or a product), one should plan for future needs (for which a combined network is a better match).

  - Since the volume of traffic for data is much less than that of voice (for a given level of performance), the data-handling capabilities of a combined network can be less than optimum without a significant increase in total cost.

  - There should be no problem in meeting the delay, throughput, and error requirements of both voice and data because:

    - If properly designed, the delay through a local network will be very small for all traffic.

    - The volume of data is negligible compared with voice.

    - Existing protocols can be used to handle error control.

- The one remaining issue is the different reliability requirements of voice and data. The reliability of the voice network is usually critical to an organization, and telephone systems are designed with this principle in mind.

- On the other hand, because data handling needs are generally less predictable and more complex, data networks tend to be less reliable. If the addition of data handling capability to a voice network increases the likelihood that the voice traffic will be disrupted, then a combined network will probably not be accepted in the marketplace.

- However, it should be possible to incorporate mechanisms into a combined network that ensure a high degree of reliability.

    - For example, voice, data connections, and traffic could be handled differently in order to ensure that if a failure occurs in the data portion, the voice portion is not affected.

    - Also, significant space capacity could be provided for this data traffic in order to avoid problems that might occur when operating near saturation. In other words, with proper design, the reliability issue should be manageable.

    - Thus, in the office environment, the potential advantages of separate networks, as listed in Exhibit III-4, either are not significant or can be overcome, and the itemized technical and economic advantages of a combined network outweigh those of separate networks.

    - Therefore, future office networks should be based upon combining voice and data.

2. NETWORK TOPOLOGY

- Consider now the possible topological structure of a combined voice/data network.

  - Four basic alternatives are:

    - A star, over which all communications flow through a central controller.

    - A ring in which data flows sequentially around a loop.

    - A bus, in which data can be broadcast to all devices.

    - A general distributed topology in which several paths exist between communicating nodes, but not all nodes are connected directly to each other.

- In evaluating these alternative topologies for local office networks, typical office traffic statistics should be generated for both voice and data. Careful analysis will then be possible and will typically indicate the high ratio of voice traffic to data traffic.

- The characteristics of star and bus/ring networks are compared in Exhibit III-5. At the present level of analysis, the flexibility and evolutionary considerations listed in the exhibit are perhaps the strongest reasons to develop star network technology (i.e., PBX technology) to support both data and voice.

  - The technology exists now for voice, it is widely used and understood, and the gain for both vendors and users appears to be great, relative to the (probably) low investment.

EXHIBIT III-5

TOPOLOGY COMPARISON FOR VOICE/DATA INTEGRATION

	STAR	BUS/RING
Reliability Controller	Limiting Resource - Impact of Failure is Great; Can be Overcome by Redundancy	Impact of Failure Should Be Only a Single Station Outage
Transmission Medium	Impact of Failure is a Single Station Outage	Limiting Resource - Risk of Failure is Small, But May be Difficult to Repair; Redundancy is not Practical
Growth Capability	Limited by Controller; Large Infrequent Additions May Require Overall Reconfiguration	Limited by Bus/Ring Capacity; Each New Connection Requires New Controller
Flexibility	Controller Can Utilize Techniques and Hardware Developed for any Physical Technology	Can Have Local, Specialized Functionality
Economics	Economy of Scale Within Controller; Additional Devices may be Required for Physically Long Lines	Cost of Controllers is Major Factor in Assessing Viability
Evolutionary Considerations	Voice Networks are Star Today (Strong Market Inertia); Data Traffic is Very Much Less than Voice, So it May be Minimal Cost to Add Data	None Exist - Would Require Massive Conversions
Maintainability	More Convenient Because Centrally Located; But Single Complex Switch May be More Difficult to Troubleshoot	Distributed Maintenance is Burdensome (e.g., synchronization of Nodes, Remote Troubleshooting)

- The vendor who can offer a switch for both voice and data can gain an additional market segment, and the user organization can acquire full communications support, probably for a lot less expense than with separate facilities.

- Product compatibility would be the goal, so that voice "controllers" could be expanded to support data; expansion should be modular so the user can isolate voice and data functionality, or combine it.

- A related advantage of a star configuration is that it might be possible to use in-building PBX wiring, thereby reducing not only the cost, but also the time and inconvenience of installing a voice/data network.

  - If an organization owns its own PBX and hence the associated wiring, then these existing wires could also carry data traffic (by a multiplexing technique, for example).

  - Also, if an organization plans to replace a Bell System PBX with a non-Bell unit, then new wiring would generally be installed; in this case, a pair of cables (rather than a single cable) could be routed to each office at little additional cost, the second cable being available for a possible data terminal.

3. SWITCHING TECHNIQUES FOR A VOICE/DATA COMPUTERIZED PBX (CBX)

- In the previous section arguments were presented showing that a combined voice/data network using a star topology is a preferable approach for designing an office communications network.

  - Since most of the traffic on such a network will be voice, the network's central switch can be referred to as a "computerized PBX" (CBX), even though this future switch may bear little resemblance to present-day digital telephone switches.

- Some design considerations for the choice of switching technique internal to an office PBX now need to be considered.

- Because of its use in existing PBXs, circuit switching is clearly a prime candidate for use in a CBX. The term "circuit-switching" is used in its broadest sense, namely to signify any switching technique which pre-allocates (and hence guarantees) certain resources to a voice or data connection. Thus, circuit switching includes, for example, both space and time division multiplexing.

  - The alternative to circuit switching is "packet switching", where the term is used in a broad sense to denote a method which does not pre-allocate specific resources to users.

  - There are many possibilities, for example, the old but simple ALOHA or carrier sense multiple access, (CSMA) which can be used if the internal CBX topology is a bus.

  - Clearly, the switching technique and the internal CBX configuration are interdependent decisions.

- Before comparing these two switching alternatives, note that there are some considerations which do not significantly influence the choice of switching technique, the most basic being performance.

  - For some networks, the performance requirements dictate certain aspects of the switching (i.e., pre-allocation of bandwidth) is clearly inappropriate, and therefore a variety of "demand assignment" techniques have been proposed.

- However, for an office network with a single CBX (or even with several CBXs), some performance issues disappear. For example, the delay and the error rates should be small regardless of the switching technique that is used.

- In addition, many of the complexities associated with multinode packet networks (such as routing and message reassembly) do not occur in a CBX-based local network.

- Finally, with circuit switching approaches in which the internal data rate of the switch is much greater than the user data rate (as in time division multiplexing), the hardware must provide some buffering and must construct small blocks of data for transmission through the switch; thus, these approaches must perform some of the same functions performed in a packet switch.

- The arguments noted above cannot be invoked a priori in order to choose one switching technique over the other.

• The relative advantages and disadvantages of circuit and packet switching are now outlined. However, because there has not been a detailed comparison, the planner must be careful to distinguish between potential and inherent benefits. Existing circuit or packet switching techniques possess certain limitations for the application under consideration, but if the planner were to design a new switching technique, especially for a voice/data CBX, he might be able to overcome those limitations.

• With this point in mind, several benefits associated with circuit switching can be shown:

- It is a proven technology (it already exists for voice).

- Because of its widespread use, circuit switching hardware components are more common and thus, should be relatively low priced.

- The processing software is less complex than with packet switching. With packet switching, the switch will need congestion control mechanisms, more sophisticated buffer management capabilities, and silence recognition for voice traffic.

- Potential advantages of circuit switching include:

  - It uses less buffer memory (with packet switching there is always some chance that a transmission will be delayed, and hence some additional buffers will be needed).

  - It is easier to isolate voice and data traffic, thereby providing the potential for achieving the required reliability of voice connections in a combined voice/data network.

  - Support for existing protocols is more readily achieved; since a "wire" is dedicated to the connection, the switch appears transparent to the communicating devices.

- The principal disadvantages of circuit switching is its much greater throughput requirements. This greater bandwidth means that more processor hardware may be needed.

- The above points are not conclusive for selecting a switching method. The decisive factor is cost, and more detailed analyses are required to evaluate this factor.

  - In a typical CBX installation, the switch constitutes a significant fraction of the overall system cost, and hence the switching technique should be chosen primarily on the basis of how much the resulting CBX would cost.

- Proper cost analysis requires conducting a more detailed study of the traffic characteristics, e.g., flow patterns, message sizes, and of the digital voice technology, to develop candidate switching techniques well-matched to the requirements, and to carefully evaluate the hardware and software requirements of these techniques.

4. DATA CONSIDERATIONS FOR PACKET NETWORKS

- Progress toward integration has thus far been slow.

  - Digitizing voice is usually too expensive, yet analog switching will not do the job needed for data.

  - Data needs front-end processors to perform switching, while voice has continued to rely on PBXs, or on common-carrier central-office switching.

  - Analog data switching is largely limited to asynchronous transmissions up to 1.2Kbit/s, and is thus, too slow and too inaccurate for data transmission.

- Many consultants see the solution to integration as a simple one: all that need be accomplished is the reduction in price of digitized voice compression to the break-even cost of analog voice. It is not that simple.

- The most important topics these days for the data communications professional are: X.25 and packet switching; IBM's systems network architecture (SNA); local networks; the automated office; and integrated voice and data.

  - But voice and data integration does not simply stand alone; it affects each of these other concerns.

- For instance, packet switching and integration are basically not compatible. it is true that packetized voice has been done by the Defense Department's Arpanet and others. Yet it is unlikely that the two processes can ever be practically merged. The Defense Department has discontinued the development and use of Arpanet.

  - It might be possible with a private, in-house network, but even then large mainframe capabilities would be needed to push the massive volumes of digitized voice bits.

  - Transmission timing is critical since it affects the structure of the data stream, and thus, its contents. When one adds a gateway for this network to interface into the world of common carriers, more transmission delays enter the picture.

  - The jumps from land lines to satellites add still more delay. These delays accumulate until critical timing for voice cannot be maintained.

- Another major consideration is the problem of interleaved virtual circuits for data.

  - Voice switching is based on the concept of point-to-point connections. That is, person A talks to B, C, or D. Yet many X.25 processors talk with many other processors simultaneously over the same line. Processor A talks to B and C and D. Sessions and data are interleaved over the same paths.

  - Special-purpose switching equipment is required for packets--equipment that is not designed to also serve as a voice PBX.

- Thus voice switching devices, such as PBXs, cannot meet the interleaving requirements that multiple virtual paths need for data.

- Nor can X.25 packets meet the requirements of digitized voice.

- Yet X.25, which is unquestionably the future in data communications, resembles oil and water as far as voice is concerned. There is now no known way to transmit voice over X.25 protocols and still have coherency at the receiving end.

- There is no choice but to separate voice and X.25 data into different switching devices.

- They could share trunks, but would have to be routed to different switches within a mode.

- This defeats one of the major objectives of integrated voice and data: to share switching devices.

5. IBM'S SYSTEMS NETWORK ARCHITECTURE (SNA)

- In comparing voice/data integration with IBM's SNA, there are both positive and negative factors, depending on the mix of interactive 3270-type terminals and remote job processors (RJP's).

- Voice cannot be economically switched in front-end processors. Throughput capacity would have to be increased 10 to 20 times.

  - Handling voice within the complexities of SNA would be difficult at best: the overhead would be excessive.

  - Each voice station would need an intelligent processor to format the voice into SDLC and conform to the architectural protocols. This would be impractical.

- A voice switch could not handle interactive SNA data, because SNA is only one of the multiple virtual paths transmitted over a single circuit, and the biggest problem is the cluster of 3270-type terminals and the polling sequence.

  - Each terminal on a cluster may be in a session with different hosts.

  - Yet all share the same controller, modem, and circuit.

- If switching were performed independently of a front-end processor, then the switch would have to be able to respond to terminal polls from multiple hosts.

  - This is simply not the kind of function performed today by voice-switching devices.

  - Again, we see that data switching is a special case that must be handled by specially designed data devices.

  - Integration of interactive SNA terminals with voice-switching equipment does not presently appear practical.

- In contrast to interactive terminals, noninterleaving Remote Job Processing (RJP) stations are well suited to voice-switching equipment, and they would be highly desirable for Binary Synchronous Communication (BSC) RJP's. The only limitation might be PBX speed.

- Switching of BSP RJP's among two or more hosts using SNA is tremendously complex, tedious, and burdened with massive overhead.

  - Use of a PBX external to and invisible to SNA would eliminate great quantities of front-end and host overhead.

- This is where cost benefits could be picked up through use of a PBX for data.

- How does SNA rate as a candidate for voice/data integration? Probably poorly.

  - A typicaly network ratio of interactive terminals to RJP's is probably about 12 to 1. This means an integration program would encompass a small minority of an organization's SNA terminals.

  - As the RJP's are converted to SDLC, they become candidates for front-end-processor switching, and the benefits of PBX switching are lost.

E. SUMMARY AND RECOMMENDATIONS

- In the report thus far, the goal has been to determine the feasibility of integrating voice and data on a single office network.

  - The functional requirements for combining voice and data were briefly considered, and then the traffic characteristics of the office were analyzed to best determine the magnitude of voice traffic and of data traffic.

  - Subsequently, design alternatives for an office network and its main switching components were also considered.

- The requirement for using systems based on both voice and data technologies is most prominent among management and professional level personnel:

  - Voice is the preferred input medium for this group of personnel.

- Digital information is the most convenient and flexible form of processing, storing, and retrieving information. The two most apparent applications for combining voice and data in the immediate future are voice mail and voice dictation.

- In the more distant future, the widespread availability of computer voice recognition and generation and their attendant systems capabilities will spur innovation of many more applications which combine voice and data.

• Voice traffic is shown to be substantially greater than data traffic. The major conclusion to be drawn is that if a single communication network handles both voice and data, then the network should be optimized for voice. Data traffic should be added to existing voice networks, as in current office practice.

• In considering design alternatives for local office networks, several conclusions are reached:

  - Future office network designs should be based upon combining voice and data. There are few advantages to separating voice from data, while there are strong technical and economic benefits in a combined network.

  - The star topology may be the most immediately suitable structure for a combined voice/data intra-office network; such a network would be based around a switch similar to that of the computerized PBX which is currently oriented to voice. Internally, the CBX would utilize any physical topology.

  - Traffic characteristics of both data and digital voice must be studied in more detail; the results of such further study would then provide the basis for identifying candidate switching techniques well matched to the requirements, and for evaluating the resource requirements of these alternative switching techniques. It would then be possible to choose a CBX design on the basis of delivered performance as well as cost of the switch.

- The circuit-switching schemes currently used within the voice CBX may or may not be optimal when switching both voice and data. In order to determine the optimal switching technique, the merits of each must be understood on the basis of resources required in the switch and on the basis of delivered performance; this would then provide the basis for a cost analysis of the switching facilities.

- Cost is a major decision factor since the switch constitutes a major portion of the cost for a star network.

IV MARKET CONSIDERATIONS

IV MARKET CONSIDERATIONS

A. INTRODUCTION

1. THE VENDORS

- Among the more arduous tasks facing the manager of a voice-network carrying data communications is the evaluation of PBXs and their features.

    - To provide some insights into a few of these, the following are descriptions of some manufacturers' switches. The list is by no means exhaustive, as its purpose is to enlighten rather than to serve as a buyer's guide.

    - The switches described below are all similar, offering TI compatibility, "companded" (compression-expansion) pulse-code modulation (an analog function), and a respectable asynchronous and synchronous data transmission rate.

    - The traffic engineering terms "blocking" and "non-blocking" refers to what happens when you try to complete a call. This "circuit busy" verb means that there are no circuits available just then, the system lacks adequate communications paths, all the outgoing lines are in use, or the line you're attempting to call is busy.

- AT&T Information Systems' top-of-the-line Dimension System 85, introduced in December 1982, is the long-awaited digital PBX touted by AT&T as being capable of meeting all user requirements now and in the future.

  - Being new, there are few, if any, of these switches in the field, and the capability of these machines has not been widely tested.

  - Among its many features, System 85 has automatic call distribution, local network, and management capabilities.

  - It is also TI compatible and can be used in energy management.

  - A newer and smaller version of this PBX, called System 75, was recently announced, but has yet to be installed.

- GTE's Omni line of PBXs comprises several different models, the smallest handling up to 120 lines on 28 trunks; the largest, 9,200 lines and 1,152 trunks.

  - It is TI compatible, nonblocking on the line side, but blocking on the trunk side.

  - It can handle data rates up to 56 Kbit/s via the RS-232-C interface. It is sold directly by the manufacturer, or by distributors in those areas where GTE is not represented.

  - The central processing unit is an Intel 8085.

- Mitel manufactures a highly sophisticated switch that is virtually nonblocking.

  - Mitel uses companded pulse-code modulation, and the company's switch can handle 19.2 Kbit/s asynchronous data and 56 Kbit/s synchronous via the RS-232-C and RS-449 interfaces.

- However, Mitel has had some difficulty in bringing its latest product to market. As a result, IBM dropped support of this organization in favor of Rolm.

- The PBX line from NEC is available in sizes starting at 144 trunks capable of supporting up to 720 lines.

  - The 2400 model, announced last year, is TI compatible, uses companded pulse-code modulation, is nonblocking, and can handle--via RS-232-C--19.2 Kbit/s asynchronous data and 56 Kbit/s synchronous.

  - At this writing, automatic call distribution capability does not exist.

  - NEC stresses the advantages of using distributed processing over common control, but that's an issue that is yet to be resolved.

- Northern Telecom Inc., one of the most highly successful PBX manufacturers, was originally part of the Bell System when Canada was one of the Bell operating companies. It currently has 10% of the market.

  - The company has at least five PBX models in the SL1 Series, ranging from a model that provides 20 stations or trunks to one that supports 100,000 lines or trunks.

  - Northern Telecom's PBXs are licensed to interface with the Ethernet local network. They have features similar to those of Rolm's products as well as those of other contemporary PBXs--that is, the Northern Telecom switches support automatic call distribution, remote diagnostics, least-cost routing, and station-message detail recording.

  - The company makes its own central processing unit for its PBX line. Its products can handle a common control switching arrangement, which is similar to centralized data processing and control--and, of course, the opposite of distributed processing.

- If dual CPUs are employed, the PBX switches automatically from one to the other upon fault detection, or, if the user so desires, automatically every 24 hours.

- Rockwell's Galaxy model, the dean of all PBXs featuring automatic call distribution, is used mostly by large hotels, airlines, and auto-rental agencies. However, since the switch is sized and priced for large users, the average customer will not be able to justify purchasing it.

  - The Galaxy switch is nonblocking and TI compatible; it uses companded pulse-code modulation. Companding the signal prevents degradation of the signal-to-noise ratio, improving the quality of the reproduced voice.

  - Galaxy's data transmission rate is 9.6 Kbit/s asynchronous, 4.8 Kbit/s synchronous.

  - It is sold only by Rockwell.

  - The central processing unit is a Digital Equipment Corp. PDP-11.

- The largest and most successful telco-independent PBX manufacturer around, Rolm currently has more than 24% of the market.

  - It has five different PBX models in the CBX line, ranging in size from 16 lines or extensions to 10,000 lines or extensions, with corresponding trunk capacity.

  - The PBXs use linear pulse-code modulation, are partially TI compatible, but are not nonblocking. The data transmission rate via an RS-232-C interface is 19.2 Kbit/s.

- The PBXs feature automtic call distribution and packet-switching capabilities, as well as energy management and remote diagnostics.

- The PBX's central processing unit is manufactured by Rolm, which started out building small digital processors for the military. Common control switching is offered.

- IBM now owns roughly 22% of Rolm, which indicates the direction in which this industry is leaning, that is, toward the transmission of digitized information regardless of whether it is data or voice.

- IBM has recently been given permission by the courts to acquire larger percentages of Rolm: the future will reveal the extent of IBM's acquisition.

- Rolm sells and maintains its equipment through its own regional distributorship.

• The decision of which switch to buy will have to be based on the usual parameters, including price, line and trunk size, delivery schedule, the vendor's volume of manufacturing and scope of distribution, and reliability.

• The PBX portion of the telecommunications industry is moving at a rapid rate, and between the writing and publishing of this report, specifications, features, and manufacturers will surely have changed.

- A fallout is sure to come.

- Who will survive will rest largely on the seven Bell Operating companies as they become licensed distributors for these highly sophisticated data processing products.

2. SOME POINTS TO CONSIDER

- The disadvantages of digital versus analog transmission include the following:

  - Bit rate. A high bit rate is required to transmit quality voice via pulse-code modulation or delta modulation.

  - Integration of voice and data in a PBX distorts traffic engineering statistics (basic voice calls: three minutes; basic data: ten minutes).

    - If you fine tune your trunking requirements for voice only and then add data, especially if usage is intermittent, you will find that your nonblocking--or minimal blocking--switch is blocking calls and creating great unhappiness among users.

    - This can really cause trouble since few people can tolerate a busy signal (or no signal) for very long. And once data-oriented users experience a blockage, they will seize a circuit and hold it indefinitely and thus compound the blocking problem and further disrupt the engineering statistics.

  - Cost. At present, digital is more expensive; if you do not need it, go analog.

- One factor that will cause few headaches is the caliber of sales personnel of the vendors. They are all of high quality, especially those employed by Rolm, Northern Telecom, and Rockwell (on a par with IBM's). They are far superior to the salespeople selling modems and multiplexers, and the buyer or user can expect pleasant experiences in dealing with them.

3. THE PBX MARKETPLACE

- It has recently been reported that AT&T currently has a little more than one-third of the total installed-base of PBX systems.

  - Less than ten years ago AT&T had virtually all of the PBX systems installed.

  - Unlike IBM, which has an estimated 60% of the data processing marketplace, AT&T has lost its dominant control in the communications marketplace.

- Exhibit IV-1 shows the market share of PBX shipments in the United States during 1982.

  - AT&T was a leader with 37%.

  - Rolm was second with 11%, followed closely by Northern Telecom with 9%. Mitel and GTE each had approximately 6% of the shipments.

- Since the top four vendors occupy almost 65% of the total market, let's take a closer look at some of them.

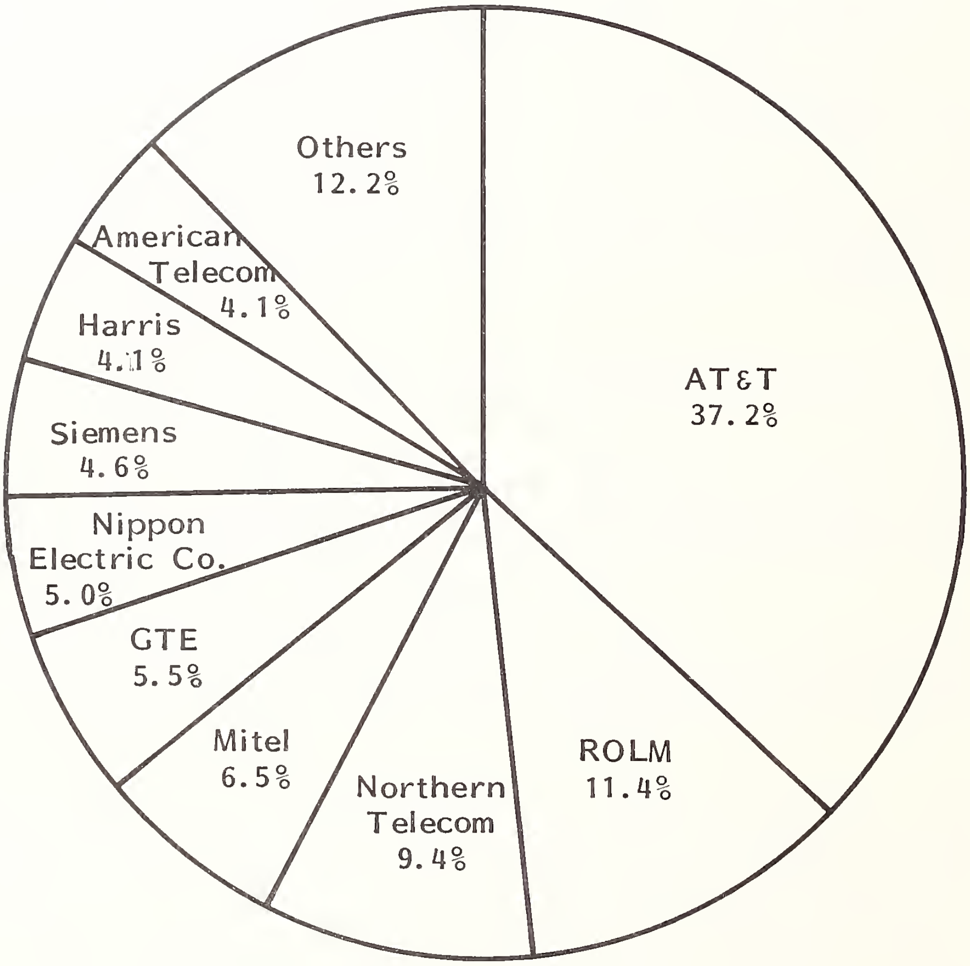
- AT&T Information System (ATTIS), at the present time, is the biggest. Northern Telecom and Rolm are AT&T's biggest competitors. Mitel was once considered a viable vendor due to their joint agreement with IBM, but when their joint agreement was dissolved, Mitel started having software problems with their large systems.

- Other leading vendors include GTE, Nippon Electric, Siemens, Harris, Intecom and American Telecom.

- Most do not have significant support staffs in many geographic locations.

EXHIBIT IV-1

PBX MARKET SHARE
BY VENDOR



Total Number of Lines: 3.6 Million Lines

Total Dollar Value of Shipments: $2.9 Billion

- Nippon does have such support staffs; however, the architecture of their Neax 22 product is analog.

- GTE makes extremely large PBX systems which are better suited to telephone company central office applications than to ordinary business use.

- Nippon Electric recently announced its IMS 2400 product line built around a new digital architecture. How successful this product is remains to be determined over time.

a. Northern Telecom's SL-1XL

- Exhibit IV-2 illustrates the basic operation of the Northern Telecom SL-1XL, PBX.

  - Each analog telephone set connects to a line card in the SL-1 cabinet. The analog voice signal passes through a coder where it is digitized. The digitized signal passes to the digital time division multiplexer bus path.

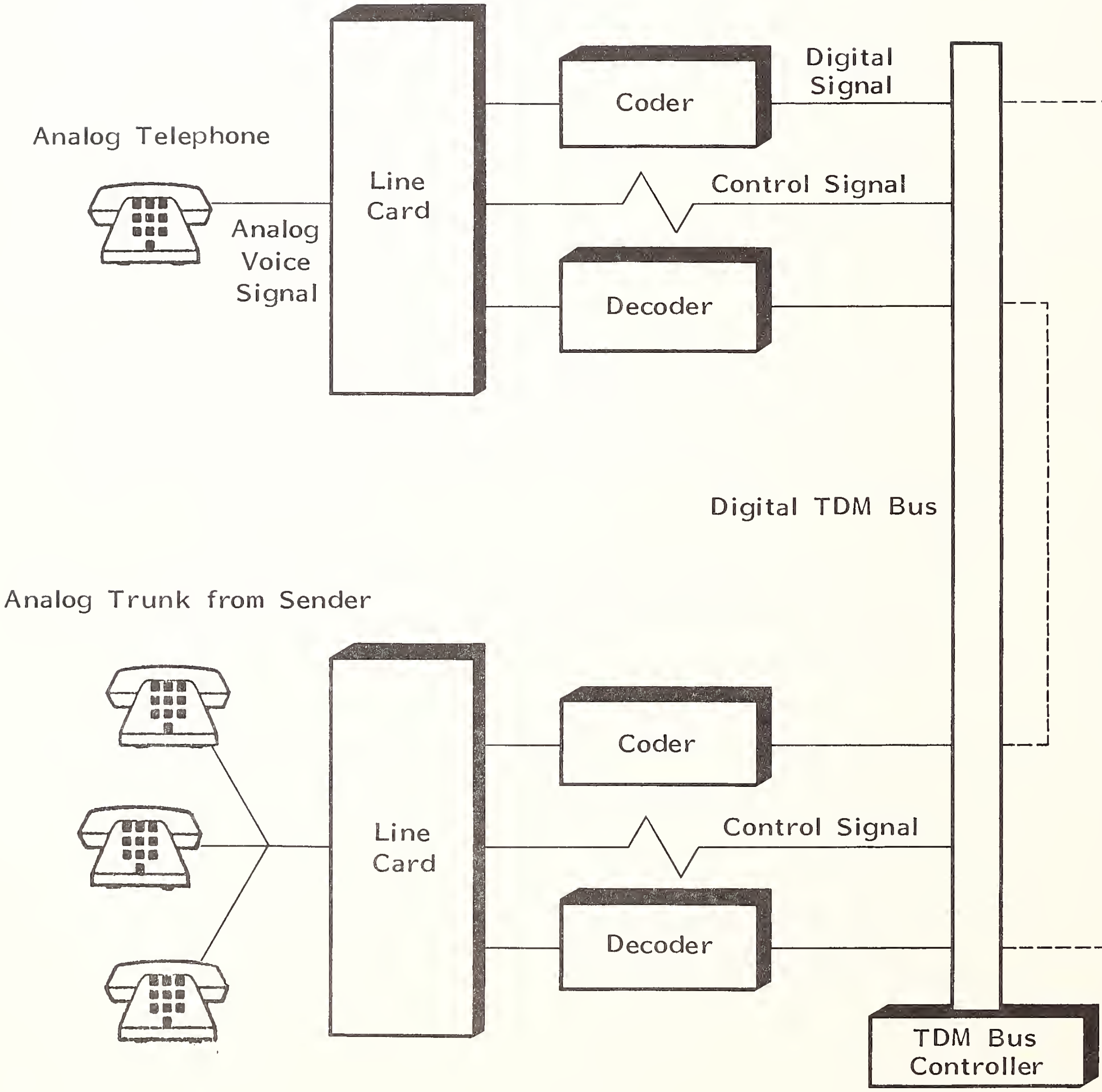
  - The telephone set also passes 2400 bps of digital signaling for control directly through the line card, to the TDM bus path and finally to the TDM bus controller.

  - After seizing a trunk, the TDM bus controller connects the trunk card decoder to the telephone set by coordinating the time slice connections.

  - The signal passes through the trunk card to the analog trunk supplied by the local telephone company.

EXHIBIT IV-2

NORTHERN TELECOM SL-1XL



- Once a connection is established, the conversation uses a coder in the trunk card and a decoder in the line card for the return transmission path.

- Northern Telecom's present generation of electronic telephone sets do not digitize voice in the telephone set.

  - Data and voice take separate paths into the line card before being digitized.

  - The future generation of data interfaces at Northern Telecom will accept data up to 64 Kbps and switch it transparently through the switch.

  - Voice control signaling and data control signaling will each have a separate 2400 bps digital transmission path.

- Northern Telecom recently announced a packet transport bus which will carry voice, but primarily data, over a separate 40 Mbps signal bus. This packet transport bus is intended for high data volume and a low volume of voice traffic.

  - This system will not packetize the voice but uses a time division multiplexing scheme which mixes PAM and PCM signal sampling. Voice is treated totally differently than data. Packetized voice is expected in this implementation around 1990.

- The packet transport bus was to have become avabilable in the fourth quarter of 1984.

  - Northern Telecom also has announced a TI interface and an SNA gateway.

- Both features will be available next year.

- Northern's support for IBM 3278-type clustered terminals through twisted-pair cabling is at least two years away.

b. Rolm's VLCBX System

- The Rolm VLCBX is made up of a maximum of 15 CBX nodes. Each node contains redundant 32-bit processors as well as completely redundant main and disk memory.

  - Exhibit IV-3 shows how a typical four node system is connected. Each processor is connected by a 56 Kbps redundant coax-based local area network for control information.

- The Rolm VLCBX is a totally distributed system where every node maintains a current copy of the system data base.

  - Like Northern's SL-1XL, the Rolm VLCBX has redundant processors. If one fails the other takes over. Unlike Northern's SL-1XL, the Rolm VLCBX loses operation on only some of its stations and trunks if both processors fail.

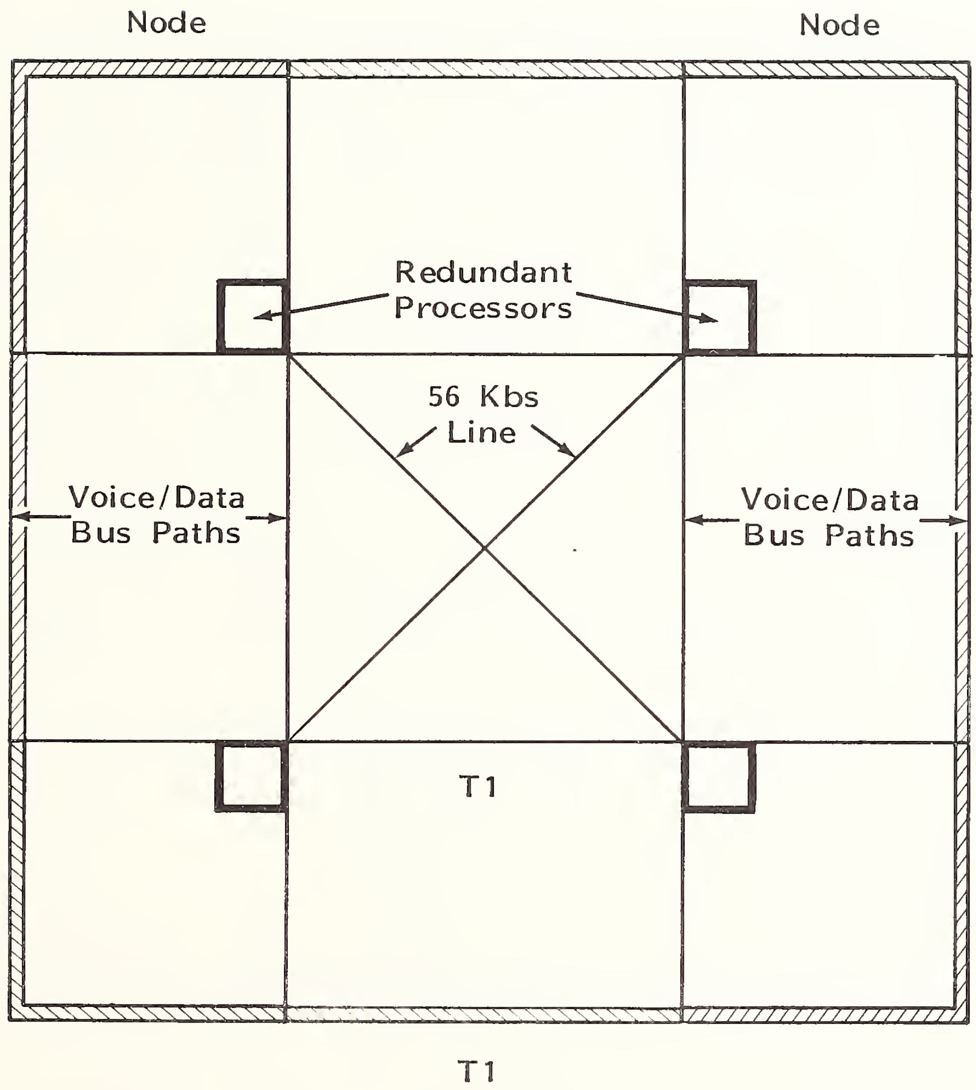
  - Rolm provides redundant T1 Carrier buses between nodes as well as a separate T1 Carrier ring bus around the nodes for overflow traffic.

  - Rolm's technology is very similar to Northern's except Rolm uses multiple redundant processors in multiple nodes connected by multiple bus paths. Northern's SL-1XL uses one set of redundant processors in a single node with a single bus path.

  - Northern's packet transport bus is a scheme which upgrades the system into a multibus architecture.

EXHIBIT IV-3

ROLM VLCBX PBX
SIGNAL PATHS



c. <u>Comparison of Selected PBX Systems</u>

- The AT&T PBX system alternatives may not be attractive to many users for several reasons:

  - AT&T was much more costly than either of its two closest competitors, Northern Telecom and Rolm.

  - AT&T's present level of customer support is a result of corporate divestiture and reorganization. The generally recognized poor level of support is well documented and could continue for some time.

  - The Dimension 2000 is based upon older analog technology, almost totally obsolete in today's marketplace.

- Exhibit IV-4 shows the basic comparison of the Rolm Northern and AT&T PBX products.

  - Northern's SL-1XL has 1,050 traffic paths of 64 Kbps per second of bandwidth each.

  - Rolm has 384 traffic paths of 192 Kbps per second. Rolm uses a technique called data sub-multiplexing to combine many data sessions into a single traffic path.

  - Northern dedicates one entire 64 Kbps traffic path to each data session, even if the data rate requires only 2-10 Kbps of bandwidth.

- The total throughput of the Northern SL-1XL is 67 Mbps which may be upgraded by adding and retrofitting with packet transport buses.

EXHIBIT IV-4

COMPARISON OF SOME MAJOR PBX SYSTEMS

	NORTHERN TELECOM SL-1XL	ROLM VLCBX	AT&T SYSTEM 85 RELEASE II
Traffic Paths	1,050 @ 64K bps	384 @ 192K bps	512 Time Slots, 256K per Slot
Total Throughput	67M bps*	74M bps*	203 Gbps
Where Voice Signal is Digitized	In set ($250 set)	In set ($140 set)	In Circuit pak (75 hybrid) or in set @ 840 (w/ Circuit pak)
Most Common Data Interface	Add-On Data Module	Data Terminal Interface	Data Terminal Interface
Cost for Each Data Interface	$700	$270	$1,000
Interface to Terminal	EIA RS-232	EIA RS-232	EIA RS-232
Maximum Synchronous Data Stream	56K bps	56K bps	56-64K bps (-Excluding Control Bits)
Maximum Distance From Device to Switch	5,000 ft.	7,000 ft.	3,500 ft. (swtch. to phn.) 100 Miles (Campus Use)
Does Data Device Require Phone Set?	Yes	No	No
Signal Scheme	1 Pair Analog Voice	1 Pair Phone and Control Two Pair Data	4 Pr. (transmit, Receive, Power, and Reserve) 2 Pr. (Data & Control)
Does Data Require Entire Traffic Path?	Yes	No	Yes
Can Multiple Data Paths Occupy a Single Traffic Path?	No	Yes	Yes if digitized
Support for T1/D3 Carrier Interface	Yes	Yes	Yes
Support for IBM SNA Gateway	Yes *Upgradeable	Yes	Currently in Development (Using LAN)

- Support for the increased throughput requires changing of all line cards and TDM bus controller cards. The cost of this throughput upgrade is estimated at between 20% and 30% of the total switch hardware cost.

- This upgrade would not be complete in that it would not support packetized voice.

● Rolm's VLCBX can be upgraded by fourfold to a total of 300 Mbps. This is accomplished by changing the TDM bus controller cards but not the line cards. The cost of Rolm's throughput upgrade is estimated at 15% of the total switch hardware cost.

  - Both PBX products are presently considered blocking switches.

  - With the throughput upgrade, both switches become nonblocking. A PBX throughput upgrade was probably not necessary in the short-term for most users, but as usage increases, it may be well to consider it.

● Both PBX products digitize voice in only their newest and more expensive electronic telephone sets. Both vendors use add-on modules withe the EIA RS-232 interface for data transmission.

  - Both vendors' data modules support synchronous data transmission at a maximum speed of 56 Kbps per station.

  - The most common data module used in the Northern SL-1XL costs $700 per unit. A new asynchronous model costing $350 is expected soon.

  - Rolm's Data Interface Unit costs $270 each.

  - Both vendors support a maximum distance from station to switch of at least one mile.

- Northern Telecom's SL-1XL PBX system uses one pair of wires for analog voice and two pairs for data plus signaling control.

  - Rolm uses one pair of wires for analog voice plus station control and two pairs of wire for data.

  - The Northern product requires a telephone set for each data device whereas Rolm does not have this requirement.

- The architecture of the SL-1XL is such that every data session requires an entire traffic path.

  - Rolm uses a submultiplexing scheme to combine many slow speed data transmissions into a single voice trunk path. This feature may be important in companies with traffic requiring both 4800 bps and 9600 bps of bandwidth.

  - One Rolm voice traffic path could contain six data sessions of 9600 bps each or 12 data sessions of 4800 bps each.

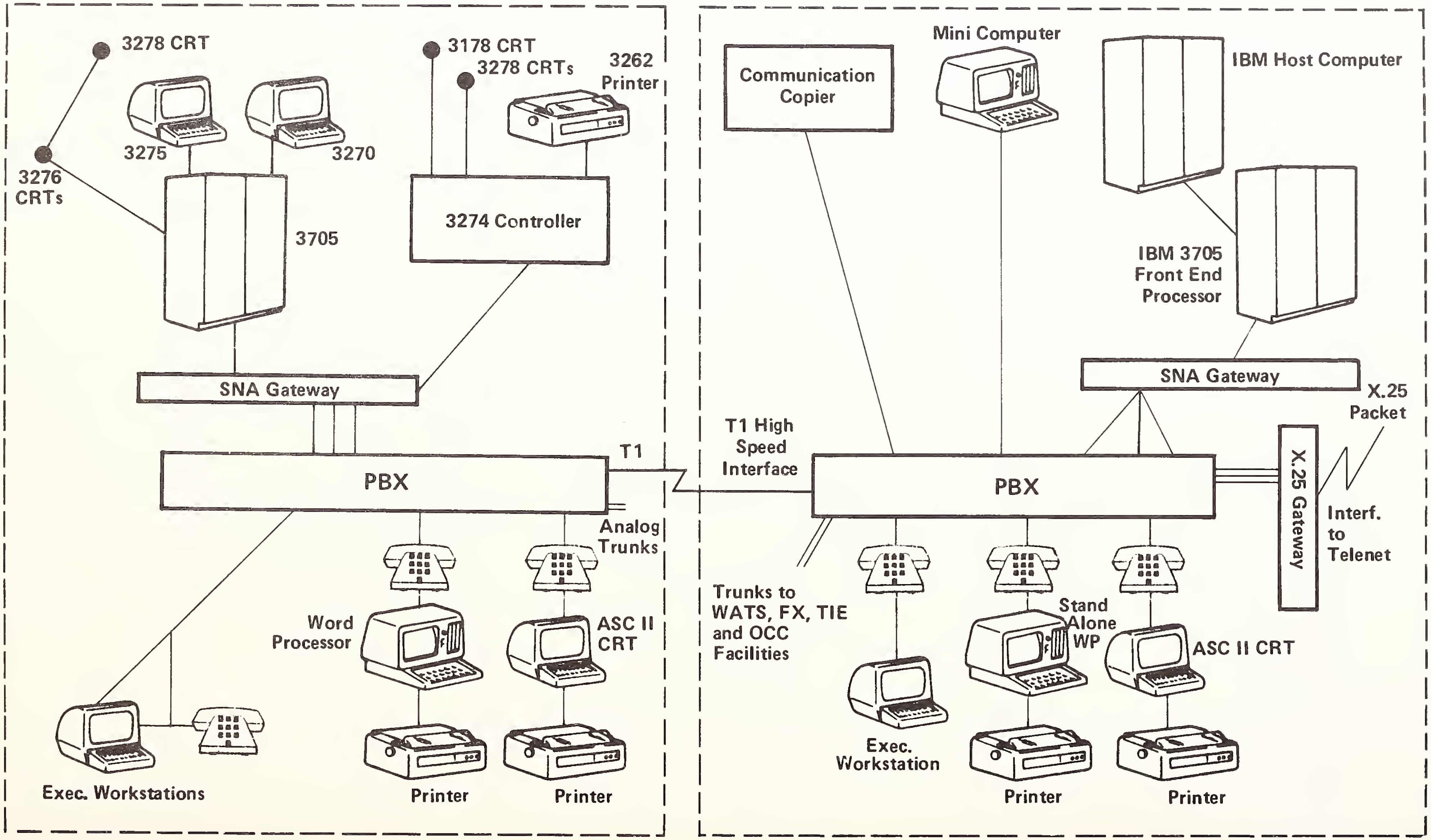
d. <u>Networking PBX Systems</u>

- Exhibit IV-5 shows a block diagram of how a user might network two PBX Systems together. One PBX might be at headquarters, and another PBX might be in a field location. The majority of voice calls between the headquarters personnel and field personnel could be routed through a high-speed T1 bulk carrier circuit at considerable cost savings. Additional T1 carriers may be added as needed.

  - Data transmissions could use the excess capacity provided by the T1 carrier for additional savings.

EXHIBIT IV-5

NETWORK PBX SYSTEMS



- Several types of devices may be connected to the PBX System including:

  . Terminals and printers.

  . Standalone word processors.

  . Executive workstations.

  . SNA gateways to the IBM network.

  . X.25 gateways to the value added networks such as Telenet and Tymnet.

  . Ports to the bank's cables network.

  . Ports to the bank's funds transfer network.

- Terminals at headquarters can access applications through the networking facilities provided by the PBX systems. Terminals at headquarters or connected to the field PBX could access Telenet through the X.25 gateway. Applications such as these make a TI interface and SNA/X.25 gateways a necessity.

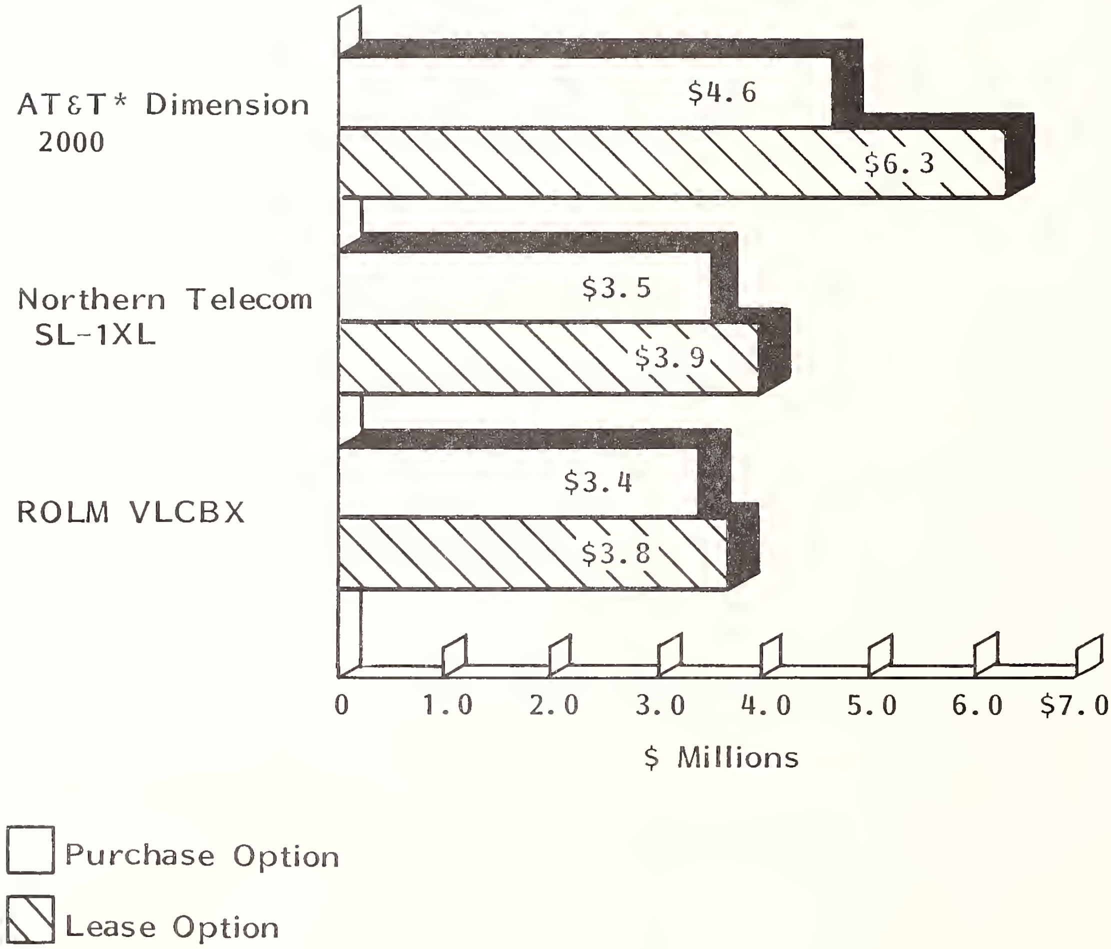
B. ECONOMIC CONSIDERATIONS

- Exhibit IV-6 details the cost comparison for lease and purchase of the following telephone PBX systems:

  - AT&T Dimension 2000.

EXHIBIT IV-6

PBX COST COMPARISON



* Does not include cost of upgrade to System 85 architecture.

- Northern Telecom SL-1XL.

- Rolm VLCBX.

- This figure shows that AT&T is the most costly with a lease cost of $6.28 million over seven years and a purchase cost of $4.63 million over the same period.

    - The Rolm VLCBX is the least costly with a lease cost of $3.64 million and a purchase cost of $3.75 million.

    - The cost for the Northern Telecom SL-1XL was very close to the cost for Rolm VLCBX system.

    - The only significant difference is the cost of additional protocol conversion facilities which are not offered by Northern Telecom.

    - The cost of the SL-1XL switch and the cost of the VLCBX switch are too close to make a significant difference. The AT&T Dimension costs are unacceptably high for most users and do not even include the cost of upgrading to a System 85 processor.

- Exhibit IV-7 details corporate profiles for Rolm and Northern Telecom.

    - Northern's total revenues of $2,469 million greatly exceed Rolm's $448 million.

    - But if you count only data processing revenues, Rolm is larger.

    - Rolm's data processing revenues grew 35% during the last two years.

    - Northern Telecom's data processing revenues decreased 16%.

EXHIBIT IV-7

COMPARATIVE PROFILES

	NORTHERN TELECOM	ROLM
I. Corporate Performance		
1982 Total Revenue	$2,469 M	$448 M
1982 DP Revenues	$ 185 M	$448 M
Growth in DP Revenue During the Last Two Years	-16%	+35%
1982 Employees	3,300	6,020
1981 Employees	4,001	4,823
1982 R & D Expenditures	9.7%	6.4%
II. Joint Corporate Agreements		
For License and Manufacturing	DEC, DG and Sperry	None
For Testing and Certification	HP	HP, DEC and DG
III. Major Corporate Stockholders	Canadian Bell	IBM
IV. Upcoming Products	1. T1 Interface 2. ASCII to SNA Conversion 3. Baseband Local Area Network 4. Async Interface for $350	1. X.25 Telenet and Tymnet Certification 2. Baseband Local Area Network

- Revenues overall at Northern have grown an average of 20% per year, but profiles have risen only 11% on average.

- Northern Telecom does spend a large dollar amount on research and development.

- Rolm's work force recently increased from 4823 to 6020 while Northern's declined from 4000 to 3300 during the same period.

- Northern has corporate licensing and manufacturing agreements with Digital Equipment Corporation, Data General, and Sperry Univac.

- Northern has testing and certification agreements with Hewlett-Packard.

- Rolm has testing and certification agreements with all these leading minicomputer manufacturers except Sperry.

• Canadian Bell is a major corporate stockholder in Northern Telecom as well as its Bell Northern Research subsidiary.

    - IBM is a major corporate stockholder in Rolm.

    - IBM's first attempt at a PBX was an in-house effort in France which failed miserably. Their second attempt was a joint effort with Mitel. IBM will not fail in their third attempt at having a PBX product and they have put up the money to prove it.

    - Northern, on the other hand, has been called a failure in its efforts to become a force in the office automation marketplace. Northern Telecom's Sycor and Data 100 acquisitions have proved to be a curse rather than a blessing.

- Both Rolm and Northern Telecom would more cost effectively meet the user's voice needs than the AT&T Dimension 2000 System. The Northern Telecom SL-1XL and Rolm VLCBX Systems both meet and exceed most user's basic and additional voice requirements.

- When it comes to data, Northern Telecom's SL-1XL meets most (but not all) of most user's data communications requirements. Rolm's VLCBX meets all the previously outlined datacomm requirements.

  - Rolm's VLCBX distributed architecture handles low speed data (1,200 bps-9,600 bps) more efficiently than Northern. For most users in a commercial environment, the data will be primarily low speed for many years.

V VOICE/DATA INTEGRATION: PROBLEMS AND POSSIBILITIES

V VOICE/DATA INTEGRATION: PROBLEMS AND POSSIBILITIES

A. INTRODUCTION

- Just as the computer business has witnessed drastic changes in technology, applications, and distribution channels, so, too, has the communications industry. And from now on both industries will progress in tandem, as they have become interrelated and interdependent.

    - There may be no greater current example of this mutuality than the so-called integrated services digital network, or ISDN, expected to evolve from the public switched telephone network.

    - But without more attention to what users think and need, this grand scheme to integrate a multitude of services ranging from voice to data, video, facsimile, videotex, and teletex may turn out to be a digital pipe dream.

- No factor has been more influential in combining computing and data communications in general, and the ISDN in particular, than the international Telegraph and Telephone Consultative Committee, better known as the CCITT.

    - Its objective is to establish standards, or what it calls "recommendations," for end-to-end performance, interconnection, and maintenance of the world's networks for telephony, telegraphy, and data communications.

- A familiar example of CCITT effort is recommendation X.25, which defines the interface between data terminal equipment and packet-switching networks.

- The more recent ISDN effort has received substantial attention by the CCITT Study Group 18, which examines digital network topics and is responsible for creating ISDN standards.

  - The outcome of these efforts may someday give users the advantage of integrated access to any of these communications services through a single worldwide standard interface.

  - Despite the blissful state some people go through envisioning these technologically wondrous digital pipes, ISDNs present some significant potential problems and do not win everybody's praise.

- In truth, much of the ISDN standardization work has occurred without much consultation of potential users.

  - Experience teaches that products or services designed without the inclusion of market research have often failed to succeed in the marketplace.

  - A good example of this are bubble memories, introduced as replacements for floppy disks and some semiconductor memories, such as EPROMs.

  - Although the commercial availability of bubble memories was considered to be a technical milestone, the commercial viability was a nightmare.

- The devices bubble memories were to supplant--conventional memories--already had satisfied most market needs. If the bubble memory manufacturers initially had read the market properly, they would have discovered that the very benefits that pleased memory purchasers--ease of use, standardization, and low cost--were lacking in the new substitutes.

- The largest supplier, Texas Instruments Inc., eventually withdrew from the bubble memory business because the company failed to attract high-volume customers.

- With the exception of the United States, most countries have government-controlled communications networks.

  - These foreign countries, to a large extent, are in the position to dictate to their users the types, qualities, and prices of communications services to be offered.

  - Consequently, much of the information put into the ISDN standardization process comes from countries that are not compelled to consider the marketplace's needs before introducing new services.

- Conversely, having just begun the new era of deregulated telecommunications with the AT&T divestiture, users in the United States are now faced with a plethora of network options and suppliers. Naturally, there is some skepticism about whether ISDNs, which were to have been standardized at the CCITT's eighth Plenary Assembly in November, 1984 meet the needs of telecommunications users in the United States.

- Realizing the controversy and confusion that could result in the United States from impending ISDN standards, the Federal Communications Commission was forced to issue a notice of inquiry in the matter of ISDNs.

- This document was designed to educate and elicit comments from participants and users within the computer and communications industries.

- The FCC will eventually regulate ISDNs, as it does all U.S. commercial communications, and would rather do so in a manner that is equitable and suitable to suppliers and users.

B. WHY ISDNs?

- Currently, communications users employ a variety of separate networks to satisfy their voice and data requirements.

  - The telephone, satellite, microwave, and packet-switching networks each have a different access scheme.

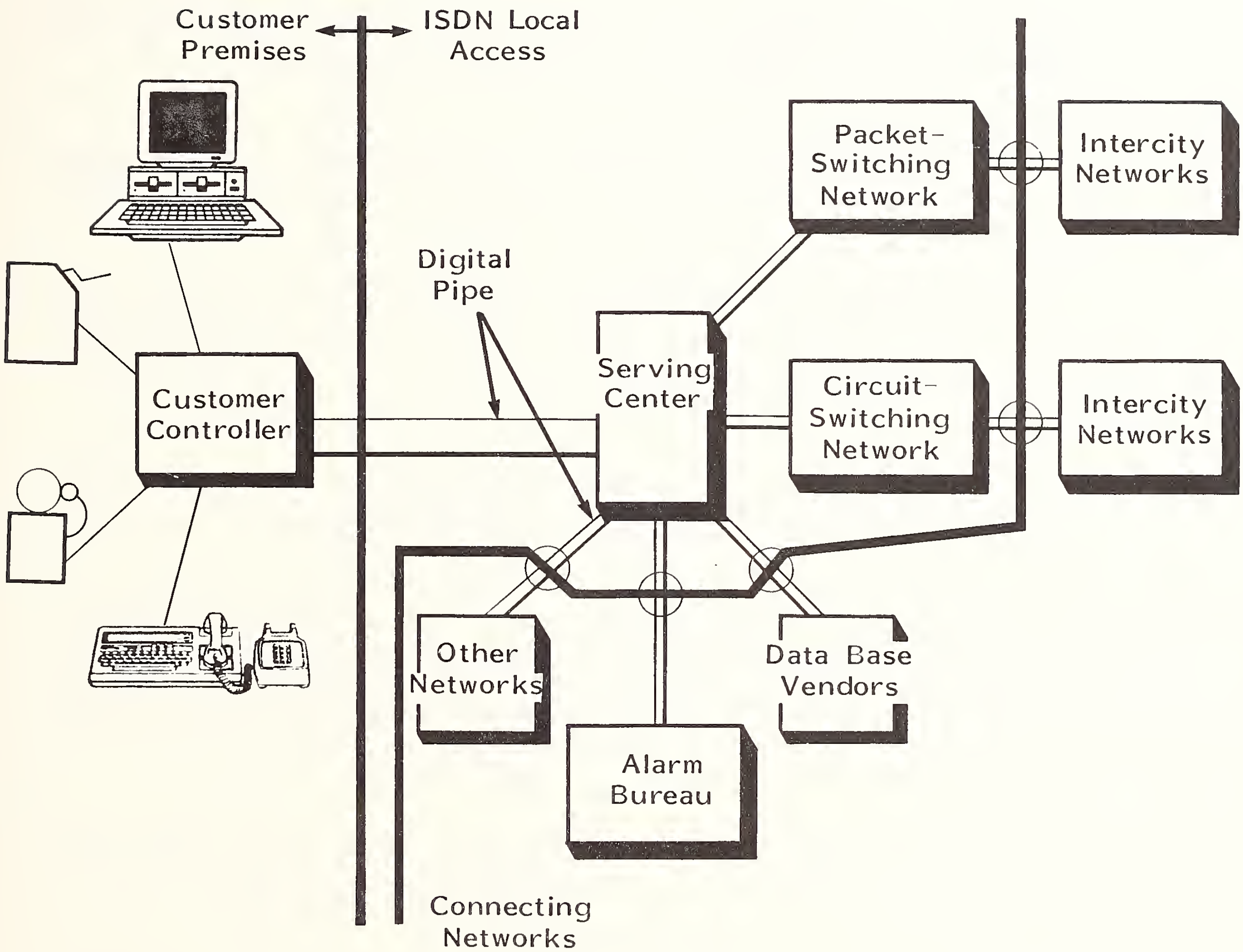
  - Alternatively, the ISDN, with the telephone network as its core, is intended to eliminate the hassles associated with managing multiple links and purchasing modems.

  - Users instead could have at their premises a digital pipe from which they may select any number of desired services and bandwidths, as shown in Exhibit V-1.

- The main objective of ISDNs is to inhibit further evolution of separate voice and data networks--taking advantage of the economies achieved in digital transmission, switching, and signaling--and to provide the user with a universal plug connected to a universal network.

EXHIBIT V-1

CONCEPT ILLUSTRATION OF AN ISDN NETWORK



- From the user's point of view, an ISDN should provide simple connections to the network for terminal devices, uncomplicated use, and the ability for all users, regardless of their terminal types or vintages, to connect to all other network users. After all, it is the user who will determine the ultimate success of ISDNs.

- The applications proposed for ISDNs are varied, ranging from those transmitted at data rates of less than 300 bps to others at 100 Mbps.

  - The low-end rates are especially suitable for telemetry, which includes remote meter-reading, energy management, and security management.

  - At rates up to 4.8 Kbps, applications associated with interactive data transfer among terminals, word processors, data bases, and computers are to become commonplace.

- Two examples of interactive data-transfer applications are Teletex and videotex, which are classified by the CCITT as "telematic services."

  - Teletex is a terminal-based telegraphy service designed for communications over the public switched telephone networks. Intended for exchange of ordinary correspondence, it combines word processing features, such as editing, with transmission functions.

  - Teletex, at 2.4 Kbps, is much faster and more efficient than Telex transmission at 70 bps.

- Videotex is a two-way, interactive service that transmits text and graphics to a user's television set from a remote computer and also permits the user to have control over the data he views. Both videotex and Teletex, along with telemetry, have bursty transmission characteristics and are appropriate for the packet-switching portion of ISDNs.

- Image applications include slow-scan, or freeze-frame, video as well as graphics and facsimile. Characterized by data representing fixed images, these applications are commonly transmitted at 64 Kbps.

- Video teleconferencing, or full-motion video, can be transmitted today at 1.544 Mbps or less, using advanced signal-compression techniques.

  - This application is being used increasingly in large corporations where executive travel is very costly, but at a slower rate than anticipated by much of the communications industry.

  - Full-motion and freeze-frame video applications are well suited for the circuit-switched portion of ISDNs.

- Voice is expected to constitute 60% to 70% of the ISDN traffic for a few years to come.

  - Digital voice transmission is commonly achieved today at the pulse-code modulation rate of 64 Kbps.

  - But that speed may be cut in half soon by the imminent recommendation by the CCITT of 32 Kbps adaptive differential pulse-code modulation.

C. THE EVOLUTION OF ISDNs

- And so the ISDN evolution unfolds, irreversibly changing the relationship between the computer and communications industries, making them virtually indistinguishable.

- Communication is no longer possible without computers; computers are becoming useless unless they can communicate.

- ISDNs in the United States are expected to evolve over three consecutive phases, spanning a decade.

- As seen in Exhibit V-2, these phases are transition, first generation, and second generation.

- The transition phase, in which the industry currently exists, is distinguished by the continued expansion into the telephone network of common channel signaling, as well as digital capability in local loops and switching exchanges.

  - Moreover, increased use of pre-ISDN services, such as AT&T's Local Area Data Transport and Circuit Switched Digital Capability, will be seen.

  - Existing 56 Kbps transmission lines ultimately will be converted to clear-channel 64 Kbps lines.

  - The United States, Canada, and Japan have been using 56 Kbps instead of the 64 Kbps rate because of the slower rate's inband signaling scheme.

  - It requires that one of eight bits be used for signaling for every sixth frame transmitted per channel. This is called "bit robbing", and the resulting rate is effectively seven-eighths of 64 Kbps or 56 Kbps.

  - Because ISDNs will be based on 64 Kbps with common channel signaling, which does not rob bits, the user of 56 Kbps is expected to eventually decline.

EXHIBIT V-2

INTEGRATION PHASES

TRANSITION 1983-1986	FIRST GENERATION 1986-1990	SECOND GENERATION 1990 and BEYOND
Pre-ISDN Services	Integrated Access	High-Speed Data and Video Capability
Separate Access Facilities - Alternate Voice and Data	CCITT-Standard Equipment, Interfaces	Integration of Circuit and Packet Switching
Expanded Digital Capability in Local Loops and Switching Exchanges	Simultaneous Voice and Data at 64KBit/s	New Services
Increased Use of Common Channel Signaling	Expanded Customer Control - D Channel Signaling	
64 K bit/s Clear Channel Transmission		
CCITT ISON Standards		

- The CCITT Plenary Assembly in November, 1984 produced the first ISDN standards. It marks the climax of the transition phase and establishes solid footing from which the first generation can proceed.

- The first-generation phase will begin in 1986 and end in about 1990.

  - Emerging in this period will be integrated access capability and CCITT-standard ISDN equipment and interfaces.

  - Integrated access implies a single interface for a wide range of voice and data services, unlike the use of separate hookups required during the transition phase.

- The second-generation phase is expected to start in 1990.

  - Because the telecommunications industry is advancing so rapidly, it is difficult to predict precisely what this era will bring. But it is anticipated that a shift toward high-speed data and video capabilities will be seen, as well as the integration of circuit and packet switching into a single transport.

  - Various new services are likely to arise as suppliers and subscribers alike gain a better understanding of the capabilities and benefits of ISDNs.

- The ISDN industry structure will be composed of two segments: hardware and services.

  - ISDN hardware markets will be further subdivided into network-related equipment and customer-premises equipment.

  - The distribution of ISDN hardware--central-office switches, PBXs, data terminals, combined voice-and-data terminals, computers, local networks, and the like--will occur through the same channels used for these devices today.

- Some of these channels are direct sales, other equipment manufacturers, interconnect companies, systems integrators, and distributors.

• The structure for distributing ISDN services--telephony, circuit-switched data, packet-switched data, telemetry, information retrieval, and so forth--is subject to the FCC's scrutiny.

  - Communications services are defined differently by the CCITT, the FCC, and the Department of Justice, which became a player on the data and telecommunications scene as divestiture loomed.

  - The CCITT's definitions are technical, while the definitions of the FCC and the Department of Justice are legal.

• United States communications services are defined as either basic or enhanced.

  - A basic service, like technology, is provided by a common carrier offering transmission capacity for the transport of information.

  - An enhanced service is one offered on a common-carrier facility by a supplier of a computer processing application, such as supplying stock market prices on inquiry.

  - Regulated common carriers, like AT&T Communications, are only permitted to offer basic services.

  - Unregulated common carriers, like MCI, can provide both basic and enhanced services, as long as these services are unbundled.

- The issue of determining charges, or tariffs, for ISDN services is presently unresolved.

  - Since all transmission on an ISDN is to be digital, there is a question currently under study by the FCC regarding the fairness of charging for all ISDN services equally.

  - To a metered switch, a digital stream is digital stream. But to a subscriber, there are differences. A simple message, for example, could be sent by Telex, facsimile, or voice. The Telex message would probably require the fewest bits for transmission completion.

  - Facsimile most likely would use more bits, and voice transmission the most bits to transmit the identical message.

- The voice transmission would therefore be the most expensive method, and Telex the least expensive.

  - It seems that in a free, pro-competitive market, per-bit tariffs would effectively determine which method a subscriber would choose for transmission.

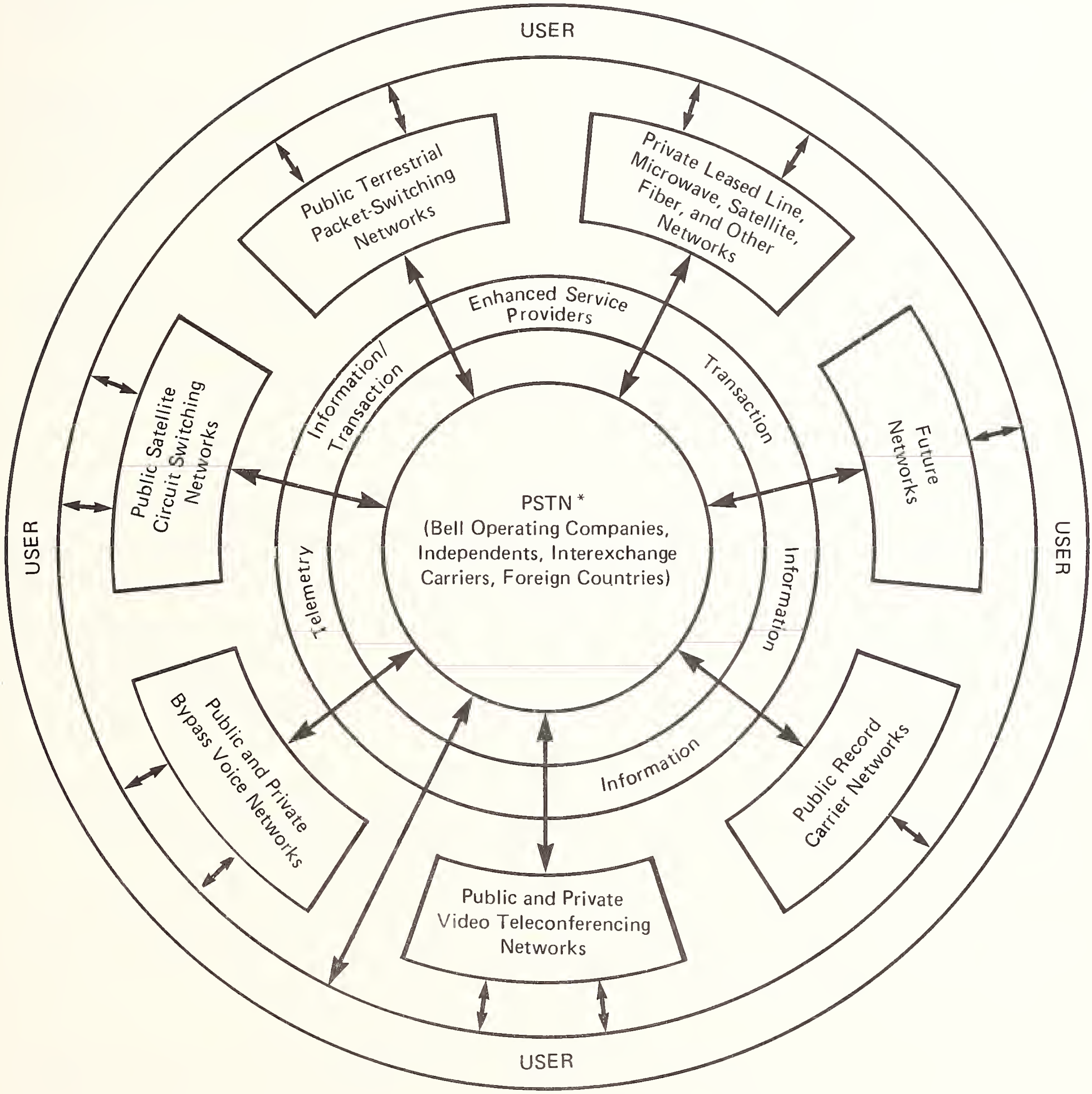
  - If bit streams are tariffed by content instead of speed and duration, then artificial demand is likely to prevail. This will lead to an inefficient supply of ISDN services.

D. ISDN SERVICE PARAMETERS

- With these issues in mind, Exhibit V-3 depicts the most likely scenario for the distribution of ISDN services.

EXHIBIT V-3

ISDN DISTRIBUTION SERVICES



* PSTN = Public Switched Telephone Network

- In the center ring is the public switched telephone network through which the majority of ISDN traffic will be routed.

- The next ring embodies the enhanced services providers. They will use the basic services carriers to transmit value-added services to the user.

- The next ring incorporates basic services suppliers. These suppliers will deliver "subscribed information" directly to the user by means of twisted-wire pairs, fiber-optic links, earth stations, and microwave dish antennas.

- Finally, the user is shown encompassing the entire ISDN, which must be designed to serve his needs. The user is the most important element of the ISDN services structure, for he has the purchasing power to determine the viability of the other elements.

● The U.S. communications and computer industries will manufacture the hardware that interfaces to ISDNs, in compliance, for the most part, with rules made during the FCC's Second Computer Inquiry; Part 68 of the FCC's "Rules Concerning Connection of Telephone Equipment, Systems, and Protective Apparratus to the Telephone Network"; and the CCITT's ISDN Draft Recommendation in the I.4xx series on user and network interfaces.

● The FCC's Second Computer Inquiry decision regulates the distribution channels that are allowed in selling customer-premises equipment (CPE).

- Regulated common carriers must first create an unregulated subsidiary to sell CPE, and they cannot sell CPE as part and parcel of their common carrier offerings.

- For example, Southern New England Telephone Co. created Sonecor Systems for this purpose.

- Part 68 of the FCC's rules provides the technical and procedural standards under which direct electrical connection of customer-provided CPE may be made to the nationwide telephone network without harm.

  - The third notice of proposed rulemaking, released June 4, 1984, seeks amendment of Part 68 of the FCC's Telephone Connection Rules to include network channel terminating equipment (NCTE) as part of customer premises equipment. NCTE, which resides at the customer's side of the local loop, is a hardware interface device that provides electrical/mechanical, maintenance (remote testing) and channel provisioning functions related to digital networks, such as ISDNs, for both the customer and the common carrier.

  - Historically, NCTE has been a tariffed part of the local loop.

- The CCITT's I.4xx Draft Recommendation series defines all user and network interfaces--electrical, mechanical, and protocol. The electrical mechanical, and other Level I physical specifications are specified in Draft Recommendation I.431.

E. ISDN HARDWARE REQUIREMENTS

- Hardware distribution may be broken down into a number of distinct identifiable steps, each relating to the ISDN-level functional groupings.

  - The non-ISDN terminal manufacturers will continue to sell their products through distributors to users directly, as well as through systems integrators.

  - Distributors will include computer supply houses, telephone interconnect companies, and unregulated subsidiaries of common carriers.

- System integrators include computer OEMs and unregulated common carriers' subsidiaries.

- Because of the growing trend toward integrating and consolidating computing and telecommunicating, product distribution and installation of computer and communications equipment will often be handled by the same entity.

• The terminal adapter manufacturer will create new products to allow non-ISDN terminals to interface with ISDNs at the PBX or at network channel terminating equipment. Therefore, the terminal adapter manufacturer is expected to channel his products through the non-ISDN terminal manufacturer, distributor, and systems integrator, as well as directly to the user.

• The manufacturers of ISDN-compatible terminals, ISDN channel terminating equipment, and ISDN-compatible PBXs and controllers are also expected to market their products through distributors, system integrators, and directly to the end user. But the ISDN-compatible terminal manufacturers will sell through the ISDN-compatible distribution channel as well, because the major PBX and controller manufacturers of this equipment are being viewed increasingly as providers of the "total solution."

• Until they are eventually phased out, what are known as analog terminals--telephones and modems--will continue to be sold directly to the user and also indirectly to him through distributors.

F. ISDN: THE NEXT WAVE OF INTEGRATION

• In the United States, there is a diverse range of ISDN-related knowledge and planning activities among future suppliers of ISDN-compatible hardware and services. One study has found, as seen in Exhibit V-4, that only 9% of data terminal manufacturers have ever heard of ISDNs.

- Of these, not one has begun any such product planning. This is especially disturbing because data terminals will be among the most common gateways to ISDNs.

- Conversely, PBX manufacturers are the most knowledgeable among future ISDN-hardware producers, and, according to the study, 88% of this group are already incorporating ISDN standards into their product planning.

- Network providers, especially telephone companies, are not only very cognizant of ISDN developments, but are actively incorporating ISDN protocol standards into their service planning activities.

- This study's market research reveals that prospective users will be interested in employing ISDNs only if they can cut their communications costs.

  - An average of almost 40% of corporate telecommunications annual budgets are presently allocated to voice communications services.

  - The managers are doing everything possible to reduce costs. If ISDNs are marketed without considering this, these digital pipes may join bubble memories in the category of solutions looking for a problem.

- Telecommunications users view ISDNs as new solutions to existing problems. These users have decreed that the amount of money they will spend to route voice and data through ISDNs must not exceed planned expenditures. If ISDNs prove to be too expensive, then, in the face of a deregulated communications industry, every user will find his own unique solution, thereby negating years of standardization work.

EXHIBIT V-4

DISTRIBUTION CHART OF ISDN FAMILIARITY

MANUFACTURER	ISDN FAMILIARITY		FAMILIAR WITH ISDN AND INCORPORATING INTO PLANNING	
	YES	NO	YES	NO
Computer	43%	57%	80%	20%
Data Terminal	9	91	0	100
PBX	73	27	88	12
Facsimile Terminal	33	67	100	0
NETWORK PROVIDER				
Common Carrier	100%	0	100%	0
Satellite Carrier	60	40	100	0
Packet Network	50	50	100	0
Record Carrier	50	50	100	0

- If they are successful technologically and economically, ISDNs for the first time will offer a standardized way for the entire world to communicate with voice, data, video, and other services, as well as to manufacture computers, terminals, and PBXs with universal interfaces.

  - The ultimate success of the ISDN concept can be achieved only through maximum cooperation among future industry participants and extensive market research into users' demands.

  - ISDN marketers who can reach out and touch someone's pocketbook will experience success very quickly.

G. SUMMARY

- The advent of Integrated Services Digital Networks will substantially alter the planning process in most large and medium-sized organizations.

  - Physical and environmental planning will be among the first areas to feel the impact of this technology.

  - Cost planning will also be strongly affected. Substantial re-allocation of budgetary efforts and cost distributions will take place as a result of lowered installation costs, reduced overhead, decreased operating expenses, and more effecient work activities.

- But unless there is either a breakthrough in the technology, or some other, yet unrealized approach is taken, all this may just be wishful thinking.

  - A tremendous amount of verbiage, spoken as well as written, has obscured the reality of voice/data integration and its attendant problems.

- No one can profitably operate a business using yesterday's technology in today's marketplace to solve tomorrow's problems. The business community has a critical need for the voice/data integration capability: when it will actually get it is a matter of considerable conjecture.

- Meanwhile, use today's technologies to solve today's communications problems, but be alert to sudden and dramatic changes in the technology.

VI CONCLUSIONS AND RECOMMENDATIONS

VI CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

- Of those companies installing a voice/data integrated system within the next year, nearly 90% will select a digital PBX, 70% expect to integrate voice and data in their new systems, and 55% will utilize the PBX in conjunction with a local area network.

- It is apparent that eventually the two technologies of voice and data will merge. To ensure that they do and that the company paying information systems personnel gets the best for its money, IS personnel should make their presence felt now in the selection of any future digital telephone systems.

- However, recognize that integration of voice with coaxial-cable local networks is not practical at today's prices.

- The ultimate integration of voice and data (along with other media, e.g., video) may never be realized because of economic and technological considerations. Wishing just doesn't make it so. Despite the huge amount of verbiage to the contrary, voice/data integration may never become economically feasible, even if the technological problems are eventually solved.

    - The current inability to packetize voice in an economical and competent manner is a major problem.

- The cost of integration for the smaller- to medium-sized-user may prohibit its implementation for those users.

B. RECOMMENDATIONS

- If possible, become a telecommunications reseller within your own organization, or if you have excess capacity, to outside companies. In this way, the telecommunications function becomes self-supporting, generating revenue rather than using it.

- Consider acquiring your own private telephone system via a PBX or PABX. This will be cheaper in the long run than relying on a central office service, and will give you better control over change and growth.

- Exercise great caution in approaching voice/data integration. The vendors who offer such a product may not be able to deliver it, for technological and/or economic reasons.

- If a PBX-type switch is required to service present needs, the Rolm VLCBX is recommended as a present technological state PBX device on the basis of its ability to meet the major portion of data communications requirements of a large number of users. It also comes closest to achieving the limited capability of voice/data integration as it is currently configured.

    - The Rolm architecture is more efficient for handling low speed data through its multiplexing and submultiplexing techniques.

    - Rolm's T-1 interface and SNA/X.25 gateways are field-proven products.

- Northern has just announced these products and is somewhat behind in their development.

• Rolm is recommended as the preferable vendor because of its proven performance in delivering new products ahead of its competition.

  - The Rolm and IBM link allows the user to take advantage of integrated technologies and products in the future.

  - The user's entire data processing facilities can be built upon IBM technology. Thus, a Rolm PBX becomes the logical communications decision.

APPENDIX: QUESTIONNAIRE

1. What is your interest (and/or activity) in Voice/Data Integration:

☐ Faster throughput

☐ More efficient use of Telecom capability

☐ Cost-effective communications usage

☐ Better response from user community

☐ Other ______________________

2. How do you tie computers and communications together within your organization?

From a technical point of view ______________________?

From an organizational reporting point of view ______________?

3. Is the IS budget separate from the telecommunications budget?

☐ Yes ☐ No

4. If not, what percentage of the total IS budget is dedicated to telecommunications?

____

5. What is the budget distribution for these two items?

Voice ________% of telecommunications budget

Data ________% of telecommunications budget

Other (______________) ________% of telecommunications budget

6. What is the approximate perdent of your total transmission activity devoted to:

Voice ________%

Data ________%

Other (______________) ________%

7. How do you expect your budget allocations to change in the next:

   6 to 12 months ________%

   12 to 24 months ________%

   Over 24 months ________%

8. Have your networks been integrated for both, voice and data?

   ☐ Yes ☐ No

9. In your data transmission, do you use data compression techniques?

   ☐ Yes ☐ No

   What are they? ______________________________

10. Was it ☐ In-house developed or ☐ Vendor supplied?

    Which Vendor? ______________________________

11. Do you use:

    ☐ Dedicated voice networks

    ☐ Dedicated Data Networks

    Whose? ______________________________

12. What kinds of lines are you currently using?

    Type ______________________________

    Speed ______________________________

    Distances ______________________________

    Number of node points ______________________________

13. What techniques are your currently using to handle voice and data?

    ____

    ____

14. Given what's known today, how would you integrated voice and data activities?

☐ Via PABX (CBX), Why? ______

☐ Via LAN, Why? ______

☐ Other Techniques, Why? ______
(______) ______

15. a. Are you currently using separate networks for voice and data?

☐ Yes ☐ No

b. Will they remain separate in the near term?

☐ Yes ☐ No

Why/Why not? ______

16. a. What do you expect your future network requirements will be?

______

17. Do you use multiplexing to transmit data and voice over the same line (if user has T1 lines) ?

☐ Yes ☐ No

18. a. Can digital technology applied to voice transmission reduce the size (or amount) of equipment required?

☐ Yes ☐ No

b. Will it increase (or decrease) the quality of the signal?

☐ Increase

☐ Decrease

19. What voice/data integration issues do you consider important? (which ones would you like to see resolved first?)

____

____

____

20. Regarding voice/data integration, what do you feel is direction that your company will take in the next 2 to 5 years?

____

____

21. Are fiber optics applicable to your transmission environment or requirements?

☐ Yes ☐ No

Why? ______________________________

22. What are your transmission speeds?

Current Requirements ______________________________

Future Requirements ______________________________

23. Do you conduct equipment tests?

For voice equipment? ☐ Yes ☐ No

For data equipment? ☐ Yes ☐ No

24. How do you deal with compatible versus non-compatible equipment within your I.S. department.

____

____

____

25. What is the range of your voice and data annual expenses?

	Less than $1 M	$1-5M	$5-10M	Over $10M
Voice	☐	☐	☐	☐
Data	☐	☐	☐	☐

26. What is your data processing budget (approximate annual)? $ ___________

27. What is the current principal transmission costs?

Equipment $___________

Lines and Flat Charges $___________

Service Overhead $___________

Shared (public) Networks $___________

Private Networks $___________

Short Haul Data $___________

Long Haul Data $___________

AT&T $___________

Other Suppliers:

____________________ $___________

____________________ $___________

28. Average estimated percentage of analog and digital media usage?

Analog ___________% Digital ___________%

29. What data transmission protocols are you currently using?

☐ SNA ☐ X.25 ☐ DECNET

☐ Other ___________ ☐ Other ________________

30. What is your network topology?

☐ Star ☐ Bus ☐ Token ☐ Ring ☐ Tree

☐ Other ______________ ☐ Other ______________

31. Are you using Binary Synchronous Communications?

☐ Yes ☐ No

32. Do you use or require packet switching?

☐ Yes ☐ No

33. Are you currently using PBX, PABX, or CBX?

For Voice, ☐ Yes ☐ No

For Data, ☐ Yes ☐ No

34. Do you transmit any other media (e.g., video)?

☐ Yes ☐ No Percentage ________ %

35. What make/model of PABX (or equivalent) are you currently using?

____

Number of lines? ______________

36. Do you plan to replace or upgrade this equipment? ☐ Yes ☐ No

When? ______________________________

With what? ______________________________

At what cost? ______________________________

37. Which LANs, VANs or specialized carriers are you currently using?

____

38. What percentage of your total transmission requirements are handled by them?

__________%

39. Any other comments on the subject integrating voice and data communications?

____

____

____

____

THANK YOU!!